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An Assessment of Physico-Chemical Properties of Irrigation Water Quality Available from Different Sources in Gangetic Basin of West Bengal, India

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ABSTRACT

Ground water quality is slowly but surely declining everywhere. The quality of ground water is a primary concern where ground water resources are used for public and domestic supply. Thirty six water samples were collected from difference sources like, deep tube well, shallow tube well, pond and river water before (April-May) and after monsoon (September-October) in year 2011 as well as in 2012 from the experimental site of Uluberia, Howrah which is located on the bank of river Hooghly, West Bengal, India where farmers of these areas use various sources of irrigation water. Analyzed water samples were compared with standardized developed irrigation water quality chart. Amongst the surface water source, pond water were found superior over river water for the irrigation purpose (during before monsoon) were falls under the classes between C1S1-C2S1 and after monsoon were found in class C1S1 in both the years of study. They have contained a lesser amount of soluble salt and safe for the irrigation use for any crops. The ground water like deep tube well and shallow tube well water was found high saline water before monsoon in classes between C2S1-C3S1 in both years. Irrigation quality of the water after the monsoon C2S1 get better due to the rainfall and its result infiltrate water in ground and improve water table and quality also. Pond water is most suitable for the irrigation than river water in surface water sources, while among the ground water sources, deep tube well water was found better compared to the shallow tube well. Shallow tube well water was found highly saline water in both season and both years compared to all water resource use by farmers.

Keywords Surface water, Irrigation water quality, Water salinity, Ground water pollution.

INTRODUCTION

The intensive use of natural resources and the large production of wastes in modern society often pose a threat to ground water quality and have already resulted in many incidents of ground water contamination (Fianko and KaranKye 2020). Pollutants are being added to the ground water system through human activities and natural processes. The problem of ground water pollution in several parts of the

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country has become so acute that unless urgent steps for detailed identification and abatement are taken, extensive ground water resources may be damaged (Verma and Rakshit 2012). Majority of the water quality problems, and in particular, groundwater quality deterioration are caused by either contamination or over-exploitation and most ground water quality problems are difficult to detect and expensive to get rid from those problems. The solutions are usually very expensive, time consuming and not always effective. Ground water pollution is intrinsically difficult to detect, since problem may well be concealed below the surface and monitoring is costly, time consuming and somewhat hit-or-miss by nature. The wide range of contamination sources is one of the many factors contributing to the complexity of ground water assessment. It is important to know the geochemistry of the chemical-soil-ground water interactions in order to assess the fate and impact of pollutant discharged on to the ground. Pollutants move through several different hydrologic zones as they migrate through the soil to the water table (Yasser *et al*. 2021).

The quality of ground water depends on a large number of individual hydrological, physical, chemical and biological factors. Generally higher proportions of dissolved constituents are found in ground water than in surface water because of greater interaction of ground water with various materials in geologic strata (Shah and Mirtry 2013). The water used for irrigation purpose should be free from any salinity hazards. Water quality refers to the amount of dissolved solids and biological pollutants in solution. The quality of ground water is determined by the chemical properties of precipitation, the mineralogy of soils and aquifer materials through which the water moves, and the length of time the water has been in contact with these soil and aquifer materials. The water quality deteriorates by the introduction of contaminants into the environment through human or natural activities. Increasing exploitation of groundwater for domestic and industrial use has also occurred in the Bengal Basin. The water has been pumped from deeper fluvial deltaic aquifer that contains high concentrations of arsenic. Higher temperatures in lower ground levels facilitate in dissolving elements such as arsenic, fluoride and radon that are more prevalent at deeper levels (Anirban *et al*. 2021). Irrigation water always includes some amount of dissolved substances, collectively called salts. These salts include dissolved solids derived from the weathering of rocks and soil by water and salts dissolved from soil the water previously passed through. Lime, gypsum and other salt sources are dissolved over time, leading to varying degrees of salinity in irrigation water (Bandyopadhyay *et al*. 2001). Water quality is related to its effects on soils, crops and management necessary to compensate problems linked to water quality (Oyerinde *et al*. 2013). It is very important to note that not all problems of soil degradation like salinity, soil permeability, toxicity can be related to irrigation water quality. Sodium adsorption ratio (SAR) is a ratio of the sodium (detrimental element) to the combination of calcium and magnesium (beneficial elements) in relation to known effects on soil dispensability (Rhoades *et al*. 1992). It is accepted that the SAR and the electrical conductivity of irrigation water can be assessed for the potential to cause dispersion in a soil. With this background, an assessment of basic physico-chemical properties of irrigation water quality had been undertaken to get an insight of its suitability for irrigation purpose in the studies area.

MATERIALS AND METHODS

Location of the experimentation

The study area is located between $22^{0}47'$ N longitude and $88^{0}11'$ E latitude in Howrah district West Bengal (Fig. 1). Uluberia is situated on the bank of river Ganga, even though most of the people fulfil their need of water from groundwater. It has an average elevation of 1 m (3.3 ft.) and is situated on the bank of river Hooghly.

Water sampling and analysis

Thirty-six (36) numbers of water samples were collected from different sources like river, pond, submersible pump and deep tube well located in Uluberia, Howrah district of lower Gangatic zone in West Bengal during pre- (April-May 2011) and post-monsoon seasons (Sept-October 2011) from various abstraction sources at various depths covering extensively cropped area. The same sampling process was also adopted during the second year of study i.e.

Fig. 1. Location of the sampling site.

2012. Samples were collected in glass bottles in place of high-density polypropylene bottles. The collected water samples were immediately covered with aluminium foils tightly. All the samples were stored in sampling kits maintained at 4°C and brought to the laboratory for detailed chemical analysis. The physico-chemical parameters, namely, pH, EC, Hardness, Ca^{+2}, Mg^{+2},Na^{+},K^{+}, CO_3^{-2}, HCO_3, Cl- were analyzed in the laboratory as per the standard procedure of (APHA, 1992). Sodium adsorption ratio (SAR) and residual sodium carbonate (RSC) were calculated from the primary database generate during the study for both the years.

Calculation and generation of secondary data

SAR

SAR of the water samples is estimated by the formula:

$$SAR = \frac{Na^{+}}{\sqrt{(Ca^{2+}+Mg^{2+})/2}}$$

Where, Na^{+}, Ca^{2+} and Mg^{2+} contents of water samples are expressed as milliequivalent per liter (meL^{-1}).

RSC

RSC of water sample is estimated by the formula: -

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

It is expressed as meL^{-1}. The values of CO_3^{2}, HCO_3^{-}, Ca^{-2} and Mg^{+2} (meL^{-1}) of water samples were obtained from previous estimation.

RESULTS AND DISCUSSION

Water quality of deep tube well

Deep tube well is important source of water which is used for irrigation and drinking purposes. The water is extracted from more than 350 ft. below the ground surface. Results revealed that the pH value of the deep tube well were found in ranges between 7.44- 7.65 in pre-monsoon and 7.24-7.42 after monsoon in 2011. The pH of the deep tube well in second year of the same water sources was found ranges 7.35- 7.82 in pre- monsoon and 7.12-7.62 after the post monsoon 2012 (Table 1). The water samples show the slightly alkaline in reaction in both year. The water samples of the deep tube well show the water is slightly saline in nature and the ranges of electrical conductivity were found 0.45-1.21 dsm^{-1} in pre monsoon and 0.32-0.75 dsm^{-1} after the monsoon in 2011 (Table 2). In the next year electrical conductivity were found ranges between 0.46- 0.94 dsm^{-1} in pre- monsoon and 0.34-0.78 dsm^{-1} after the monsoon 2012 (Table 3). The sodium adsorption ratio (SAR) value were found the

ranges between 1.9-4.8 in pre-monsoon and 1.2- 3.9 in post- monsoon 2011 (Table 2). The SAR values varies in next year in ranges between 3.1- 6.9 pre-monsoon and 3.0-6.6 after the post-monsoon 2012 (Table 3). Residual sodium carbonate (RSC) wear found the ranges between -110.58 to -88.33 in before-monsoon and -88.06 to -65.52 after the monsoon in 2011 (Table 2). The next year RSC values vary between -123.72 to -52.87 before monsoon and -86.59 to -41.80 after the monsoon in 2012 (Table 3). RSC were found both year and season negative it means calcium and magnesium found dominant in water samples. The improvement of water quality after the monsoon was observed by the reducing the salinity and sodium content in water samples due to increasing the water content and dissolved the salt concentration of water (Choudhury *et al*. 2012). On the basis of the EC and SAR value of the deep tube well water was classified for irrigation purpose in class C2S1-C3S1 before monsoon and class C2S1-C2S1 after the monsoon 2011 (Table 2). In 2012 water quality of the deep water were found in class C2S1 –C3S1 before monsoon and C2S1-C2S1 after the monsoon (Table 3). It's a suitable for the irrigation purposes.

Water quality of shallow tube well

Shallow tube well water is an important water lifting resource anciently used in agriculture, as this requires low input and low boring comparison to the deep tube well. Depth of the shallow tub well generally found is 100-150 fit into the soil. The pH of shallow tub well was found in the range between 7.36- 7.64 in pre-monsoon and 6.82-7.41 after the post –monsoon in 2011. During second year, the same sources of water samples pH value were found ranges between 7.43- 7.71 (Table 1) in pre-monsoon and 7.22-7.41 after the post –monsoon in 2012 (Table 1). These results are in line with the findings of (Gupta and Nag 2014).

The Electrical conductivity of the water samples found in ranges between 0.49-1.31 dsm^{-1} in pre-monsoon and 0.38-0.81 dsm^{-1} after post-monsoon in 2011 (Table 2). Electrical conductivity of shallow tub well in next year varies in ranges between 0.54 -0.91 dsm^{-1} (Table 3) in pre-monsoon and 0.42 - 0.74 dsm^{-1} (Table 3) after the monsoon in 2012. Electrical conductivity of the shallow tub well water was found higher compared to deep tube well in both year and season.

The sodium adsorption ratio (SAR) of the shallow tube well varies between 1.2-5.1 in pre-monsoon and 0.7-3.8 after monsoon in 2011 (Table 2). Second year in dry season SAR values were found rages between 3.4- 7.1 and 3.0- 7.0 in post- monsoons 2012 (Table 3). SAR value of the shallow tube were found high due to the calcium (Ca^{++}), Magnesium (Mg^{++}) and Sodium (Na^{+}) content found high in range in both years. (Richards 1954) categorized the groundwater based on SAR values (<10 as excellent, between 10-18 as good, 18-26 as fair and >26 as poor quality). Residual sodium carbonate (RSC) of shallow tube well were observed ranges between -100.34 to -74.75 in pre- monsoon and after monsoon were found ranges between -77.38 to -48.21 in year 2011. RSC values were found in 2012 ranges between -105.06 to -58.23 (Table 3) in pre-monsoon and – 85.98 to -44.73 (Table 3) after the monsoon in year 2012. RSC found negative in both year and season it means calcium and magnesium found dominant in water samples. Similar trend of results are also reported by (*Mitran et al*. 2016) in different parts of the State.

Irrigation water quality of slightly improve in first years after the monsoon due to the rainwater it's

Table 1. pH of the irrigation water quality of different sources.

Sources of water	pH of irrigation water							
	Year 2011				Year 2012			
	Before monsoon		After monsoon		Before monsoon		After monsoon	
	Min	Max	Min	Max	Min	Max	Min	Max
Deep tube well	7.44	7.65	7.24	7.42	7.35	7.82	7.12	7.62
Shallow tube well	7.36	7.64	6.82	7.41	7.43	7.71	7.22	7.41
Pond	6.50	8.50	6.24	7.62	7.42	8.31	7.16	7.58
River	7.30	7.60	7.21	7.45	7.54	7.62	7.42	7.54

Table 2. Irrigation water quality of the different water sources (EC, SAR and RSC) during the year 2011.

Source of water	EC (dsm^{-1})				SAR				Classes of irrigation water		RSC			
	Before monsoon		After monsoon		Before monsoon		After monsoon		Before monsoon	After monsoon	Before monsoon		After monsoon	
	Min	Max	Min	Max	Min	Max	Min	Max			Min	Max	Min	Max
Deep	0.45	1.21	0.32	0.75	1.9	4.8	1.2	3.9	C2S1-C2S1	C2S1-C2S1	-110.58	-88.33	-88.06	-65.52
Shallow	0.49	1.31	0.38	0.81	1.2	5.1	0.7	3.8	C3S1-C2S1	C2S1-C2S1	-100.34	-74.75	-77.38	-48.23
Pond	0.25	0.71	0.16	0.33	0.5	2.2	0.3	2.0	C1S1-C2S1	C1S2-C2S1	-48.24	-41.53	-57.17	-22.26
River	0.33	0.61	0.21	0.37	1.7	4.4	1.2	2.8	C2S1-C2S1	C1S1-C2S1	-52.29	-45.74	-42.73	-28.81

dilute the concentration of the soluble salt (Swati *et al*. 2012). On the basis of the EC and SAR value of the shallow tube well water classify for irrigation purpose in class C3S1-C3S1 before monsoon and class C3S1- C3S1 also found after the monsoon 2011 (Table 2). In 2012 water quality of the shallow water were found in class C3S1-C3S1 before monsoon and C2S1-C3S1 found after the monsoon (Table 3). Shallow tube well water were found saline in nature before monsoon 2011 and 2012 and its required management before the use for irrigation purposes. Its slightly improve in after the monsoon due to the reduce the concentration of salts.

Water quality of pond

Pond water is a collection of natural water like rain fall this water is free form the soluble salt. In the Uluberia block many farmers use pond water for the irrigation purpose they also use pond for fish production. In research areas found many ponds water body but, I was selected ten (10.0) pond water body and take water samples before and after monsoon in 2011 and 2012.

The pH value of the selected water body was found ranges between 6.50- 8.50 (Table 1) in pre-monsoon and 6.24- 7.62 (Table 1) after the post-monsoon in year 2011. The pH value of pond water in second year varies between 7.42-8.31 in pre-monsoon and 7.16-7.58 after the post-monsoon in year 2012 (WHO 2012).

Electrical conductivity (EC) of the pond water samples were found in ranges between 0.25- 0.71 dsm^{-1} in pre-monsoon and 0.16-0.33 after the post-monsoon (Table 2) in the year 2011. In second year electrical conductivity of pond water samples varies between 0.20-0.56 dsm^{-1} in pre-monsoon and 0.14 -0.34 dsm^{-1} (Table 3)after the monsoon in 2012. (Singh *et al*. 2020).

Sodium adsorption ratio (SAR) of the pond water samples were found ranges between 0.5-2.2 in pre- monsoon and 0.3 -2.0 after the post-monsoon 2011(Table 2). SAR values of the pond water samples in second year were found reneges between 0.8-1.6 (Table 3) in pre-monsoon and 0.5-1.2 (Table 3) found after the post-monsoon 2012. Richards (1954) categorized the groundwater based on SAR values (<10 as excellent; between 10-18 as good; 18-26 as fair and >26 as poor quality). According to SAR and EC values of pond water samples in both year and season found good for irrigation purposes comparison to the deep tube well and shallow tube well water. Residual sodium carbonate (RSC) of the pond water

Table 3. Irrigation water quality of the different water sources (EC, SAR and RSC) during the year 2012.

Source of water	EC (dsm^{-1})				SAR				Classes of irrigation water		RSC			
	Before monsoon		After monsoon		Before monsoon		After monsoon		Before monsoon	After monsoon	Before monsoon		After monsoon	
	Min	Max	Min	Max	Min	Max	Min	Max			Min	Max	Min	Max
Deep	0.46	0.94	0.34	0.78	3.1	6.9	3.0	6.6	C2S1-C2S1	C2S1-C2S1	-123.72	-52.87	-86.59	-41.80
Shallow	0.54	0.91	0.42	0.74	3.4	7.1	3.0	7.0	C2S1-C3S1	C2S1-C2S1	-105.06	-58.23	-85.98	-44.73
Pond	0.20	0.56	0.14	0.34	0.8	1.6	0.5	1.2	C1S1-C2S1	C1S1-C1S1	-76.69	-49.05	-67.67	-36.12
River	0.37	0.49	0.32	0.36	6.6	8.4	6.5	7.8	C2S1-C2S1	C2S1-C2S1	-62.84	-45.92	-58.09	-43.72

samples was found ranges between -57.17 to -39.49 in pre-monsoon and -41.53 to -22.26 (Table 2) after the post monsoon in the year 2011. RSC values of pond water in next year varies between the -76.69 to -49.05 in pre-monsoon and -67.67 to -36.12 (Table 3) after the post monsoon in 2012. It means calcium and magnesium found dominant in both year and both seasons. Based on the EC and SAR value of the water pond water classify for irrigation purpose were varies class C1S1- C2S1 before monsoon and class C1S1 after the monsoon 2011. In 2012 water quality of the pond water were found in class between C1S1- C2S1 before monsoon and C1S1 after the monsoon (Table 3). Pond water was found good for irrigation both year and season (Tan and Thanh 2021).

Water quality of river

River water is an important source of irrigation during ancient times in many parts of the country which depends upon the river water. River water lifted through canal and reaches the farmers field. Eight (8.0) rivers water samples were collected from different location in pre and post monsoon in year 2011-2012. The physico-chemicals quality of water was analyzed using standard method. pH of the analyzed water samples was found ranges between 7.30-7.60 in pre-monsoon and 7.21-7.45 after the post monsoon 2011 (Table 1). In the second year pH of the pond water varies between the ranges 7.54 -7.62 in pre-monsoon and after monsoon pH values varies in ranges 7.42-7.55 in 2012 (Table 1).

The electrical conductivity of the river water was found ranges between 0.33-0.62 dsm^{-1} in pre-monsoon and 0.21-0.37 dsm^{-1} after the post-monsoon in 2011. Electrical conductivity of the pond water in second year were found ranges between the 0.37- 0.49 dsm^{-1} in pre-monsoon and 0.32-0.36 dsm^{-1} after the post monsoon in 2012 (Table 3) (Yasser *et al*. 2020).

Sodium adsorption ratio (SAR) values of the river water found in ranges between 1.7 to 4.4 in pre-monsoon and 1.2-2.8 in post-monsoon season during the year 2011 (Table 2). In the next year, SAR of the river water samples were found ranges between 6.6- 8.0 in pre-monsoon and 6.5-7.8 in post monsoon 2012 (Table 3). Richards (1954) categorized the groundwater based on SAR values (<10 as excellent; between 10-18 as good; 18-26 as fair and >26 as poor quality). Residual sodium carbonate of the river water samples was found negative in both year. The RSC values of the river water vary in the rages between -52.29 to -45.74 in pre monsoon and -42.71 to -28.81 after the monsoon 2011 (Table 2). During the second year of study, the RSC values of river water were found ranges between -62.84 to -45.92 in pre-monsoon and -58.09 to -43.72 in post monsoon 2012 (Table 3). The value indicates the dominancy of calcium and magnesium in water samples. Similar findings were also reported by (Verma and Rakrhit 2017).

If water quality of the river classifies based on the (Richards 1954) for the irrigation purpose, we find the river water before monsoon 2011 under the C1S1- C2S1 class and also C1S1-C1S1 class were found after the monsoon 2011 (Table 2). During 2012 river water quality for the irrigation use were found before monsoon is C2S1 class and C1S1-C2S1 class after the monsoon 2012 (Table 3).

CONCLUSION

Farmers of the studied areas use different sources of irrigation water for production of crops. Analyzed water samples were compared with standardized developed irrigation water quality chart. It was found that among the surface water sources, pond waters were superior in quality than river water for the irrigation purpose which falls in the water quality classes between C1S1-C2S1 in both the years of study. They have contained less soluble salt and safe for the irrigation use for any crops. They have not required any management practice before the use. Surface water sources (Pond, River) were found more suitable for irrigation purposes compare to ground water (Deep and shallow) in before and after monsoon season in both years.

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