

Sources and quality of irrigation water in different agro-climatic zones of upper, middle and lower gangetic plains region*

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Indo-Gangetic plains cover 36.0% area of India's geographical area and 30.6% of total water resources (Minhas and Samra 2003) and is the most fertile and productive agro-climatic region. Out of this region, the area under present study, ie Gangetic plains cover Uttar Pradesh, Bihar and West Bengal. In Trans-Gangetic plains region (covering Haryana and Punjab), the prevalence of underground irrigation water is very common (Sidhu *et al.* 2007, Minhas and Samra 2003). The poor quality of underground irrigation water is also encountered in other areas of the Indo-Gangetic plains region, ie upper, middle and lower Gangetic plains regions. Extent and quality of underground irrigation water are considered most vital factors for higher productivity especially in rice (*Oryza sativa* L.)–wheat (*Triticum aestivum* L. emend Fiori & Paol.) cropping system areas in Gangetic plains region where availability of canal irrigation is insufficient. Sanyal and Dhillon (2005), Singh *et al.* (2006) and Ambast *et al.* (2006) reported different types of problems while assessing quality of underground irrigation water in different parts of the region. These studies, however, mostly confined to small patches or parts of one state only. Realizing the importance of these regions in food grain production, the present study was undertaken to assess the extent of irrigation sources and quality of underground irrigation water by adopting uniform methodology in the whole region.

Water samples were collected from the farmers' fields on the basis of multistage statistical sampling designs in selected villages and blocks within the respective district in the agro-climatic zones of upper, middle and lower-Gangetic plains region. Water samples were taken in following districts representing different agro-climatic regions/zones.

*Short note

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I Upper Gangetic plains region

North-western plains: Meerut, Sahajahanpur, Rampur, Bijnaur

Central plains zone: Unnao, Sitapur, Barabanki,

South-western plains zone: Aligarh, Mainpuri, Etawah

II Middle Gangetic plains region

Eastern plains zone: Faizabad, Gazipur, Sidharthnagar

North-eastern plains: Gorakhpur, Padrona

Vindhyan plains zone: Mirzapur

South Bihar plains zone: Buxor, Aurangabad

North Bihar plains zone: Madhubani, Sitamarhi, Gopalganj

North-eastern plains: Kathiar

III Lower Gangetic plains region

Barind zone: West Dinajpur, Malda

Central alluvial plains zone: Murshidapur, Medinipur

Alluvial coastal plains zone: North 24-Parganas

Rarh plains zone: Birbhum

Different parameters for assessing irrigation water quality, eg electrical conductivity, pH and residual sodium carbonate were determined by following standard procedures. To know the types of area covered under different resources of irrigation water the secondary data was utilized and reported in Table 1.

Upper Gangetic plains region has highest area under irrigation (81.65%), followed by middle Gangetic plains region (54.96%) and lower Gangetic plains region (35.1%). Canal irrigation found to be cover almost similar area in all regions. The trend of tube well irrigation was almost similar as that of total area under irrigation. Highest area (74.28%) under tube well irrigation was found in upper Gangetic plains regions followed by middle Gangetic plains region (60.5%) and lower Gangetic plains region (36.05%). Tank irrigation was only found in lowers Gangetic plains region (13.76%) and middle Gangetic plains region (2.36%).

Quality of irrigation water data indicated that in upper

Gangetic plains region the value of residual sodium carbonate (RSC) ranged from 0 to 6.4 meq / litre (Mean 3.92 meq / litre) in north-western plains agro-climatic zone, 0 to 7.80 meq / litre (Mean 1.32 meq / litre) in central plains zone and 0 to 4.90 meq / litre (Mean 0.93 meq / litre) in south-western plains zone. Similar trend was also observed in electrical conductivity and chloride content. According to US Salinity Laboratory (USDA 1968) an RSC value less than 1.25 meq/litre is safe for irrigation. The value between 1.25 and 2.5 meq/litre is of marginal quality and more than 2.5 meq/litre is unsuitable for irrigation. From the above data it is evident that in upper Gangetic plains region the mean RSC value of 3.92 meq/litre indicate the poor quality of water. Similarly Singh *et al.* (2006) also reported that groundwater in northern Indo-Gangetic alluvium region also belongs to the poor quality of irrigation water. The values of electrical conductivity ranged from 1.05 to 3.30 dS/m (mean 1.923 dS/m) in north-western plains, followed by 0.50 to 4.00 dS/m (mean 1.448 dS/m) in south-western plains and 0.40 to 3.30 dS/m (mean 0.929 dS/m) in central plains. The chloride concentration ranged from 1.0 to 10.6 meq / litre (mean 3.45 meq / litre) in north-western plains, followed by 0.5 to 13 meq / litre (mean 3.67 meq / litre) in central plains and 0.6 to 12.6 meq / litre (mean 1.58 meq / litre) in south-western plains. The quality of under ground irrigation water within an agro-climatic zone is related with intensity of cropping system. Higher the cropping intensity, poorer is the quality of irrigation water. As the north-western plains zone comprising districts of Meerut, Sahajahanpur, Rampur and Bijnaur is intensively cultivated area, has poor quality of water as compared to other zones which are lowly intensity cultivated areas. Climate does not play much role in influencing the quality of irrigation water with in the zone as the rainfall, temperature and evapo-transpiration rate are almost similar.

In middle Gangetic plains region, the quality of irrigation water is comparatively good as compared to upper Gangetic plains region. The mean residual sodium carbonate ranges from 0.05 to 0.92 meq / litre. The electrical conductivity (mean) ranged from 0.438 to 1.109 dS/m and chloride concentration (mean) ranged from 0.91 to 2.68 meq/ litre. In south and north Bihar plains agro-climatic zones, values of residual sodium carbonate are slightly higher (0.59 to 0.92

meq / litre) as compared to north-eastern, eastern, Vindhyan and north-eastern plains zones pertaining to Uttar Pradesh (0.05 to 0.80 meq / litre). Similar trend was also observed in case of electrical conductivity and chloride concentration. The mean values of electrical conductivity ranged from 0.438 to 0.885 dS/m in zones of Uttar Pradesh and these ranged from 0.976 to 1.109 dS/m in zones of Bihar. The mean chloride concentration 0.91 to 1.28 dS/min zones of Uttar Pradesh and 2.17 to 2.68 dS/m in zones of Bihar. In Uttar Pradesh due to advantage of well developed canal net work in conjunction with humid climate, good quality of irrigation water is maintained. It is because of recharge of under groundwater with good quality of canal water. The quality of underground irrigation water in the region as a whole is good due to prevalence of sub-humid climate as compare to semi-arid climate in upper Gangetic plains region. In addition to this, adjacent river Ganges also contributed to maintain good quality of irrigation water due to sufficient seepage and recharge of underground water. It is interesting to note that the quality of irrigation water is comparatively good as reported in Trans-Gangetic plains region (Sidhu *et al.* 2007). In spite of the fact that rice-wheat system is being practiced since very long time (> 300 years) in this region.

In lower Gangetic plains region the residual sodium carbonate ranged from 0 to 4.20 meq/litre (mean 0.79 meq/litre), electrical conductivity ranged from 0.25 to 1.20 dS/m (mean 0.580 to 0.732 dS/m) and chloride contents ranged from 0.4 to 4.0 meq/litre (mean 1.0 to 1.44 meq/litre). Zone-wise, the highest mean values of residual sodium carbonate (1.51 meq/litre) was observed in Barind plain, followed by central alluvial (1.10 meq/litre), Rarh (0.79 meq/litre) and alluvial coastal plains zones (0.71 meq/litre). The mean values of chloride concentration was highest (1.44 meq/litre) in central alluvial plains, followed by 1.21, 1.01 and 1.00 meq/ litre in Rarh, Barind and alluvial coastal plains zones, respectively. The quality of irrigation water is almost good in all agro-climatic zones in this region. Sub-humid to humid climate with mean annual rainfall as high as 1 900 mm contributed to maintain good quality irrigation water. Moreover, there is less withdrawal of underground irrigation water by tube wells occupying only about 36% area as compared to 74% area in Upper Gangetic plains region and 60 % in middle Gangetic plains region (Table 1).

Table 1 Source of irrigation in different regions of Indo-Gangetic plains

Region	Net cultivable area	Net irrigated area	Percent of irrigated area	Area '000 ha			
				Source-wise irrigation percentage			
				Canal	Tubewell	Tanks	Others
Upper Gangetic plains (Uttar Pradesh)	9 288	7 583	81.65	21.75	74.28	0.00	3.98
Middle-Gangetic plains (Uttar Pradesh and Bihar)	11 191	6 150	54.96	24.75	60.50	2.36	12.18
Lower-Gangetic plains (West Bengal)	5 440	1 911	35.10	24.98	36.05	13.76	12.66
Indo-Gangetic plains (India)	33 785	22 490	66.57	37.52	62.84	1.82	5.87

Table 2 Residual sodium carbonate, electrical conductivity and chloride distribution in under groundwater in different regions of Indo-Gangetic plains

Zone/Region	Residual sodium carbonate (meq/litre)		Electrical conductivity (dS/m)		Cl (meq/litre)	
	Range	Mean	Range	Mean	Range	Mean
<i>Upper Gangetic plains</i>						
North-western plains	0–6.40	3.92	1.05–3.30	1.923	1–10.6	3.45
South-western plains	0–4.90	0.93	0.40–3.30	0.929	0.6–12.6	1.58
Central plains	0–7.80	1.32	0.50–4.00	1.448	0.5–13	3.67
<i>Middle-Gangetic plains</i>						
North-eastern plains	0–0.60	0.05	0.10–1.20	0.696	0.4–3	0.91
Eastern plains	0–0.50	0.23	0.25–0.60	0.438	0.8–1	0.95
Vindhyan plains	0–4.40	0.80	0.50–1.80	0.820	0–3.7	0.94
North Bihar plains	0–2.0	0.59	0.45–3.00	0.976	0.6–8.6	2.17
North-eastern plains	0–3.0	0.76	0.40–2.70	0.885	0.2–2.8	1.28
South Bihar plains	0–4.40	0.92	0.35–2.70	1.109	0.6–9	2.68
<i>Lower-Gangetic plains</i>						
Barind plains	0–4.20	1.51	0.40–1.20	0.732	0.5–2	1.01
Rarh plains	0–4.0	0.79	0.50–0.85	0.628	1.0–3.0	1.21
Central alluvial plains	0–4.10	1.10	0.25–1.10	0.580	0.8–4.0	1.44
Alluvial coastal saline plains	0–2.0	0.71	0.25–1.20	0.626	0.4–2.4	1.00
SEm±		0.09		0.011		0.033
CD (P=0.05)		0.027		0.031		0.096

The areas having poor quality of irrigation water or potential areas which may subject to development of poor quality of water in future need appropriate ameliorative and crop management measures for sustained production of crops. Sarkar *et al.* (2005) suggested that by adopting farmers' participatory approach this problem can be mitigated. While, Singh (2005 a, b) and Minhas (2005) strongly advocated adaptation of integrated farming system incorporating plantation of salt-resistant agroforestry spp. For example, integration of dairy, poultry, piggery, duckery, fishery with dominant crop/cropping systems has found much beneficial in term of economic returns, judicious use of farm inputs, improvement of natural resources. Strategies for large-scale adaptation of crop diversification/ multi-enterprise agricultural practices to sustain soil/water quality are urgently required. Bijoy-Singh *et al.* (2005) cautioned that continued increase in the use of fertilizers in rice-wheat system and degradation of groundwater quality is essentially a nitrate leaching problem.

SUMMARY

The present study was undertaken in different agro-climatic zones of upper, middle and lower Gangetic plains regions covering dominantly rice-wheat system areas in Uttar Pradesh, Bihar and West Bengal. The water samples were collected from farmers' fields on the basis of multi-stage statistical approach in selected villages and blocks within the respective district in the zone. Residual Sodium carbonate and electrical conductivity content is relatively high in north-

western plains. The quality of irrigation water found to be good in middle and lower Gangetic plains region as compared to upper Gangetic plains region. The aridity in upper Gangetic plains region as compared to middle Gangetic plains region and lower Gangetic plains regions is directly related to the poor quality of underground irrigation water. Also more withdrawal of irrigation water through tubewells in upper Gangetic plains region is responsible for poor quality of irrigation water. In addition, the well developed canals and river system in middle Gangetic plains region and lower Gangetic plains regions resulted to maintain good quality of water.

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