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Appraisal of quality of irrigation water around Khunti district of Jharkhand, India

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Abstract
Water quality has become a global concern due to over increasing population and developmental activities that had over exploit and polluted the water resources available to us. In this context an attempt has been made to assess the suitability of irrigation water around Khunti district, Jharkhand. Thirty six geo-referenced (Lat. N22^{0}53'29.2" - N 23^{0}14'35.1", Long. E85^{0}00'40.4" - E85^{0}37'32.6" and Alt. 250-693 msl) water samples were collected randomly from different sources *viz*., well, bore well, canal, pond, dam and river during *Rabi* season of 2016. The results obtained from chemical analysis were compared with standard permissible limits of Rowe and Abdel- Magid guidelines of irrigation water. In the present study all the parameters such as pH, Electrical conductivity, Zinc, Copper, Iron, Manganese, Boron, Lead, Sulphur, Calcium and Magnesium were found to be within the permissible limits, except only Co content in well, canal and pond waters were found slightly higher the concentration as permissible limit. This water body is not suitable for irrigation purpose, so need to monitor and control the contaminants in order to utilize this effectively for irrigation purpose particularly in post-rainy season crops.

Keywords: Suitability, irrigation water, permissible limit

1. Introduction
"*Water is life, no water no life*" an immortal speech in all living being. When water is used for plant growth and development then become a question- is it suitable for the cultivated land and crops? Because water is an impotent resources for growing plants, by weight, are comprised of 90-95 percent water. Poor quality water may affect irrigated crops by causing accumulate of salts in the root zone, loss of permeability of the soil due to excess sodium or calcium leaching, containing pathogens, specific ion toxicity and a group of other miscellaneous problems, which are directly toxic to plants or to those consuming them (Rhoades, 1972; Cooper and Lipe, 1992) [12, 7] and often requires improvement before it is acceptable for a given use (Ayers, 1977; Anikwe *et al*., 2002) [5, 2]. Therefore, the aim of the present study was to evaluate on Appraisal of Quality of Irrigation Water around Khunti District of Jharkhand, India. The specific objectives of the study are (i) The preliminary investigation and interpretation of the water quality and (ii) finding the suitability of water for irrigation purposes.

Khunti is a tribal populated district lies in the South Chotanagpur Division of Jharkhand, India (Fig. 1). It is among the smaller districts in the state and is the second least populated district with 531,885 people. Khunti has the highest concentration of tribal populations in the state and more than 90% of people live in rural areas. The total geographical area of the district is 7,59,250 hectares. Net area shown is 276091 hectors. Area under double crop is 6%. The forest cover is about 18% of the total geographical area. With hilly and forested terrain, the district's main sources of income are rain-fed agriculture and trading of forestry products. The average rainfall varies from 1050 mm to 1500 mm. Agriculture is characterized by mono cropping practices with only the net irrigated area is 36,620 hectares, which is 14% the net cultivated area. Paddy based primary cropping system is in practice in the district while vegetables, mustard and pulses also in practice as secondary cropping system near water resources.

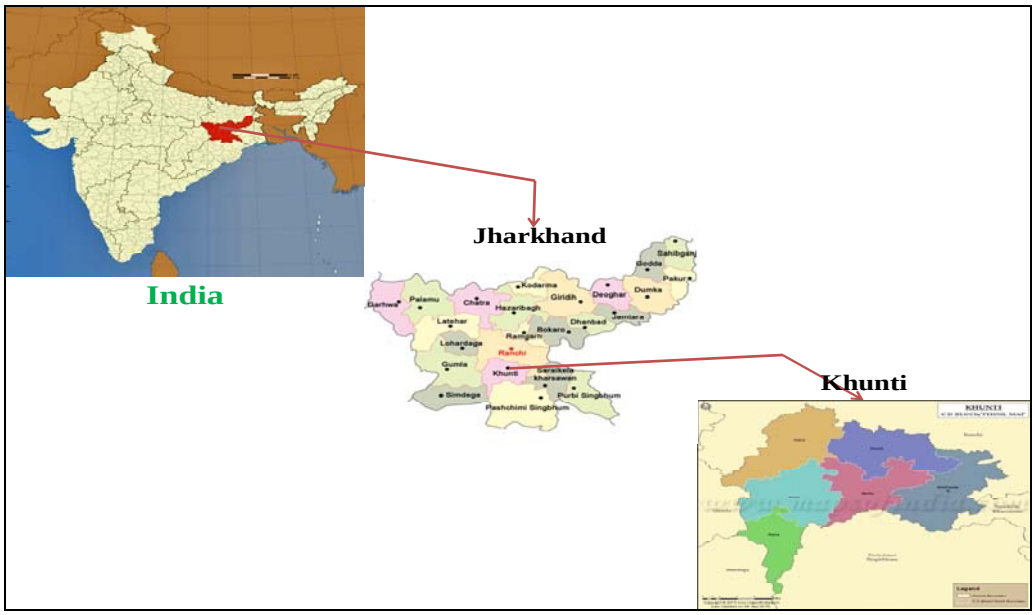


Fig 1: Location map of study place.

Materials and Methods

Thirty six geo-referenced (ranged from N22^{0}53'29.2" to N 23^{0}14'35.1", latitude and E85^{0}00'40.4" to E85^{0}37'32.6" longitude with an altitude ranging from 250 to 693 m above the sea level) water samples were collected randomly from different sources *viz*., well, bore well canal, pond, dam and river (which are used for irrigation purpose) of around Khunti district in Jharkhand during *Rabi* season of 2016. Samples were collected in plastic bottles by standard procedure from different irrigation sources and after reading of pH and EC immediately acidified with 2 mL concentrated HNO_3. In laboratory, 200 mL of water sample was transferred into a beaker to which 5 mL of concentrated HNO_3 was added. The solution was evaporated till 20 mL water was left in beaker and then 5 mL of concentrated $HNO_3$was again added and covered with watch glass, the solution was gently heated to obtain reflux action. More HNO_3 was added in the same samples, if needed, and heated till a light coloured clear solution was obtained. After adding 2 mL HNO_3, solution was gently heated to dissolve any residue left. The solution was filtered through Whatman No. 42 filter paper in a 25 mL volumetric flask and final volume was made with double distilled water. Total trace metals (*i.e.*, Zn, Cu, Fe, Mn, Pb, Ni, Co and Cd) and along with Ca, Mg estimation in digested water was done by a fully automated double beam atomic absorption spectrophotometer (AAS4139). The pH and EC of water were determined by the method as outlined by Jackson (1993) [9]. The Boron and Sulphur were estimated by UV-Spectrophotometer methods.

Results and Discussion

pH and EC in water

The present investigation of the collected water samples indicated that they are acidic to slightly alkaline in nature that raged varied from 5.51 to 7.92 with the mean value of 6.76 pH (Table 1), whereas all the water samples except well and bore well water were found to be within the standard limit of 6.5 – 8.4 pH (Ayers and Westcot, 1976) [4] (Fig. 2), while water sample of well and bore well were found below the 6.5 pH could cause the prolong and intensive fertilizer *i.e.*, ammonium fertilizers and corrosion of metal parts in irrigation equipment. While, Kumar *et al*., 2015 [10] reported that the pH of different irrigation waters of Ghatshila (East Singhbhum), Jharkhand varied from 7.04 to 9.01. Bichi and Bello (2013) [6] also reported that the pH values in surface and ground waters used for irrigation ranged from 6.71 to 8.07 and 6.20 to 6.71, respectively.

Table 1: Variation of pH and electrical conductivity (EC) in water around Khunti district of Jharkhand.

Sources	No. of samples	pH		EC (dS m^{-1})	
		Range	Mean	Range	Mean
Well	15	6.14-6.67	6.42	0.02-0.99	0.25
Bore well	7	5.51-6.07	5.81	0.06-0.59	0.24
Canal	4	7.09-7.28	7.14	0.08-0.61	0.25
Pond	4	6.66-6.73	6.70	0.04-1.06	0.37
Dam	3	6.82-6.88	6.85	0.18-0.42	0.26
River	3	7.51-7.92	7.66	0.23-0.44	0.34
Overall	36	5.51-7.92	6.76	0.02-1.06	0.29

The most influential water quality guideline on crop productivity is the water salinity hazard as measured by electrical conductivity (EC) (Ahmed *et al.*, 2002) [1]. In our study, the EC in collected water samples were ranged between 0.02-1.06 dS m^{-1} with the mean value of 0.29 dS m^{-1} (Table 1). Considering the safe limit of EC is 1.50 dS m^{-1} (Hameed *et al*., 1966) [8] (Fig. 3), all the irrigated water samples were found non-saline and are not likely to have any harmful effect to agricultural land and crop. While, our result also conformity with that of the reported by Kumar *et al*. (2015) [10], they were reported that the EC of some collected irrigation water of Ghatshila (East Singhbhum), Jharkhand,

varied from 0.030 to 1.280 with the mean value of 0.34 dS m^{-1}.

Trace metals contents in water

The concentration of trace metals *i.e.*, Zn, Cu, Fe, Mn, Pb, Ni, and Co in collected water samples ranged between 0.008-1.625, 0.001-0.016, 0.078-0.493, 0.010-0.248, 0.001-0.116, 0.003-0.053 and 0.010-0.124 mg L^{-1} with their mean values of 0.045, 0.005, 0.259, 0.090, 0.017, 0.26 and 0.052 mg L^{-1}, respectively (Table 2, 3, 4 & 5). Considering the maximum permissible limit of trace metals *i.e.*, 2.0, 0.20, 5.0, 0.20, 5.0, 0.20 and 0.05 mg L^{-1}, respectively for Zn, Cu, Fe, Mn, Pb, Ni and Co (Rowe and Abdel- Magid, 1995) [13] (Fig. 4, 5, 6, 7, 8, 9 & 10) in irrigation water, whereas all the collected water samples except Co was found suitable for used as irrigation purpose, while Co content in bore well, dam and river were found below the permissible limit and other water sources like well, canal and pond of this district had slightly higher concentration of Co content may be due to the different industrial influents drain out in water bodies. Moreover, Varalakshmi and Ganeshamurthy (2010) [15] reported that the heavy metal concentration of water bodies in peri-urban Bangalore varied from 0.014 to 0.039 for Cd, 0.039 to 0.075 for Pb and 0.027 to 0.042 mg L^{-1} for Ni, respectively. Nazif *et al*. (2006) [11] also reported wide variations in the heavy metal concentration in canal and river water used for irrigation purpose. Aweng *et al*. (2011) [3] reported that the average concentration of B, Cd, Fe, Pb, Mn and Zn in irrigation water of coastal village and industrial area of Malaysia were 3.5, 0.08, 0.23, 0.22, 1.10 and 0.22 mg L^{-1}, respectively.

Table 2: Zinc (Zn) and copper (Cu) content (mg L-1) in irrigation water resources in Khunti district of Jharkhand.

Sources	No. of samples	Zn		Cu	
		Range	Mean	Range	Mean
Well	15	0.008-1.625	0.132	0.001-0.015	0.006
Bore well	7	0.015-0.094	0.029	0.001-0.009	0.005
Canal	4	0.008-0.030	0.019	0.001-0.005	0.003
Pond	4	0.011-0.025	0.019	0.003-0.013	0.006
Dam	3	0.011-0.016	0.014	0.004-0.016	0.008
River	3	0.019-0.119	0.056	0.001-0.004	0.003
Overall	36	0.008-1.625	0.045	0.001-0.016	0.005

Table 3: Iron (Fe) and manganese (Mn) content (mg L^{-1}) in irrigation water resources in Khunti district of Jharkhand.

Sources	No. of samples	Fe		Mn	
		Range	Mean	Range	Mean
Well	15	0.081-0.314	0.191	0.010-0.245	0.114
Bore well	7	0.078-0.451	0.228	0.010-0.223	0.099
Canal	4	0.194-0.341	0.266	0.026-0.248	0.092
Pond	4	0.219-0.455	0.306	0.034-0.139	0.074
Dam	3	0.108-0.401	0.303	0.044-0.233	0.112
River	3	0.094-0.493	0.259	0.034-0.070	0.050
Overall	36	0.078-0.493	0.259	0.010-0.248	0.090

Table 4: Lead (Pb) and nickel (Ni) content (mg L^{-1}) in irrigation water resources in Khunti district of Jharkhand.

Sources	No. of samples	Pb		Ni	
		Range	Mean	Range	Mean
Well	15	0.002-0.116	0.025	0.006-0.053	0.030
Bore well	7	0.001-0.064	0.022	0.003-0.046	0.020
Canal	4	0.005-0.013	0.008	0.004-0.051	0.030
Pond	4	0.004-0.026	0.012	0.011-0.048	0.026
Dam	3	0.005-0.036	0.015	0.005-0.018	0.012
River	3	0.006-0.035	0.018	0.008-0.026	0.035
Overall	36	0.001-0.116	0.017	0.003-0.053	0.026

Table 5: Cobalt (Co) and cadmium (Cd) content (mg L^{-1}) in irrigation water resources in Khunti district of Jharkhand.

Sources	No. of samples	Co		Cd
		Range	Mean	
Well	15	0.014-0.124	0.070	ND
Bore well	7	0.023-0.109	0.049	ND
Canal	4	0.010-0.120	0.070	ND
Pond	4	0.026-0.110	0.059	ND
Dam	3	0.010-0.041	0.027	ND
River	3	0.016-0.061	0.035	ND
Overall	36	0.010-0.124	0.052	ND
ND= not detected				

Boron, sulphur, calcium and magnesium content in water

The boron content in collected water samples varied from 0.019 to 0.328 with the mean value of 0.147 mg L^{-1} (Table 6), that value was lower the earlier reported by Kumar *et al*., 2015 [10], they were observed that the B concentration varied from 0.059 to 1.088 with the mean value of 0.187 mg L^{-1}. All the water samples were found suitable for irrigation purpose as per prescribed by Rowe and Abdel- Magid (1995) [13] (permissible limit of B in irrigation water is 0.75 mg L^{-1}) (Fig. 11).

Table 6: Boron (B) and sulfur (S) content (mg L^{-1}) in irrigation water resources in Khunti district of Jharkhand.

Sources	No. of samples	B		S	
		Range	Mean	Range	Mean
Well	15	0.053-0.328	0.193	0.022-0.297	0.161
Bore well	7	0.019-0.291	0.133	0.022-0.259	0.107
Canal	4	0.044-0.319	0.195	0.013-0.288	0.164
Pond	4	0.084-0.294	0.167	0.053-0.263	0.136
Dam	3	0.044-0.122	0.087	0.013-0.091	0.056
River	3	0.059-0.172	0.106	0.028-0.141	0.075
Overall	36	0.019-0.328	0.147	0.013-0.297	0.116

The Sulphur, Ca and Mg content (Table 6 & 7) in collected water samples ranged between 0.013-0.297, 1.930-14.925 and 1.188-3.500 with the mean values of 0.116, 6.62 and 2.07, respectively. All the water samples were found suitable for irrigation purpose as per prescribed by Biczok (1972) [16] (permissible limit of S in irrigation water is 100 mg L^{-1}) (Fig. 12). Whereas Mg: Ca ratio ranged from 0.21 to 0.39 with the mean value of 0.31, all the collected water samples found suitable for irrigation purpose as prescribed by Simson *et al*. (1979) [14] (Fig. 13), they were reported that the Mg: Ca ratio less than 1 in water is suitable for use as irrigation purposes.

Table 7: Calcium (Ca) and Magnesium (Mg) content in water of different irrigation sources around Khunti district of Jharkhand.

Name of Sources	No. of Sample	Ca (mg L^{-1})		Mg (mg L^{-1})		Mg: Ca
		Range	Mean	Range	Mean	
Well	15	3.175–12.325	7.00	2.008 – 3.500	2.55	0.36
Bore Well	7	1.930 – 5.000	2.96	1.295 – 2.250	1.74	0.39
Cannel	4	3.775 – 8.00	5.70	1.583 – 2.750	2.26	0.39
Pond	4	7.100 -14.925	10.55	1.420 – 3.200	2.22	0.21
Dam	3	2.145-11.875	5.98	1.188 – 3.050	2.04	0.34
River	3	5.275 -10.650	7.52	1.505 – 1.853	1.65	0.21
Overall	36	1.930 –14.925	6.62	1.188 – 3.500	2.07	0.31

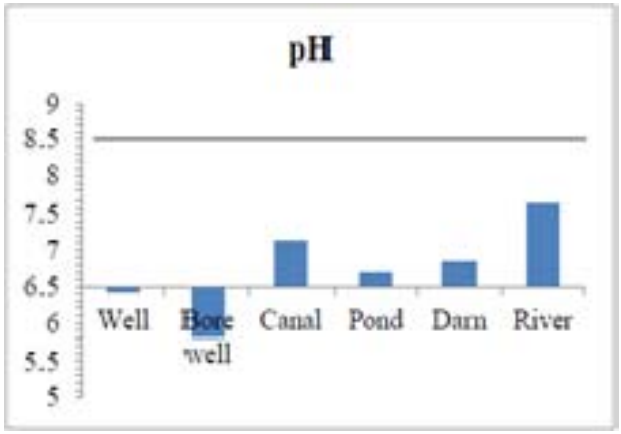
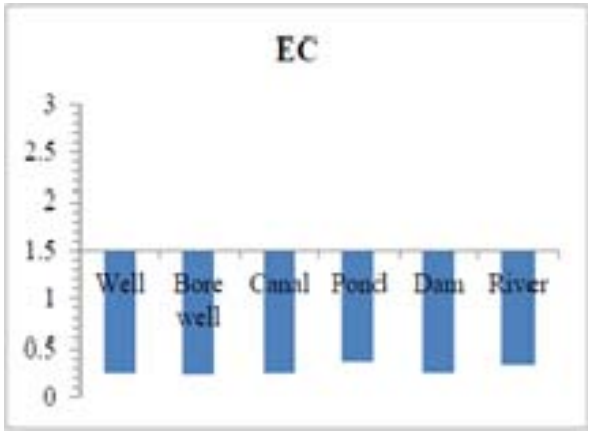


Fig 2



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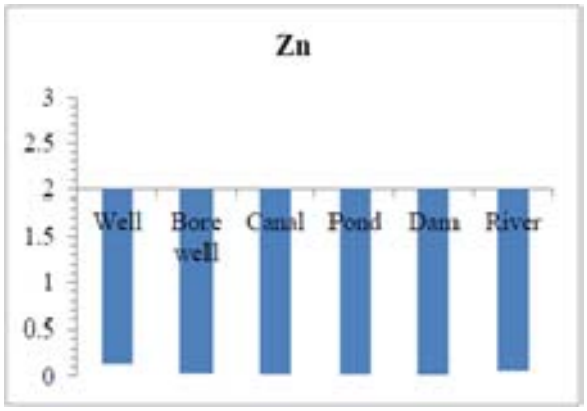

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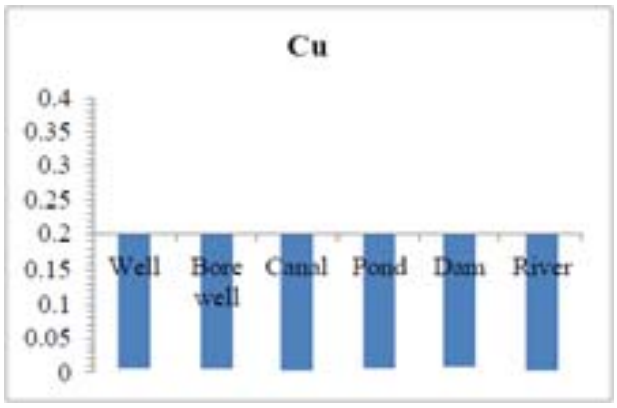
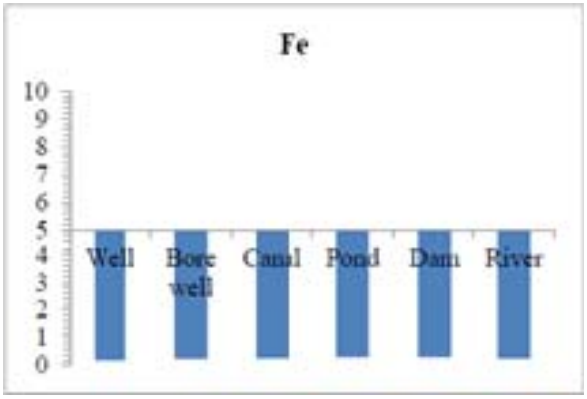


Fig 5



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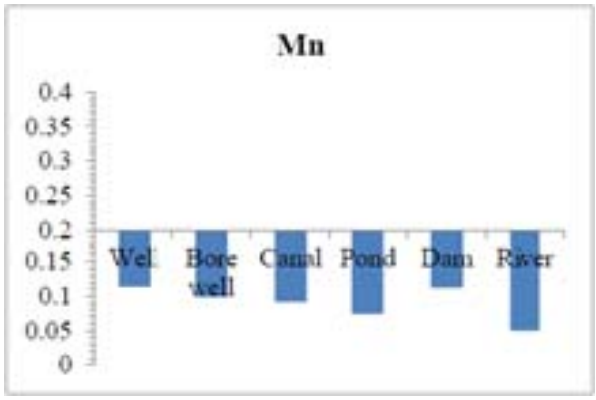

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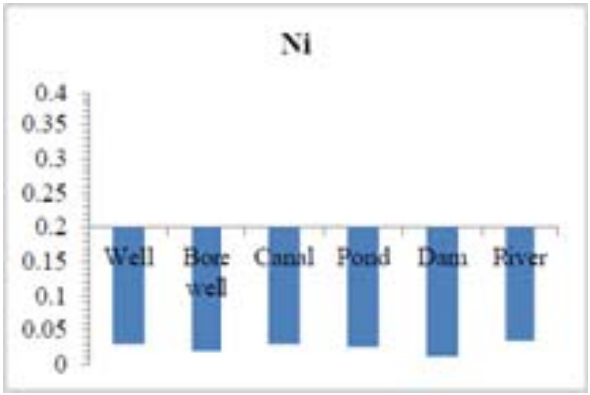

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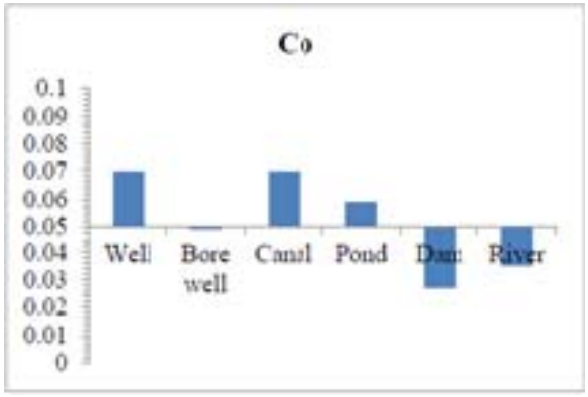

Fig 9

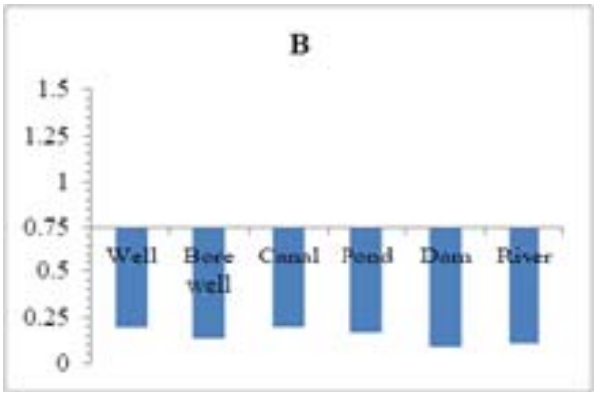

Fig 10

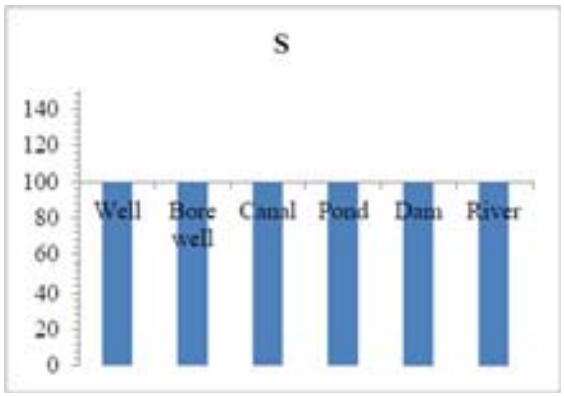

Fig 11

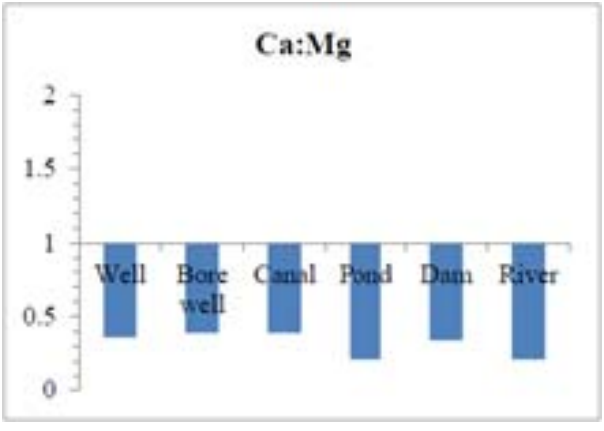

Fig 12

Conclusions

Based on the guidelines for the interpretation of water quality for irrigation, the results of analysis and assessments of water quality from different irrigation sources revealed that all elements except Co have to be safe limit concentration for irrigation purposes. While, Co are above the permissible limits in some water resources *viz*., well, cannel and pond of Khinti district indicate the need to monitor and control the contaminants in order to utilize this effectively for irrigation purpose particularly in post-rainy season crops.

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