International Journal of Agricultural Sciences
Volume 8 |Issue 1| January, 2012 | 276-283

RESEARCH PAPER

Quality assessment of underground water nearby the Ganga canal, Muzaffarnagar, Uttar Pradesh for drinking and irrigation purposes

PRAMOD KUMAR*, ASHOK KUMAR[1], B.P. DHYANI[1], R.R. SINGH[1], VIVEK[2], R.S. SENGAR[3], U.P. SHAHI[1] AND J.P. SINGH[4]

Department of Soil Science, Sardar Vallabhbhai Patel University of Agriculture and Technology, MEERUT (U.P.) INDIA

Abstract **:** Water is the most important natural resource which needs to be properly and scientifically utilized for improving the productivity, environment and economic condition of the rural area. The present study is conducted to assess the underground water nearby the Ganga canal, Muzaffarnagar, Uttar Pradesh for drinking and irrigation. Water samples were analyzed for their chemical properties i.e. pH, total salt (electrical conductivity), Anions (Cl^- CO_3^{--}, HCO_3^-, SO_4^{--}, NO_3^-), Cations (Ca^{++}, Mg^{++}, Na^+, K^+), TDS, water quality indices, toxic element and heavy metals. Water samples pH varied from 7.22 to 8.78and electrical conductivity of water varied from 0.11 to 1.02 dSm^{-1}. Sodium, potassium content of water samples varied from 1.7 to 8.0 and 1.9 to 7.6 mg L^{-1}. Chloride content ranged from 0.11 to 0.53 g L^{-1}. The TDS value varied from 83 to 635 ppm. The carbonate and bicarbonate sample varied from 3 to 18 and 3 to 18 me L^{-1}. Correlation was also worked out between different parameters. The nitrate, sulphate, chloride, potassium, negative correlation electrical conductivity, sodium, TDS bicarbonate, Ca + Mg and As were associated positively and significantly.

Key Words **:** Water, Quality assessment, Drinking, Irrigation purpose and Ganga Canal

View Point Article **:** Kumar, Pramod, Kumar, Ashok, Dhyani, B.P., Singh, R.R., Vivek, Sengar, R.S., Shahi, U.P. and Singh, J.P. (2012). Quality assessment of underground water nearby the Ganga canal, Muzaffarnagar, Uttar Pradesh for drinking and irrigation purposes. *Internat. J. agric. Sci.*, **8**(1): 276-283.

Article History **: Received :** *15.12.2010;* **Revised :** *05.12.2011;* **Accepted :** *30.12.2011*

INTRODUCTION

Water is essential for life. It is used for irrigation, drinking, industrial and another various daily necessities. If the quality of water happens to be below the standard prescribes, for drinking purpose from time to time, with respect to its different chemical constituents, it is likely to affect human health and life span. The main factors responsible for deterioration in water quality are excess of soluble salts, disproportion of dissolve ions, industrial effluents. Whatever may be the source of water i.e. river, canal, well and tanks etc. some soluble salts sodium, potassium, calcium, magnesium, chloride, ferrous copper, Zinc, fluoride lithium, silicon, sulphate and phosphorus etc. are dissolve therein, depending upon the nature of the source, geological surroundings and climatology conditions determines the quality of water.

Excess of soluble salts adversely affect the human health and in case of some constituents even amount in excess of a few ppm causes serious diseases. The well water if saline and used for irrigation purpose, it not only adversely affects the soil properties and crop productivity but also the quality of produce and indirectly health of the consumers with the

*** Author for correspondence.**
[1]Department of Soil Science, Sardar Vallabhbhai Patel University of Agriculture and Technology, MEERUT (U.P.) INDIA
[2]Department of Agronomy, Sardar Vallabhbhai Patel University of Agriculture and Technology, MEERUT (U.P.) INDIA
[3]Department of Agricultural Biotechnology, Sardar Vallabhbhai Patel University of Agriculture and Technology, MEERUT (U.P.) INDIA
[4]S.K.D. Horticulture Research and Training Institute, Nara, MUZAFFARNAGAR (U.P.) IINDIA

industrials development in the country, the water quality is further deteriorated by industrials effluents specially near the industrial town.

Water quality of canal generally reflect that of the river from which it originates, until and unless it is contaminated by salts, if passing over a salt infested area. Hence the canal originated from north Indian rivers have good quality water, but indirectly by way of seepage and increase water table they have been responsible for the development of saline soils. This is true to a large extent of area in U.P, Delhi, Punjab, Chambal commended area of Rajasthan and Punjab (Paliwal 1972).

Ground water is an important water supply source worldwide. It is the major source of water in both urban and rural area in India. An adequate water resource for future generation is not only a fresh water wealth and human influence. Arsenic, fluoride, and heavy metals occur as major constituents of ground water in all categories of hydro-geological setting in India. The concentration of these minor constituents including iron and nitrate is of concern as large amount of ground water is abstract by drilling water – well both in rural and urban areas for drinking and irrigation purpose. The sixteen state in India – Andhra Pradesh, Bihar, Delhi, Gujarat, Haryana, Jammu and Kashmir, Karnataka, Kerala, Madhya Pradesh, Maharastra, Manipur, Orrisa, Punjab, Rajasthan, Tamilnadu, and Uttar Pradesh have already identified endemic to flourosis (Marippan *et al.,* 2006). Keeping these in mind the present study was conducted.

MATERIALS AND METHODS

Geographical outline of study area:

Muzaffarnagar is located at northern part of Uttar Pradesh. It is roughly rectangular in shape, lying between north latitude 29^0 11' 30'' and 29^0 45' 15'' and east longitude 770 3' 45'' and 78^0 7'. Study area enjoys sub tropical and semi arid climate with hot desiccating summers and cold winters. High rainfall and wide temperature variations (Maximum temperatures exceed even 42^0 C during the hot summer and minimum temperature occasionally touches 3^0C during winter) are the characteristics features of this region. Average rainfall of the area is 760 mm of which 75 per cent is received during monsoon season in June-September. Few showers are also expected during the winter season. Frost generally occur towards the end of December and may continue till the end of January.

Ground water samples were collected from various locations and analyzed for their chemical properties *i.e.* pH, total salt (electrical conductivity), Anions (Cl^- CO_3^{--}, HCO_3^-, SO_4^{--}, NO_3^-), Cations (Ca^{++}, Mg^{++}, Na^+, K^+), TDS, water quality indices, micronutrient, toxic element and heavy metals (APHA 1998). All the analysis of soil and ground water was carried out in the laboratory of Department of Soil Science, SVPUAT Meerut, UP, India by adopting the standard methods.

Collin's ratio:

Collin's ratio is the ratio of chloride ions to the sum of CO_3^{--} and HCO_3^- ions in epm. For drinking water this ratio should be less than one (Tiwari, 1988).

Kelley's ratio:

Kelley's ratio was computed for all the water samples to describe the water quality for irrigation purpose. Kelley's ratio is the ratio of Na^+ ions to the sum of $Ca^{++} + Mg^{++}$ ions on epm and gives indication of Na Hazards if any for good irrigation water.

US salinity laboratory (SAR):

The United States of Salinity diagram (USLL, 1954) of the water is based on the EC and the sodium adsorption ratio (SAR). SAR can be calculated by the formula:

$$\mathbf{SAR = Na^+/[(Ca^{2+} + Mg^{2+})/2]^{0.5}}$$

According of the U.S. Salinity laboratory classification of irrigation water (USLL, 1954), the shallow ground waters fall in the field of C1S1-C2S1, which indicates a low to medium salinity hazard but not an alkalinity hazard due to low Sodium Adsorption Ratio (SAR 0.37 to 1.19).

Residual sodium carbonate (RSC):

Another way to examine the irrigation water is to estimate the residual sodium carbonate (RSC) as suggested by Eaton, 1950. The RSC has the following equation.

$$\mathbf{RSC = (CO_3 + HCO_3)-(Ca^{2++} + Mg^{2++})}$$

If the RSC<1.25, the water is considered safe. On the other hand, if the SC>2.5 the water is not appropriate for irrigation.

RESULTS AND DISCUSSION

The results obtained from the present investigation as well as relevant discussion have been presented under following heads :

Suitability of ground water for drinking purpose:

The suitability of ground water for drinking purpose has been evaluated on the basis of pH, EC, Cl^-, $Ca^{++} + Mg^{++}$, Na^+, K^+, $CO_3^{2-} + HCO_3^-$, NO_3^-, SO_4^{2-}, TDS, As, RSC/RSBC, SAR. Moreover, Kelly's and Collin's ratio has also been computed for the evaluation of suitability of ground water of drinking purpose. The observed values are compared with different standard set by different organization for the suitability of ground water for the drinking purpose.

pH:

The value of collected water samples varied from 7.22 to 8.78. Maximum value of 8.78 was recorded for water sample of 16.5 m depth in Kamheda (TP), while minimum 7.22 at a depth of 3.4 m Bhopa locations (Table.1). Observed values for all the collected water samples were within the permissible limit as set by different organization *i.e.* WHO, BIS and U.S.EPA. Higher values of pH above permissible limit hasten the scale formation in water heating apparatus and also reduce the germicidal potential of chloride. The pH below 6.5 stands corrosion in pipes, thereby releasing toxic metals, such as Zn, Pb, Cd and Cu etc. pH has no direct adverse effect on human health, but lower value 5.0 produce sour taste and higher value about 8.5 an alkaline test.

The electrical conductivity ranged from 0.11 to 1.02 dSm^{-1} (Table 2). Maximum value of 1.02 dSm^{-1} at 4.6m water depth in Bhopa location while minimum 0.11 dSm^{-1} at 6.1m water depth of same location.

Sodium:

The sodium content in the study area varies from 1.7 to 8.0 mg/L (Table3). The sodium content 8.0 mg/L was maximum in the sample of Janshath location at 7.6m water depth, while minimum 1.7 mg/L in the sample of Baldea location at 4.6 m water depth. By comparing Na^+ content of water with different standard it was found that Na^+ content was in permissible limit as per standard of WHO but above the permissible limit in most of the cases as per U.S.EPA norms.

Table 1 : pH of underground water sample collected at different distance from Ganga canal

Sr. No.	Locations	Water samples distance (m) from Ganga canal				
		1000	2000	3000	4000	5000
1.	Purkaji	8.18(5.3)	8.06(7.5)	8.00 (10.0)	7.89 (12.0)	7.50 (3.5)
2.	Kamheda (TP)	8.15 (11.6)	8.10 (13.8)	8.78 (16.5)	8.40 (20.5)	7.56 (31.5)
3.	Baldea	7.96 (4.6)	7.34 (6.0)	8.18 (7.6)	8.23 (12.4)	8.00 (20.0)
4..	Bhopa	8.12 (4.6)	7.25 (6.1)	7.22 (3.4)	7.50 (10.0)	7.65 (15.4)
5.	Jouli	8.03 (1.2)	8.14 (2.0)	8.70 (4.5)	8.57 (3.7)	8.26 (10.0)
6.	Janshath	8.12 (2.5)	7.97 (3.7)	7.85 (6.0)	7.40 (7.6)	7.24 (13.5)
7.	Tajpur	8.12 (1.5)	7.24 (2.4)	7.97 (4.5)	7.40 (5.8)	7.85 (7.6)
8.	Khatauli	7.23 (1.8)	7.78 (3.0)	7.52 (5.4)	7.30 (7.6)	7.97 (10.7)

Table 2 : Electrical conductivity (dSm^{-1}) of underground water sample collected at different distance from Ganga canal

Sr. No.	Locations	Sampling distance (m)				
		1000	2000	3000	4000	5000
1.	Purkaji	0.34 (5.3)	0.42 (7.5)	0.33 (10.0)	0.56 (12.0)	0.48 (3.5)
2.	Kamheda (TP)	0.33 (11.6)	0.78 (13.8)	0.56 (16.5)	0.44 (20.5)	0.52 (31.5)
3.	Baldea	0.36 (4.6)	0.42 (6.0)	0.48 (7.6)	0.72 (12.4)	0.32 (20.0)
4.	Bhopa	1.02 (4.6)	0.11 (6.1)	0.90 (3.4)	0.84 (10.0)	0.37 (15.4)
5.	Jouli	0.61 (1.2)	0.59 (2.0)	0.39 (4.5)	0.55 (3.7)	0.66 (10.0)
6.	Janshath	0.25 (2.5)	0.89 (3.7)	0.16 (6.0)	0.52 (7.6)	0.46 (13.5)
7.	Tajpur	0.69 (1.5)	0.31 (2.4)	0.38 (4.5)	0.13 (5.8)	0.36 (7.6)
8.	Khatauli	0.43 (1.8)	0.16 (3.0)	0.23 (5.4)	0.29 (7.6)	0.67 (10.6)

Table 3 : Sodium (mg/L) of underground water sample collected at different distance from Ganga canal

Sr. No.	Locations	Sampling distance (m)				
		1000	2000	3000	4000	5000
1.	Purkaji	3.1 (5.3)	3.9 (7.5)	4.0 (10.0)	5.0 (12.0)	6.6 (3.5)
2.	Kamheda (TP)	3.6 (11.6)	4.1 (13.8)	4.8 (16.5)	5.2 (20.5)	5.9 (31.5
3.	Baldea	1.7 (4.6)	3.4 (6.0)	3.7 (7.6)	4.6 (12.4)	6.9 (20.0)
4.	Bhopa	3.2 (4.6)	7.0 (6.1)	5.9 (3.4)	5.1 (10.0)	6.0 (15.4)
5.	Jouli	7.7 (1.2)	6.5 (2.0)	3.9 (4.5)	4.3 (3.7)	3.5 (10.0)
6.	Janshath	5.2 (2.5)	7.2 (3.7)	2.6 (6.0)	8.0 (7.6)	7.6 (13.5)
7.	Tajpur	5.9 (1.5)	6.4 (2.4)	7.1 (4.5)	2.1 (5.8)	6.9 (7.6)
8.	Khatauli	5.5 (1.8)	2.6 (3.0)	6.5 (5.4)	4.6 (7.6)	5. (10.6)

Calcium + Magnesium:

The Ca+ Mg varied from 5.0 to 18.7 me/L (Table 4). Maximum value of 18.7 was found at 10.0 m water depth in Bhopa location while minimum 5.0 at 7.6 m water depth Baldea location. The content of Ca^{+2} + Mg^{+2} in most of the water sample were above the permissible limit as set by different organization.

Potassium:

The K^{+} content varied from 1.9 to 7.6 mg/L (Table 5). The potassium content found maximum 7.6 mg/L in the sample of Baldea location at 6.0m water depth, while minimum 1.9 mg/L in the Purkaji location at 5.3 m water depth. By comparing observed value with the standard value it was found that K^{+} content of water samples were within permissible limit as per standard set by WHO.

Chloride:

The chloride in water varied from 0.11 to 0.53 gL^{-1} (Table 6). The maximum Cl^{-} content 0.53 gL^{-1} was found in the Beldea location at 7.6 m water depth, while minimum 0.11 gL^{-1} in Purkaji location at 3.5 m water depth. The range of permissible limit as per BIS of potable water is 250 mg L^{-1}. In all most of the cases chloride concentration was within permissible limit almost as per WHO standard but according to BIS it was above the permissible limit in most of the cases.

Table 4 : Ca^{++} + Mg^{++} (me/L) of underground water sample collected at different distance from Ganga canal

Sr. No.	Locations	Sampling distance (m)				
		1000	2000	3000	4000	5000
1.	Purkaji	10.0 (5.3)	9.0 (7.5)	5.8 (10.0)	6.8 (12.0)	8.9 (3.5)
2.	Kamheda (TP)	10.7(11.6)	11.5(13.8)	10.4(16.5)	11.8(20.5)	13.6 (31.5)
3.	Baldea	8.6 (4.6)	6.1 (6.0)	5.0 (7.6)	9.4 (12.4)	8.2 (20.0)
4.	Bhopa	6.4 (4.6)	16.1 (6.8)	22.2 (3.4)	18.7(10.0)	17.2 (15.4)
5.	Jouli	9.4 (1.2)	10.7 (2.0)	6.4 (4.5)	9.8 (3.7)	5.8 (10.0)
6.	Janshath	6.8 (2.5)	12.9 (3.7)	8.9 (6.0)	15.1 (7.6)	14.0 (13.5)
7.	Tajpur	10.0 (1.5)	12.2 (2.4)	13.3 (4.5)	6.6 (5.8)	11.8 (7.6)
8.	Khatauli	13.6 (1.8)	9.4 (3.0)	13.3 (5.4)	7.9 (7.6)	12.5 (10.6)

Table 5 : Potassium (mg/L) of underground water sample collected at different distance from Ganga canal

Sr. No.	Locations	Sampling distance (m)				
		1000	2000	3000	4000	5000
1.	Purkaji	1.9 (5.3)	2.8 (7.5)	3.0 (10.0)	4.1 (12.0)	3.9 (3.5)
2.	Kamheda (TP)	4.3 (11.6)	5.2 (13.8)	5.8 (16.5	2.1 (20.5)	4.0 (31.5)
3.	Baldea	6.5 (4.6)	7.6 (6.0)	5.3 (7.6)	4.9 (12.4)	4.7 (20.0)
4.	Bhopa	3.3 (4.6)	4.5 (6.1)	3.1 (3.4)	2.4 (10.0)	2.0 (15.4)
5.	Jouli	4.2 (1.2)	4.0 (2.0)	4.9 (4.5)	6.0 (3.7)	4.3 (10.0)
6.	Janshath	5.0 (2.5)	2.9 (3.7)	3.5 (6.0)	2.9 (7.6)	2.0 (13.5)
7.	Tajpur	3.2 (1.5)	4.5 (2.4)	5.7 (4.5)	3.9 (5.8)	4.8 (7.6)
8.	Khatauli	3.4 (1.8)	3.1 (3.0)	4.2 (5.4)	3.1 (7.6)	4.3 (10.6)

Table 6 : Chloride (g/L) of underground water sample collected at different distance from Ganga canal

Sr. No.	Locations	Sampling distance (m)				
		1000	2000	3000	4000	5000
1.	Purkaji	0.35 (5.3)	0.18 (7.5)	0.31 (10.0)	0.25 (12.0)	0.11 (3.5)
2.	Kamheda (TP)	0.23 (11.6)	0.13(13.8)	0.32(16.5)	0.14 (20.5)	0.40 (31.5)
3.	Baldea	0.25 (4.6)	0.43 (6.0)	0.53 (7.6)	0.25 (12.4)	0.50 (20.0)
4.	Bhopa	0.28 (4.6)	0.23 (6.8)	0.43 (3.4)	0.50 (10.0)	0.39 (15.4)
5.	Jouli	0.32 (1.2)	0.46 (2.0)	0.21 (4.5)	0.32 (3.7)	0.43 (10.0)
6.	Janshath	0.28 (2.5)	0.36 (3.7)	0.32 (6.0)	0.39 (7.6)	0.49 (13.5)
7.	Tajpur	0.39 (1.5)	0.25 (2.4)	0.36 (4.5)	0.32 (5.8)	0.43 (7.6)
8.	Khatauli	0.46 (1.8)	0.36 (3.0)	0.43 (5.4)	0.28 (7.6)	0.46 (10.6)

Total dissolve solids (TDS):

TDS indicate the general quality of ground water. The TDS value in the study area varied from 83 to 635 mg L^{-1} (Table 7). The maximum TDS 635 mg L^{-1} was found in the Bhopa location at 3.4 m water depth, while minimum 83 mg L^{-1} in same location at 4.6 m water depth. As per the standard of WHO, BIS and U. S. EPA the all observed value for ground water of Bhopa location at 3.4 and 4.6 m water depth are within permissible limit and found suitable for the drinking and irrigation purpose.

Bicarbonate:

The concentration of bicarbonate in water samples of study area varied from 3 to 18 me L^{-1} (Table 8) at various depth of eight different locations. The Maximum bicarbonate 18 meL^{-1} was found in Janshath location at 2.5 m depth while minimum 3.0 in Bhopa location at 4.6 m depth.

Carbonate:

The carbonate in different locations at various depths varied from 1.5 to 5.0 me L^{-1} (Table 9).The Maximum carbonate 5.0 me$L^{-1}$was found in Kamheda (TP) and Tajpur location at 11.6 and 7.6m depth, while minimum 1.5 me L^{-1} in Tajpur location at 4.5 m depths of water.

Nitrate:

The Nitrate content of water sample in study area varied from 0.13 to 3.46 mg L^{-1}(Table 10). The Maximum nitrate content

Table 7 : Total dissolve salts (mg/L) of underground water sample collected at different distance from Ganga canal

Sr. No.	Locations	Sampling distance (m)				
		1000	2000	3000	4000	5000
1.	Purkaji	181 (5.3)	165 (7.5)	130 (7.5)	128 (12.0)	154 (3.5)
2.	Kamheda (TP)	188 (11.6)	210 (13.8)	235 (16.5)	105 (20.5)	315 (31.5)
3.	Baldea	155 (4.6)	121 (6.0)	138 (7.6)	504 (12.4)	565 (20.0)
4.	Bhopa	83 (4.6)	304 (6.8)	635 (3.4)	509 (10.0)	278 (15.4)
5.	Jouli	268 (1.2)	178 (2.0)	118 (4.5)	134 (3.7)	108 (10.0)
6.	Janshath	206 (2.5)	560 (3.7)	480 (6.0)	434 (7.6)	392 (13.5)
7.	Tajpur	243 (1.5)	275 (2.4)	266 (4.5)	90 (5.8)	230 (7.6)
8.	Khatauli	311 (1.8)	116 (3.0)	207 (5.4)	148 (7.6)	447 (10.6)

Table 8 : Bicarbonate (me/L) of underground water sample collected at different distance from Ganga canal

Sr. No.	Locations	Sampling distance (m)				
		1000	2000	3000	4000	5000
1.	Purkaji	10 (5.3)	7 (7.5)	8 (7.5)	10 (12.0)	11 (3.5)
2.	Kamheda (TP)	8 (11.6)	13 (13.8)	7 (16.5)	4 (20.5)	6 (31.5)
3.	Baldea	6 4.6)	11 (6.0)	14 (7.6)	7 12.4)	9 (20.0)
4.	Bhopa	3 (4.6)	8 (6.8)	10 (3.4)	14 (10.0)	16 (15.4)
5.	Jouli	12 (1.2)	10 (2.0)	11 (4.5)	10 (3.7)	8 (10.0)
6.	Janshath	18 (2.5)	8 (3.7)	14 (6.0)	9 (7.6)	5 (13.5)
7.	Tajpur	5 (1.5)	14 (2.4)	8 (4.5)	7 (5.8)	9 (7.6)
8.	Khatauli	8 (1.8)	11 (3.0)	9 (5.4)	12 (7.6)	8 (10.6)

Table 9 : Carbonate (me/L) of underground water sample collected at different distance from Ganga canal

Sr. No.	Locations	Sampling distance (m)				
		1000	2000	3000	4000	5000
1.	Purkaji	3 (5.3)	2.0 (7.5)	3.0(10.0)		
2.	Kamheda (TP)	5 (11.6)				
3.	Baldea					
4.	Bhopa					
5.	Jouli	3.0 (1.2)	2.1 (2.0)			
6.	Janshath		2.4(3.7)		2.0 (7.6)	
7.	Tajpur	3.0 (1.5)		1.5 (4.5)		5.0 (7.6)
8.	Khatauli					3.0 (10.6)

Table 10: Nitrate (mg/L) of underground water sample collected at different distance from Ganga canal

Sr. No	Locations	Sampling distance (m)				
		1000	2000	3000	4000	5000
1.	Purkaji	0.78 (5.3)	0.47 (7.5)	0.41 (10.0)	0.40 (12.0)	0.30 (3.5)
2.	Kamheda (TP)	3.46 (11.6)	0.82 (13.8)	0.55 (16.5)	0.42 (20.5)	0.26 (31.5)
3.	Baldea	1.10 (4.6)	0.80 (6.0)	0.64 (7.6)	0.61 (12.4)	0.42 (20.0)
4.	Bhopa	0.52 (4.6)	0.20 (6.8)	2.0 (3.4)	0.64 (10.0)	0.33 (15.4)
5.	Jouli	0.73 (1.2)	0.63 (2.0)	0.60 (4.5)	0.30 (3.7)	1.03 (10.0)
6.	Janshath	0.50 (2.5)	0.33 (3.7)	0.30 (6.0)	0.21 (7.6)	0.70 (13.5)
7.	Tajpur	0.13 (1.5)	0.51 (2.4)	0.41 (4.5)	0.21 (5.8)	0.16 (7.6)
8.	Khatauli	0.14 (1.8)	2.54 (3.0)	0.71 (5.4)	0.70 (7.6)	0.52 (10.6)

3.46 mg L^{-1} was found in water samples of Kamheda (TP) at 11.6m depth, while minimum 0.13 mg L^{-1} in Tajpur location at 1.5 m depth. It was found that most of the water samples are below the permissible limit in nitrate content.

Sulphate:

The sulphate varied from 0.16 to 2.11 mg L^{-1} (Table 11). The Maximum sulphate 2.11 mg L^{-1} was found in water samples of Janshath location at 3.7 m depth, while minimum 0.16 mg L^{-1} in Baldea location at 6.0 m depth. The values of all the water samples are within the limit ((500 mg L^{-1}) as per the standard of WHO.

Arsenic:

The Arsenic ranged from 1.18 to 18.32 ppb (Table 12). The maximum As 18.32 ppb was found in Tajpur location at 1.5 m depth and minimum 1.18 ppb in water sample of Janshath at 6.0 m depth. The acceptable limit is 0.01 mg L^{-1} and beyond this limit water becomes toxic. The As in all the water samples was below the permissible limit as set by different organization BIS, WHO and ISS it is safe for drinking purpose.

Collin's ratio:

Collin's ratio was also calculated for all the water samples for drinking purpose. Based on the Collin's ratio 85. per cent of the ground water samples are safe for drinking purpose

Table 11 : Sulphate (mg/L) of underground water sample collected at different distance from Ganga canal

Sr. No.	Locations	Sampling distance (m)				
		1000	2000	3000	4000	5000
1.	Purkaji	0.30 (5.3)	0.21 (7.5)	0.80 (10.0)	0.35 (12.0)	0.26 (3.5)
2.	Kamheda (TP)	0.19 (11.6)	0.29 (13.8)	0.63 (16.5)	0.50 (20.5)	0.46 (31.5)
3.	Baldea	0.23 (4.6)	0.16 (6.0)	0.44 (7.6)	0.40 (12.4)	0.23 (20.0)
4.	Bhopa	1.00 (4.6)	0.86 (6.8)	0.80 (3.4)	0.70 (10.0)	0.54 (15.4)
5.	Jouli	0.51 (1.2)	0.52 (2.0)	0.70 (4.5)	0.45 (3.7)	0.35 (10.0)
6.	Janshath	0.21 (2.5)	2.11 (3.7)	1.25 (6.0)	1.00 (7.6)	0.30 (13.5)
7.	Tajpur	0.89 (1.5)	0.55 (2.4)	0.24 (4.5)	0.20 (5.8)	0.17 (7.6)
8.	Khatauli	1.05 (1.8)	0.94 (3.0)	0.50 (5.4)	0.30 (7.6)	0.20 (10.6)

Table 12 : As (ppb) of underground water sample collected at different distance from Ganga canal

Sr. No.	Locations	Sampling distance (m)				
		1000	2000	3000	4000	5000
1.	Purkaji	14.46 (5.3)	10.06 (7.5)	7.32 (10.0)	3.36 (12.0)	14.23 (3.5)
2.	Kamheda (TP)	10.89(11.6)	8.09 (13.8)	4.62 (16.5)	6.33 (20.5)	5.16 (31.5)
3.	Baldea	3.21 (4.6)	13.70 (6.0)	6.24 (7.6)	12.81(12.4)	5.24 (20.0)
4.	Bhopa	13.11 (4.6)	11.44 (6.8)	10.38 (3.4)	7.37 (10.0)	4.73 (15.4)
5.	Jouli	14.39 (1.2)	5.41 (2.0)	13.43 (2.0)	4.02 (3.7)	1.27 (10.0)
6.	Janshath	10.06 (2.5)	1.60 (3.7)	1.18 (6.0)	15.53 (7.6)	1.48 (13.5)
7.	Tajpur	18.32 (1.5)	10.39 (2.4)	8.12 (4.5)	17.36 (5.8)	17.08 (7.6)
8.	Khatauli	11.67 (1.8)	4.66 (3.0)	9.76 (5.4)	11.88 (7.6)	13.31(10.6)

without hazards and about 15 per cent samples are slightly contaminated which may be harmful for drinking purpose and Can be used for irrigation purpose.

Assessment of ground water quality for irrigation purpose:

The general chemical characteristics of ground water of various depths in eight different locations are given in Table. The water quality of the study area has been evaluated on the basis of EC, SAR, RSC/ RSBC and Kelley's ratio for irrigation purpose.

On the basis of salinity 12.5 per cent samples are safe for irrigation without any hazards, 75 per cent samples require moderate leaching and 12.5 per cent samples are used with adequate drainage.

Sodium Adsorption Ratio (SAR):

The SAR was computed to describe the suitability of ground water for irrigation purpose on the basis of USDA Handbook and presented in Table 15. As per SAR the ground water at different depth of study area is safe for irrigation purpose. The ground water of study area is found excellent for irrigation purpose on the basis of SAR.

Classification of ground water on the basis of RSC/RSBC for irrigation purpose:

Data are presented in Table 16. Based on the alkalinity hazards only 75 per cent of the ground water samples are useful for irrigation purpose without any hazards, about 12.5 per cent samples are used for irrigation with little danger of

Table 13 : Classification of underground water on the basis of Collin's ratio for drinking purpose

Sr. No.	Collin's ratio	Class	No of sample	Percentage
1.	< 1	Safe	34	85
2.	1 – 3	Slightly contaminated	06	15
3.	3 – 6	Moderately contaminated	-	-
4.	> 6	Injuriously contaminated	-	-

Table 14 : Assessment of underground water quality based on EC measurement for irrigation purpose

EC (dSm^{-1}) at 25 ^0C	Water class	No. of samples	Percentage	Interpretation
< 0.25	Low salinity C_1	05	12.5	Safe with no likelihood of any salinity problem
0.25 – 0.75	Medium salinity C_2	30	75.0	Need moderately leaching
0.75 – 2.25	High salinity C_3	05	12.5	Can't be used on soil with inadequate drainage, since saline condition are likely to develop
2.25 - 5.0	Very high salinity C_4			

Table 15 : Classification of ground water on the basis of SAR for irrigation purpose

Alkali hazards	Class of water	No. of samples	Percentage
<10	Excellent	40	100
10-18	Good	-	-
18-26	Fair	-	-
>26	Poor	-	-

Table 16 : Evaluation of irrigation water on the basis of alkalinity hazards RSC/ RSBC

Alkali hazards	Class of water	No. of samples	(%)	Remarks
A0- (- ve)	Non alkaline	17	42.5	Used for irrigation on almost all soils and crops
A1- (0 meL^{-1})	Normal water	1	2.5	Used for irrigation on almost all soils and crops
A2- (< 2.5 meL^{-1})	Low alkalinity	12	30.0	Used for irrigation on almost all soils and crops
A3- (2.5-5.0 meL^{-1})	Medium alkalinity	5	12.5	Use for irrigation and little danger of development of harmful limit of alkalinity
A4- (5-10 meL^{-1})	High alkalinity	4	10	Use for irrigation with good drainage
A5- (> 10 meL^{-1})	Very high alkalinity	1	2.5	Not suitable for irrigation with consumption with low alkalinity water

Table 17 : Assessment of ground water quality based on Kalley's ratio measurement for irrigation purpose

Sr. No.	Kalley's ratio	Class of water	No. of samples	Percentage
1.	Upto 1	Excellent	39	97.5
2.	1 -3	Good	01	2.5
3.	3 - 6	Permissible	-	-
4.	> 6	Not suitable	-	-

development of alkalinity hazards,10 per cent samples required good drainage while 2.5 per cent samples are not suitable for irrigation purpose.

Kelley's ratio:

Kalley's ratio was calculated for all the water samples to describe the suitability for irrigation purpose. Based on the Kelley's ratio, 97.50. per cent of the ground water samples are excellent for irrigation purpose without any Hazards while about 2.5 per cent samples are good for irrigation purpose.

Conclusion:

From the study it can be concluded that the water of different depth of eight different location of left side of Ganga canal flowing through Muzaffarnagar district is safe for drinking and irrigation purpose on the basis of most parameters, however its suitability is questionable on the basis of few parameters for drinking as well irrigation purpose.

REFERENCES

American Public Health Association (1998). Standard Methods for the Examination of Water and Wastewater, 20th edn. American Public Health Association Amercian Water Works Association/Water Pollution Control Federation, Washigton, DC.

BIS (1991). Indian Standard specification for drinking water, BS:10500.

EPA (1998). Method for chemical analysis of industrial effluents. Environmental Protection Agency.USA.

FAO (1985). Water quality for agriculture. Food and Agricultural Organization (FAO) of the United Nations. FAO, Irrigation and Drainage Paper 29, Rome.

Kelley, W.P. (1951). Alkali soils – their formation properties and reclamation. Reinold Publ. Corp., NY.

Paliwal, K.V. (1972). *Irrigation with saline water.* Water Technology Centre, Indian Agric.Res. Inst., Monograph no. 2, New Delhi.

Tiwari, T.N. and Ali, Mansoor (1988). Water Quality Index for Indian Rivers, In Ecology and Pollution of Indian Rivers. Ed. R. K. Trivedi, Ashish Publishing House New Delhi, pp. 271-286.

WHO (1988). Guidelines for Drinking Water Quality, Vol – 1 Recommendations, Geneva.

*_*_*_*_*_*