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Study of Irrigation water quality in Chevella watershed of Rangareddy district, Telangana State, India

KEYWORDS Chevella watershed, agriculture water quality, SAR, KR, SSP, PI, RSC

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ABSTRACT Parameters such as Permeability Index (PI), Kelly's Ratio (KR), Soluble Sodium Percentage (SSP), Residual Sodium Carbonate (RSC) and Sodium Absorption Ratio (SAR) are considered for the Study. In pre monsoon of 2009 PI varies from 58.7 to 62.7 with mean 59.9; KR varies from 0.7 to 0.8 with 0.8 mean; SSP varies from 42.4 to 44.2 with mean 43.8; RSC differ from -1.8 to -1.2 with an average of -1.5; SAR varies from 3.7 to 5.7 with an average of 5.0; In pre monsoon of 2013 PI varies from 45.7 to 50.3 with mean 47.1; KR varies from 0.5 to 0.6 with 0.6 mean; SSP varies from 35 to 35.2 with mean 35.1; RSC differ from - 4.8 to -3.0 with an average of – 4.0; SAR varies from 1.5 to 2.3 with an average of 1.9; In post monsoon of 2009 PI varies from 55.5 to 62.1 with mean 57.3; KR varies from 0.7 to 0.71 with 0.7 mean; SSP has 41.1; RSC differ from -3.4 to -1.6 with an average of - 2.7; SAR varies from 3.3 to 4.8 with an average of 4.3; PI varies from 58.7 to 62.7 with mean 59.9; KR varies from 0.7 to 0.8 with 0.8 mean; SSP varies from 42.4 to 44.2 with mean 43.8; RSC differ from -1.8 to -1.2 with an average of -1.5; SAR varies from 1.7 to 2.5 with an average of 2.3.

Introduction: Present study is focused on the recognization of watershed activities constructed about 420 water harvesting structures in terms of impact of irrigation suitability of groundwater for pre and post monsoon of 2009 and 2013. A watershed, also called a drainage basin or catchment area, is defined as an area in which all water flowing into it goes to a common outlet.Geographically Chevella basin forms part of survey of India toposheet no. 56 K/3 of 1: 50,000 scale lying between East longitude 78° 04' 10" and 78° 13 58" and North latitude 17° 26 50" and 17°17 52" [1]. Chevella watershed covering 23 villages of Chevella, Sankarpalli and Moinabad mandals (Fig: 1). Prominent geological formations are granitic gneissic complex overlain by the Deccan traps and laterites. These are about 1,778 bore wells and 859 dug wells are drilled to trap the ground water for their livelihood especially for irrigation. Four major streams are flowing towards North from south to drain into Musi River which is flowing along north of the watershed

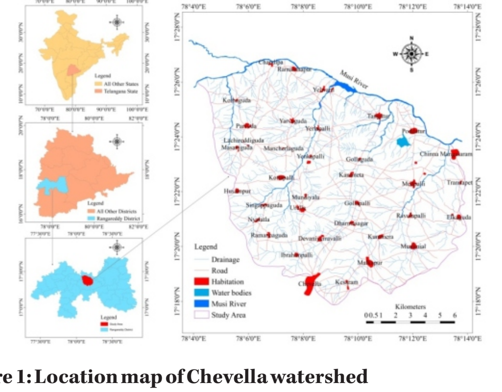

Figure 1: Location map of Chevella watershed

Materials and Methods: In order to study water quality for irrigation, groundwater samples are collected from pre and post monsoons from 23 villages during 2009 and 2013. Permeability Index (PI), Sodium Absorption Ratio (SAR), Residual Sodium Carbonate (RSC), Kelly Ratio (KR), Soluble Sodium Percent (SSP), and Salinity Hazard is computed based on the empirical formulas [2].

Results and Discussions: Results of pre and post monsoon groundwater quality characteristics for irrigation purpose of the twenty three villages were presented in the study.

Permeability Index: The effect of permeability has been calculated by the term Permeability Index (PI). It can be calculated by the following formula [3], [14].

$$PI = \{[Na^{+}] + SQRT\ [HCO^{3-}]\}\ X\ 100 / [Ca^{2+}] + [Mg^{2}] + [Na^{+}]$$

In the year 2009 permeability index of pre monsoon varies from 58.7 to 62.7 where as mean and standard deviations are 59.9 and 1.2 respectively. In post monsoon varies from 55.5 to 62. The mean and standard deviations are 57.3 and 1.7 respectively (table 1).

In the year 2013 permeability index of pre monsoon varies from 45.7 to 50.1 where the mean and standard deviations are 47.1 and 1.1 respectively; Post monsoon values varies from 44.3 to 50.4. The mean and standard deviations are 48.5 and 1.3 respectively (table 2).

The analysis shows that groundwater in Chevella watershed is categorized as class-II which shows that PI is between 25 to 75 in both seasons where as in 2013 it is categorized as class-I (greater than 75) (table 3).

Table 1: Irrigation water quality parameters - 2009

Sl. No	Village	Pre monsoon					Post monsoon				
		SAR	KR	SSP	PI	RSC	SAR	KR	SSP	PI	RSC
1	Chandippa	5.2	0.8	44.1	59.8	-1.5	4.4	0.7	41.1	56.7	-2.9
2	Devunierravally	5.4	0.8	44.1	59.3	-1.6	4.6	0.7	41.1	56.1	-3.1
3	Earlapally	4.8	0.8	43.8	60.8	-1.4	4.1	0.7	41.1	58.0	-2.4
4	Elverthy	5.7	0.8	44.2	58.7	-1.7	4.8	0.7	41.1	55.5	-3.4
5	Gollapally	5.5	0.8	44.1	59.0	-1.6	4.7	0.7	41.1	55.9	-3.2
6	Hussainpur	3.7	0.7	42.4	62.7	-1.3	3.3	0.7	41.1	62.1	-1.6
7	Ibrahimpalli	4.8	0.8	43.7	60.5	-1.4	4.1	0.7	41.1	58.0	-2.4

8	Kammeta	4.1	0.8	43.1	62.2	-1.2	3.6	0.7	41.1	60.5	-1.8
9	Kesaram	5.1	0.8	44.2	60.3	-1.4	4.3	0.7	41.1	57.1	-2.7
10	Kothapalli	5.3	0.8	44.0	59.4	-1.6	4.5	0.7	41.1	56.4	-3.0
11	Kummera	5.1	0.8	43.8	59.4	-1.7	4.4	0.7	41.1	56.8	-2.9
12	Malkapur	5.0	0.8	44.0	60.2	-1.4	4.3	0.7	41.1	57.2	-2.6
13	Masaniguda	4.6	0.8	43.8	61.3	-1.3	3.9	0.7	41.1	58.7	-2.2
14	Mudimyal	5.3	0.8	43.8	59.1	-1.7	4.5	0.7	41.1	56.3	-3.0
15	Nyalata	5.0	0.8	43.7	59.8	-1.6	4.3	0.71	41.1	57.3	-2.6
16	Parveda	5.0	0.8	43.9	60.1	-1.5	4.3	0.7	41.1	57.3	-2.7
17	Proddutur	5.7	0.8	44.2	58.7	-1.7	4.8	0.7	41.1	55.5	-3.3
18	Ramanthapur	5.2	0.8	43.6	58.9	-1.8	4.5	0.7	41.1	56.5	-2.9
19	Ravulapally	5.3	0.8	43.8	59.0	-1.7	4.5	0.7	41.1	56.4	-3.0
20	Tangatoor	5.6	0.8	44.1	58.7	-1.7	4.7	0.7	41.1	55.6	-3.3
21	Urella	4.2	0.8	43.1	61.8	-1.3	3.6	0.7	41.1	60.1	-2.0
22	Yenkapally	5.2	0.8	43.8	59.3	-1.7	4.4	0.7	41.1	56.7	-2.9
23	Yervaguda	5.4	0.8	44.1	59.2	-1.6	4.6	0.7	41.1	56.1	-3.2
	Minimum	**3.7**	**0.7**	**42.4**	**58.7**	**-1.8**	**3.3**	**0.7**	**41.1**	**55.5**	**-3.4**
	Maximum	**5.7**	**0.8**	**44.2**	**62.7**	**-1.2**	**4.8**	**0.71**	**41.1**	**62.1**	**-1.6**
	Mean	**5.0**	**0.8**	**43.8**	**59.9**	**-1.5**	**4.3**	**0.7**	**41.1**	**57.3**	**-2.7**
Standard Deviation		**0.5**	**0.01**	**0.4**	**1.2**	**0.2**	**0.4**	**0.01**	**0.0**	**1.7**	**0.5**

Residual Sodium Carbonate (RSC): The excess sum of carbonate and bicarbonate in groundwater over the sum of calcium and magnesium also influences the unsuitability of groundwater for irrigation. This is denoted as residual sodium carbonate (RSC), which is calculated as follows [4], [10], [15]

$$RSC = \{[HCO^{3-}] + \{[CO^{3-}]\} - \{[Ca^{2+}] + [Mg^{2}]\}$$

In the year 2009 RSC of pre monsoon varies from -1.8 to -1.2 where as mean and standard deviations are -1.5 and 0.2 respectively. Post monsoon value varies from -3.4 to -1.6; and mean and standard deviations are -2.7 and 0.5 respectively (table 1).

In the year 2013 RSC of pre monsoon varies from -4.8 to -3.0 where as mean and standard deviations are -4.0 and 0.5 respectively. Post monsoon RSC varies from -7.6 to -3.6; and mean and standard deviations are -6.2 and 1.1 respectively (table2).

The analysis shows that RSC values of 2009 and 2013 groundwater is categorized as good for irrigation, i.e., less than 1.25 (table 3).

Table 2: Irrigation water quality parameters - 2013

Sl. No	Village	Pre monsoon					Post monsoon				
		SAR	KR	SSP	PI	RSC	SAR	KR	SSP	PI	RSC
1	Chandippa	2.2	0.6	35.1	46.7	-4.1	2.3	0.5	34.0	50.3	-6.4
2	Devunierravally	2.2	0.6	35.0	46.1	-4.4	2.4	0.5	32.8	48.9	-7.0
3	Earlapally	1.6	0.5	34.9	47.3	-3.7	2.1	0.4	28.6	47.4	-5.5
4	Elverthy	2.3	0.6	35.1	45.7	-4.7	2.5	0.5	33.2	48.8	-7.6
5	Gollapally	1.9	0.6	35.2	46.1	-4.5	2.5	0.4	29.4	46.3	-7.2
6	Hussainpur	1.5	0.6	35.0	50.3	-3.0	1.7	0.4	30.0	50.4	-3.6
7	Ibrahimpalli	1.8	0.6	35.1	47.6	-3.7	2.2	0.5	30.7	48.7	-5.5
8	Kammeta	1.5	0.6	35.1	49.4	-3.0	1.9	0.4	29.8	50.0	-4.1
9	Kesaram	1.7	0.6	35.0	46.8	-3.8	2.3	0.4	29.2	47.3	-6.2
10	Kothapalli	2.1	0.6	35.1	46.5	-4.3	2.4	0.5	32.1	48.6	-6.6
11	Kummera	2.0	0.6	35.0	46.6	-4.3	2.3	0.5	32.0	48.5	-6.4
12	Malkapur	1.8	0.6	35.0	46.9	-3.9	2.3	0.5	30.5	48.2	-6.0
13	Masaniguda	1.7	0.6	35.1	48.1	-3.4	2.1	0.4	29.8	49.1	-5.0
14	Mudimyal	1.8	0.6	35.2	46.5	-4.4	2.4	0.5	30.8	47.5	-6.7
15	Nyalata	1.9	0.6	35.2	47.1	-4.0	2.3	0.5	31.2	48.5	-6.0
16	Parveda	2.0	0.6	35.2	47.1	-3.9	2.3	0.5	31.9	49.2	-6.0
17	Proddutur	2.3	0.6	35.1	45.7	-4.8	2.5	0.5	33.3	48.7	-7.6
18	Ramanthapur	1.7	0.6	35.1	46.5	-4.5	2.4	0.4	27.0	44.3	-6.6
19	Ravulapally	2.0	0.6	35.0	46.3	-4.4	2.4	0.5	31.6	47.9	-6.8
20	Tangatoor	2.3	0.6	35.0	45.8	-4.6	2.5	0.5	33.7	49.4	-7.4
21	Urella	1.5	0.5	34.9	48.8	-3.2	1.9	0.4	29.4	49.4	-4.4
22	Yenkapally	1.9	0.6	35.1	46.6	-4.3	2.3	0.5	30.7	47.7	-6.5
23	Yervaguda	2.2	0.6	35.2	46.3	-4.4	2.4	0.5	33.1	49.1	-7.0
	Minimum	**1.5**	**0.5**	**35.0**	**45.7**	**-4.8**	**1.7**	**0.4**	**27.0**	**44.3**	**-7.6**
	Maximum	**2.3**	**0.6**	**35.2**	**50.1**	**-3.0**	**2.5**	**0.5**	**33.9**	**50.4**	**-3.6**
	Mean	**1.9**	**0.6**	**35.1**	**47.1**	**-4.0**	**2.3**	**0.5**	**31.1**	**48.5**	**-6.2**
Standard Deviation		**0.3**	**0.001**	**0.10**	**1.1**	**0.5**	**0.2**	**0.04**	**1.8**	**1.3**	**1.1**

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Sodium Absorption Ration (SAR): Sodium absorption ratio is a measure of water suitability of water for agriculture use as concentration of solids dissolved in water. This can be calculating by using following formula [5], [12]

$$SAR = [Na^{+}] / SQRT\{[Ca^{+}] + [Mg+]\}/2$$

In the year 2009, SAR of pre monsoon varies from 3.7 to 5.7 where as mean and standard deviations are 5.0 and 0.5 respectively. Post monsoon SAR varies from 3.3 to 4.8; and mean and standard deviations are 4.3 and 0.4 respectively (table1).

In the year 2013 SAR of pre monsoon varies from 1.5 to 2.3 where as mean and standard deviations are 1.9 and 0.3 respectively. Post monsoon of same year varies from 1.7 to 2.5; and mean and deviations are 2.3 and 0.2 respectively (table 2).

The analysis shows that SAR of 2009 and 2013 groundwater is categorized as excellent for irrigation use where SAR is less than 10 in the Chevella watershed (table 3)

Table 3: Classification of groundwater for irrigation purpose - 2009 and 2013

Parameter	Year	Range	Water class	No. of Samples	Pre monsoon					Post monsoon				
					% age	Max	Min	Avg	St. Dev	%age	Max	Min	Avg	St. Dev
SAR	2009	<10	Excellent (S1)	23	100	5.7	3.7	5.0	0.5	100	4.8	3.3	4.30	0.4
		10-18	Good (S2)	-	-	-	-	-	-	-	-	-	-	-
		18-26	Doubtful (S3)	-	-	-	-	-	-	-	-	-	-	-
		>26	Unsuitable (S4)	-	-	-	-	-	-	-	-	-	-	-
	2013	<10	Excellent (S1)	23	100	2.3	1.5	1.9	0.3	100	2.5	1.7	2.3	0.2
		10-18	Good (S2)	-	-	-	-	-	-	-	-	-	-	-
		18-26	Doubtful (S3)	-	-	-	-	-	-	-	-	-	-	-
		>26	Unsuitable (S4)	-	-	-	-	-	-	-	-	-	-	-
KR	2009	<1	Good	23	100	0.8	0.7	0.8	0.01	100	0.7	0.7	0.7	0.0
		>1	Unsuitable	-	-	-	-	-	-	-	-	-	-	-
	2013	<1	Good	23	100	0.6	0.5	0.5	0.002	100	0.5	0.4	0.5	0.04
		>1	Unsuitable	-	-	-	-	-	-	-	-	-	-	-
SSP	2009	<50	Good	23	100	44.2	42.4	43.8	0.4	100	41.1	41.1	41.1	0.0
		>50	Bad	-	-	-	-	-	-	-	-	-	-	-
	2013	<50	Good	23	100	35.2	34.9	35.1	0.1	100	33.9	27	31.1	1.8
		>50	Bad	-	-	-	-	-	-	-	-	-	-	-
RSC	2009	<1.25	Good	23	100	-1.2	-1.8	-1.5	0.2	100	-1.6	-3.4	-2.7	0.5
		1.25-2.50	Doubtful	-	-	-	-	-	-	-	-	-	-	-
		>2.50	Unsuitable	-	-	-	-	-	-	-	-	-	-	-
	2013	<1.25	Good	23	100	-3.0	-4.8	-4.0	0.5	100	3.6	-7.6	-6.2	1.1
		1.25-2.50	Doubtful	-	-	-	-	-	-	-	-	-	-	-
		>2.50	Unsuitable	-	-	-	-	-	-	-	-	-	-	-
PI	2009	>75	Class -1	-	-	-	-	-	-	-	-	-	-	-
		25-75	Class -II	23	100	62.7	58.7	59.9	1.2	100	62.1	55.5	57.3	1.7
		<25	Class -III	-	-	-	-	-	-	-	-	-	-	-
	2013	>75	Class -1	23	100	50.3	45.7	47.1	1.1	100	50.4	44.3	48.5	1.3
		25-75	Class -II	-	-	-	-	-	-	-	-	-	-	-
		<25	Class -III	-	-	-	-	-	-	-	-	-	-	-

Kelly Ratio (KR): It is also one of the measures for assess the water suitability for agriculture and considering sodium ion concentration against calcium and magnesium ion concentrations. The following equation can be used for calculating KR to determined irrigation water quality [6], [9], [11]

$$KR = [Na^{+}] / [Ca^{+}] + [Mg+]$$

In the year 2009 KR of pre monsoon varies from 0.7 to 0.8 where as mean and standard deviations are 0.8 and 0.01 respectively. Post monsoon of 2009 varies from 0.7 to 0.71; and mean and standard deviations are 0.7 and 0.01 respectively (table1).

In the year 2013 KR of pre monsoon varies from 0.5 to 0.6 where as mean and standard deviations are 0.6 and 0.001 respectively. Post monsoon of 2013 varies from 0.4 to 0.5; and mean and standard deviation is 0.5 and 0.04 respectively (table2).

The analysis shows that KR of 2009 and 2013 groundwater are categorized as good for irrigation as the Kelly Ratio is less than 1(table 3)

Soluble Sodium Percent (SSP): SSP can be calculated from the following formula.

$$SSP = [Na^{+}] X 100/ [Ca^{2+}] + [Mg^{2}] + [Na^{+}]$$

In the year 2009 SSP of pre monsoon varies from 42.4 to 44.2 where as mean and standard deviations are 43.8 and 0.4 respectively (table 1). During the Post monsoon there is no variation in SSP values (41) (table1).

In the year 2013 SSP of pre monsoon varies from 35.0 to 35.2 where as mean and standard deviations are 35.1 and 0.10 respectively. Post monsoon of same year varies from 27 to 33.9; and mean and standard deviations are 31.1 and 1.8 respectively (table2).

The analysis shows that SSP of 2009 and 2013 groundwater is categorized as good for irrigation use as the value less than 50 (table 3)

Classification water for irrigation

Table 4 revealed that groundwater in Chevella can be classified into three categories namely good, medium and unsuitable types; labeled as moderately saline (C2), medium to high saline (C3) and high to excessive saline (C4) types respectively [7],[8],[13] .

Table 4: Classification of ground water, Salinity Hazard for irrigation in relation to EC

Sl. No	Electrical Conductivity (umhos/cm)	Type of quality	Type of water	Suitability for irrigation	No. of villages			
					Pre monsoon		Post monsoon	
					2009	2013	2009	2013
1	< 250	Excellent	Low saline (C1)	Entirely safe	-	-	-	-
2	250 - 750	Good	Moderately saline (C2)	Safe	-	-	-	3
3	750 - 2250	Medium	Medium to high saline (C3)	Safe only with permeable soil and moderate leaching	23	6	23	20
4	> 2250	Unsuitable	**High to Excessive saline (C4)**					
a	2250 - 4000		High saline	Unfair for irrigation	-	17	-	-
b	4000 - 6000		Very high saline		-	-	-	-
c	> 6000		Excessive saline		-	-	-	-

In pre and post monsoon of 2009 groundwater in Chevella watershed has medium to high saline water i.e., medium quality. So, the water is only useful in permeable soils and moderately leaching soils (table 4)

In pre monsoon of 2013, medium to high saline water is distributed in six villages. It is safe only with permeable and moderately leaching soil. Seventeen villages have high saline water which is unsuitable for irrigation. In post monsoon three villages had good quality (moderately saline) and safe for irrigation. Remaining twenty one villages noticed with medium quality (medium to high saline) and safe only with permeable and moderate leaching soils (table 4).

SAR values are plotted against salinity hazard (conductivity) over the U.S. Salinity diagram to categorize water sample according to irrigation suitability index. According U.S. salinity diagram (Figure 2). Water samples of Pre and post monsoon of 2009 and 2013 falls in the C3S1, considered for only safe with permeable soil and moderate leaching; pre and post monsoon of 2009 which falls in the C4S2 and C4S1 is unsuitability for irrigation. Post monsoon of 2013 has characteristics of C2S1 considered as safe for irrigation.

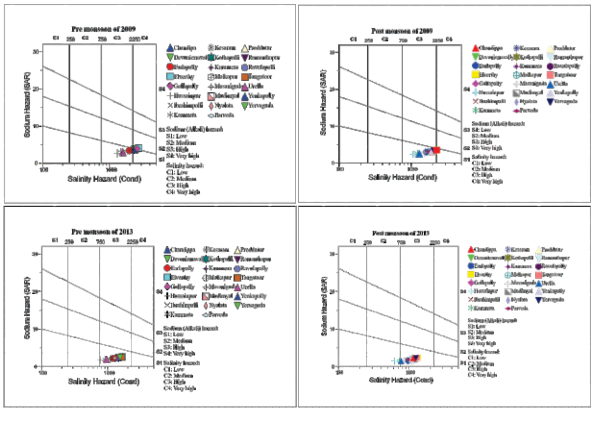

Figure 2: US salinity diagram of pre and post monsoon (2009 and 2013)

Conclusions: Study results revealed that parameters such as SAR, KR, SSP, RSC and PI groundwater in the Chevella basin is suitable for the Irrigation. At the end of the watershed of post monsoon of 2013, 3 samples become safe for irrigation according to salinity of water. SAR of all samples is classified as Excellent (S1) in pre and post monsoon of 2009 and 2013. According to PI it is classified as Class-II in pre and post monsoon of 2009 as well as in 2013 it falls in Class –I. All samples of 2009 in pre monsoon have medium and high salinity (C3) which is suitable in permeable and moderately leaching soils. Pre monsoon of 2013, 74 % of samples are very hard which is unsuitable for irrigation and remaining 26 % of samples has medium quality. In post monsoon of 2013, 13 % of samples are good for irrigation remaining 87 % of samples are suitable for permeable soils and moderate leaching soils.

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