Int.J.Curr.Microbiol.App.Sci (2018) Special Issue-7: 569-575

International Journal of Current Microbiology and Applied Sciences
ISSN: 2319-7706 **Special Issue-7 pp. 569-575**
Journal homepage: http://www.ijcmas.com

Original Research Article

Appraisal of Quality of Irrigation Water around Dumka District of Jharkhand, India

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Keywords

Appraisal, cultivated land, crop production, irrigation water, quality

A B S T R A C T

"*Water is life, no water no life*" an immortal speech in all living being. When water is used for the plant growth and development then would become a question- is it suitable to use as irrigation purposes for the cultivated land and crops? Because 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 appraisal of quality of irrigation water around Dumka district of Jharkhand, India. Twenty two geo-referenced (Lat. $N24^{0}02.983'$ - $N\ 24^{0}35.881'$, Long. $E87^{0}00.897'$ - $E87^{0}31.871'$ and Alt. 74 - 211 meter) water samples were collected randomly from different sources *viz*., well, canal, river, bore well, pond and dam during *Rabi* season of 2015. The results indicated that the chemical properties and all the elements except nickel (Ni) and cobalt (Co) have to be safe for irrigation while, Ni and Co were found slightly higher concentration as comparing with guidelines of irrigation water. Therefore, a monitoring programme is needed to provide reliable information about the current irrigation water quality and control the contaminants in order to utilize this effectively for irrigation purpose particularly in post-rainy season crops.

Introduction

Irrigated agriculture is dependent on adequate water supply of usable quality. Water quality or suitability for use in irrigation is judged on the potential severity of problems that can be expected to develop during long term use. The problems that result vary both in kind and degree, and are modified by soil, climate and crop, as well as by the skill and knowledge of the water user. The suitability of water for use in irrigation is determined by the conditions of use which affect the accumulation of the water constituents and which may restrict crop yield. The soil problems most commonly encountered and used as basis to evaluate water quality are those related to salinity, water infiltration rate, phytotoxicity and a group of other miscellaneous problems such as high nitrogen concentrations in the water which supplies nitrogen to the crop and may cause excessive vegetative growth, lodging, and delayed crop maturity (Ayers and Westcot, 1994).

High quality crops can be produced only by using high-quality irrigation water keeping other inputs optimal. Characteristics of irrigation water that define its quality vary

with the source of the water. The chemical constituents of irrigation water can affect plant growth directly through toxicity or deficiency, or indirectly by altering plant availability of nutrients (Ayers and Westcot, 1985; Rowe and Abdel-Magid, 1995). Therefore, to evaluate the quality of irrigation water, we need to identify the characteristics that are important for plant growth and their acceptable levels of concentrations. But a detailed investigation regarding the irrigation water quality and its suitability for crops has not yet been done. Keeping these in mind, the present research reports are gone to be on appraisal of quality of irrigation water around Dumka district of Jharkhand, India.

Materials and Methods

twenty two geo-referenced (ranged from N24^{0}02.983' to N 24^{0}35.881' latitude and E87^{0}00.897' to E87^{0}31.871' longitude with an altitude ranging from 74 to 211 meter above the sea level) (Tab. 1) water samples were collected randomly from different sources *viz*., well, canal, river, bore well, pond and dam (which are used for irrigation purpose) around Dumka district of Jharkhand, India during *Rabi* season of 2015. 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 colour 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 elements estimation in digested water was done by a fully automated double beam atomic absorption spectrophotometer. The pH and EC of water were determined by the method as outlined by Jackson (1993). Boron, sulfur, calcium and magnesium were determined by standard methods of APHA (2005).

Results and Discussion

pH and EC in water

The present investigation of different waters collected from different irrigation sources *viz*., well, canal, river, bore well, pond and dam indicated that they are slightly acidic to alkaline in nature that raged varied from 6.15 to 7.79 with the mean value of 7.03 pH (Tab. 2). Among all the sources of water samples, canal, river and dam were found slightly higher than pH 7.0 may be due to the anthropogenic or biogenic activity and also different type of industrial influents that drain out in surface water bodies around Dumka district of Jharkhand. Moreover, Nazif *et al.*, (2006) reported that the average pH of canal and river water ranged from 8.1 to 8.3 and 8.4 to 8.9, respectively and Bichi and Bello (2013) 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. Considering the guideline of pH in irrigation water ranged from 6.5 to 8.4 (Ayers and Westcot, 1976), all the sources waters except bore well were found to be within the ranged of standard limit, while water sample of bore well (6.15 pH) was 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.

The most influential water quality guideline on crop productivity is the water salinity hazard as measured by electrical conductivity (EC) (Ahmed *et al.*, 2002). In our study, the EC in different sources of water samples were ranged between 0.340-1.090 dS m^{-1} with the mean value of 0.570 dS m^{-1} (Tab. 2).

While, our result also conformity with that of the reported by Kumar *et al.*, (2015), they were reported that the EC of some collected irrigation water around Ghatshila (East Singhbhum), Jharkhand, varied from 0.030 to 1.280 with the mean value of 0.34 dS m^{-1}. Hameed *et al.*, (1966) stated that the water having EC value less than 1.5 dS m^{-1} are safe for irrigation, those having 1.5 to 3.0 dS m^{-1} are marginal and waters having EC values more than 3.0 dS m^{-1} are unsafe. So, all the collected water samples were found non-saline and are not likely to have any harmful effect to agricultural lands and crops.

Micronutrients content in water

Micronutrients have specific and essential function in plant metabolism. Because most of micronutrients are constituents of organic structure, predominantly of enzyme molecules, where they are either direct or indirectly would be required for a distinct metabolic step by catalytic reaction of the enzymes. In our study, the concentration of micronutrients in different sources of irrigation water varied from 0.015 to 0.105, 0.012 to 0.025, 0.013 to 0.913, 0.050 to 0.340 and 0.006 to 0.550 with their mean value of 0.041, 0.018, 0.445, 0.083 and 0.161 mg L^{-1}, respectively for Zn, Cu, Fe, Mn and B (Tab. 3 and 4). While, present results also conformity with that of the reported by Kumar *et al.*, (2015) in some collected irrigation water around Ghatshila (East Singhbhum), Jharkhand. Moreover, Aweng *et al.*, (2011) reported that the average concentration of Zn, Fe, Mn and B in irrigation water of coastal village and industrial area of Malaysia were 0.22, 0.23, 1.10 and 3.5 mg L^{-1}, respectively.

Heavy metals content in water

The results of heavy metals analysis in different water of irrigation sources around Dumka district are presented in Tab. 5. These results were showed that the heavy metals level varied from 0.248 to 0.875, 0.160 to 0.513 and 0.043 to 0.125 with their mean value of 0.370, 0.337 and 0.098 mg L^{-1}, respectively for Pb, Ni and Co. While, Cd concentration in all sources of water samples analyzed were found to non-detectable.

As per mean content, the Pb and Ni were found higher in river (0.479 and 0.439 mg L^{-1}) and Co was higher in dam water (0.108 mg L^{-1}) as compared to other sources of irrigation water. Moreover, Varalakshmi and Ganeshamurthy (2010) 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) also reported wide variations in the heavy metal concentration in canal and river water used for irrigation purpose. Aweng *et al.*, (2011) also reported that the average concentration of Cd and Pb in irrigation water of coastal village and industrial area of Malaysia were 0.08 and 0.22 mg L^{-1}, respectively.

The concentration of trace elements (*i.e.*, Zn, Cu, Fe, Mn, B, Pb, Ni, Co and Cd) in different water sources *viz*., well, canal, river, bore well, pond and dam were justified by the maximum recommended concentration in irrigation water by Rowe and Abdel-Magid (1995) for suitability of irrigation water (Tab. 6).

Table.1 GPS range of irrigated water samples collected from different sources around Dumka district of Jharkhand, India

Name of Sources	No. of Sample	GPS range		
		Latitude	Longitude	Altitude (m)
Well	5	N $24^0$14.604'-N $24^0$29.316'	E $87^0$11.590'-E $87^0$31.871'	102-178
Canal	4	N $24^0$23.301'-N $24^0$28.276'	E $87^0$02.277'-E $87^0$03.991'	176-211
Bore Well	4	N $24^0$29.191'-N $24^0$32.493'	E $87^0$00.897'-E $87^0$01.623'	183-206
Pond	3	N $24^0$34.476'-N $24^0$35.881'	E $87^0$05.229'-E $87^0$07.839'	171-199
River	3	N $24^0$10.357'-N $24^0$13.605'	E $87^0$15.947'-E $87^0$18.004'	125-143
Dam	3	N $24^0$02.983'-N $24^0$06.144'	E $87^0$22.930'-E $87^0$25.428'	74-102
Overall	22	N $24^0$02.983'-N $24^0$35.881'	E $87^0$00.897'-E $87^0$31.871'	74-211

Table.2 pH & Electrical conductivity (EC) in different sources of irrigation water around Dumka district of Jharkhand, India

Name of Sources	No. of Sample	pH		EC (dS m^{-1})	
		Range	Mean	Range	Mean
Well	5	6.48 - 6.88	6.63±0.15*	0.39 - 1.09	0.55±0.30
Canal	4	7.29 - 7.79	7.38±0.10	0.35 - 0.98	0.69±0.28
Bore Well	4	6.15 - 6.46	6.34±0.14	0.34 - 0.62	0.49±0.12
Pond	3	6.90 - 7.02	6.95±0.06	0.48 - 0.56	0.51±0.04
River	3	7.61 - 7.79	7.70±0.09	0.44 - 0.74	0.58±0.15
Dam	3	7.10 - 7.20	7.15±0.05	0.44 - 0.87	0.59±0.24
Overall	22	6.15 - 7.79	7.03±0.10	0.34 - 1.09	0.57±0.19
*Data were recorded in mean ± standard division					

Table.3 Zinc, copper and iron content (mg L^{-1}) in different sources of irrigation water around Dumka district of Jharkhand, India

Name of Sources	No. of Sample	Zn		Cu		Fe	
		Range	Mean	Range	Mean	Range	Mean
Well	5	0.018-0.078	0.042±0.024*	0.014-0.017	0.016±0.001	0.013-0.850	0.330±0.346
Canal	4	0.018-0.105	0.055±0.039	0.018-0.022	0.020±0.002	0.113-0.748	0.375±0.307
Bore Well	4	0.018-0.025	0.023±0.003	0.012-0.014	0.013±0.001	0.013-0.913	0.254±0.441
Pond	3	0.025-0.055	0.038±0.015	0.016-0.018	0.017±0.001	0.405-0.850	0.683±0.243
River	3	0.020-0.093	0.045±0.041	0.021-0.025	0.023±0.002	0.595-0.683	0.624±0.051
Dam	3	0.015-0.075	0.039±0.032	0.017-0.019	0.018±0.001	0.200-0.728	0.403±0.285
Overall	22	0.015-0.105	0.041±0.026	0.012-0.025	0.018±0.001	0.013-0.913	0.445±0.279
*Data were recorded in mean ± standard division							

Table.4 Manganese and boron content (mg L^{-1}) in different sources of irrigation water around Dumka district of Jharkhand, India

Name of Sources	No. of Sample	Mn		B	
		Range	Mean	Range	Mean
Well	5	0.054 - 0.340	0.113±0.127*	0.015 - 0.408	0.172±0.185
Canal	4	0.051 - 0.093	0.063±0.020	0.033 - 0.550	0.314±0.213
Bore Well	4	0.051 - 0.055	0.053±0.002	0.006 - 0.550	0.194±0.252
Pond	3	0.052 - 0.138	0.081±0.049	0.029 - 0.265	0.108±0.136
River	3	0.050 - 0.056	0.053±0.003	0.008 - 0.031	0.019±0.012
Dam	3	0.053 - 0.295	0.134±0.140	0.011 - 0.265	0.157±0.131
Overall	22	0.050 - 0.340	0.083±0.057	0.006 - 0.550	0.161±0.155
*Data were recorded in mean ± standard division					

Table.5 Heavy metals content (mg L^{-1}) in different sources of irrigation water around Dumka district of Jharkhand, India

Name of Sources	No. of Sample	Pb		Ni		Co		Cd
		Range	Mean	Range	Mean	Range	Mean	
Well	5	0.273 - 0.375	0.325±0.049*	0.195 - 0.513	0.333±0.122	0.043 - 0.125	0.084±0.035	ND
Canal	4	0.318 - 0.365	0.342±0.019	0.318 - 0.435	0.366±0.053	0.070 - 0.118	0.097±0.025	ND
Bore Well	4	0.298 - 0.650	0.414±0.160	0.320 - 0.378	0.347±0.025	0.088 - 0.125	0.107±0.015	ND
Pond	3	0.255 - 0.303	0.286±0.027	0.160 - 0.413	0.319±0.138	0.055 - 0.105	0.088±0.028	ND
River	3	0.248 - 0.875	0.479±0.344	0.373 - 0.483	0.439±0.058	0.090 - 0.118	0.103±0.014	ND
Dam	3	0.360 - 0.390	0.373±0.016	0.200 - 0.248	0.221±0.025	0.103 - 0.115	0.108±0.006	ND
Overall	22	0.248 - 0.875	0.370±0.103	0.160 - 0.513	0.337±0.070	0.043 - 0.125	0.098±0.020	ND
*Data were recorded in mean ± standard division, ND=non-detectable								

Table.6 Suitability of various irrigation water on the basis of trace elements concentration around Dumka district of Jharkhand, India

Trace metals	Max. recommended conc. (mg L^{-1})[a]	Conc. (mg L^{-1}) of collected irrigated water		Suitability for irrigation purpose
		Range	Mean	
Zn	2.00	0.015 - 0.105	0.041	All the collected water samples of different sources *viz*., well, cannel, river, bore well, pond and dam were found safe for irrigation in respect to Zn, Cu, Fe, Mn, B, Pb and Cd.
Cu	0.20	0.012-0.025	0.018	
Fe	5.00	0.013 - 0.913	0.445	
Mn	0.20	0.050 - 0.340	0.083	
B	0.75	0.006 - 0.550	0.161	
Pb	5.00	0.248 - 0.875	0.370	
Cd	0.01	ND	ND	
Ni	0.20	0.160 - 0.513	0.337	Ni and Co content in all the collected water samples of different sources were found unsafe for irrigation
Co	0.05	0.043 - 0.125	0.098	
[a]Rowe and Abdel-Magid (1995)				

Table.7 Macronutrients content (mg L^{-1}) in different sources of irrigation water around Dumka district of Jharkhand, India

Name of Sources	No. of Sample	S (mg L^{-1})		Ca (mg L^{-1})		Mg (mg L^{-1})	
		Range	Mean	Range	Mean	Range	Mean
Well	5	0.09 - 5.56	2.50±2.79*	3.18 - 12.33	7.00±3.71	2.01 - 3.50	2.56±0.64
Canal	4	0.20 - 0.82	0.58±0.31	3.78 - 8.00	5.71±2.15	1.58 - 2.75	2.27±0.51
Bore Well	4	0.09 - 0.46	0.20±0.18	1.93 - 5.00	2.96±1.40	1.30 - 2.25	1.75±0.43
Pond	3	0.15 - 0.46	0.27±0.17	7.10 -14.93	10.55±3.99	1.42 - 3.20	2.23±0.90
River	3	0.04 - 0.25	0.18±0.12	5.28 -10.65	7.53±2.79	1.51 - 1.85	1.65±0.18
Dam	3	0.30 - 0.41	0.34±0.06	2.15-11.88	5.98±5.18	1.19 - 3.05	2.04±0.94
Overall	22	0.04 - 5.56	0.68±0.60	1.93 - 14.93	6.62±3.20	1.19 - 3.50	2.08±0.60
*Data were recorded in mean ± standard division							

The concentrations of Zn, Cu, Fe, Mn, B, Pb and Cd in collected water samples were found below than maximum recommended concentration in irrigation waters. So, results indicated that all the waters that have used as irrigations are not likely to have any harmful effect to agricultural land and crop productions in respect of Zn, Cu, Fe, Mn, B, Pb and Cd. While, the levels of Ni and Co in collected water samples were found slightly higher than maximum recommended concentration in irrigation water, may be due to the anthropogenic or biogenic activity and also different type of industrial influents that drain out in surface water bodies and leach to underground water, which are likely to enter into the food chain over a period of time unless remedial measures are taken immediately.

Macronutrients content in irrigated water

Sulphur, calcium and magnesium are playing an important element for plant growth and development that are not commonly incorporated in fertilizers. It is measured in irrigation water to give an indication of possible deficiency problems. If the concentration is less than about 50, 150 and 50 ppm supplemental of sulphur, calcium and magnesium may need to be applied for good plant growth (Biernbaum, 1995). In our present experiment observed that the sulphur calcium and magnesium content in water samples ranged between 0.04-5.56, 1.93-14.93 and 1.19-3.50 with its mean values of 0.68, 6.62 and 2.08 mg L^{-1}, respectively (Tab. 7). All the water samples were found lower concentration than recommended concentration of sulphur calcium and magnesium, so, it is indicated that they are safe for irrigation, used as agricultural lands and crop productions. The main goal of this research was to assess the status of irrigation water quality around Dumka district of Jharkhand. The results indicated that the chemical properties and all the elements except Ni and Co have to be safe for irrigation while, Ni and Co were found unsafe for irrigation as comparing with guidelines of irrigation water. A powerful monitoring programme is needed to provide reliable information about the current irrigation water quality and control the contaminants in order to utilize this effectively for irrigation purpose particularly in post-rainy season crops.

Acknowledgement

Authors are grateful to the Indian Council of Agricultural Research, New Delhi for providing necessary financial assistance for research programme.

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