Use of Iron-Rich Groundwater for Irrigation in Sonitpur District of Assam

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Abstract: In the North-Eastern region, abstraction of ground water brings lot of iron from the subsurface layers to the surface. The deposition of iron takes place on the surface and in the sub-surface soil due to continuous use of iron-rich groundwater for irrigation. Installation of 1,00,000 Shallow Tube Wells (STW) during the 9th plan under NABARD's funding and another 47,250 STW under the Assam Rural Infrastructure and Agriculture Services Project (ARIASP) has further raised the problem. About 10,000 more STW are proposed under the 10th five-year plan period. Tests carried out indicated that the ground water being used for irrigation contains high iron in most parts of Assam.

The study carried out in the Sonitpur district aimed at to analyze the scenario of gradual deposition of total iron on irrigated soil also gave a picture of threat. The effect of rainfall on the iron deposited soil was also studied for both monsoon and non-monsoon period. The periodical changes in the iron content of the ground water were also studied. The water table fluctuation was also monitored on monthly basis. The soil macronutrient parameters namely, potassium, phosphorus, organic carbon, pH of soil were also analyzed.

Based on the observed data of nearly two years (October, 2000 to August, 2002), it was found that the iron content in ground water was higher (4.63 to 22.92 ppm) in areas located nearer to river Brahmaputra and to the other small rivers than in areas (8.24 to 10.35 ppm) located far off from the rivers. The concentration of total iron was found varied from 409 to 867 mg/kg in surface soils depth ranges 0 to 30 cm, whereas this concentration for the sub-surface soil depth between 30 cm and 60 cm varied 463 to 687 mg/kg. It was found that monsoon rain has an effect on the deposited iron content. On an average, percentage decrease of total iron because of dilution varied from 36 to 47. The paper presents results and analysis of the study conducted in the Sonitpur district along with few suggestions for management of iron rich for its effective use in surface irrigation.

INTRODUCTION

The economy of Assam is mainly agrarian. More than 80% of population of Assam is dependent on agriculture. The food production of the State is not sufficient to meet the domestic requirement of food grain. Moreover, with the increase in population, the demand for food grain production is increasing rapidly. The reason for deficient food grain production in the State is mainly because farmers do not practice multiple cropping owing to lack of assured irrigation facility. The State has a number of major, medium and minor irrigation schemes, which are not sufficient to meet the irrigation requirement throughout the year. To enhance agricultural production, the Government of Assam has implemented an ambitious programme of installation of shallow tube wells (STW) under the 9th five-year plan period. Under this scheme, Govt. of Assam provided STW at subsidized rate to the farmers with financial support from NABARD. In addition, many STW and DTW were installed earlier by the Irrigation Department, Public Health Engineering Department and Agricultural Department. Alike in other North-Eastern States, ground water in Assam contains high iron concentration. Therefore, the use of the iron-rich water raised the issue of its impact on agricultural productivity. It also raises concerns on sustainability of agricultural production as soil health representing physical, chemical or biological properties are degrading. Keeping this in view, a pilot study was conducted in Sonitpur district to investigate the impact of deposition of excessive iron on the soil surface as well as on the crop production.

THE STUDY AREA

The district is located in the northern part of Assam between Latitudes 26°30′ N and 27° 02′ N and Longitudes 90°17′ E and 93°47′ E. It occupies an area of 4,92,145 hectares, which is 6.27% of the total geographical area of the State. It is bounded on the east by Lakhimpur district of Assam, on the west by Darrang district, on the north by Arunachal Pradesh and on the south by the river Brahmaputra and Nagaon district of Assam.

PHYSIOGRAPHY AND DRAINAGE

The Sonitpur district consists of a narrow strip of land with an average width of about 40 kms from north to south along the northern bank of the river Brahmaputra. Some parts of the district are covered by long grass jungle with scattered patches of rice fields. On the north the level rise is covered by dense green forest. West of Behali, the Biswanath plain, is an elevated region stretching to the bank of the river Brahmaputra.

The topography of the district is characterized by almost flat plain. It is a narrow strip of flat land lying between the Arunachal hills and the river Brahmaputra. It comprises elevated flat uplands along the foothills of Arunachal Pradesh. It is slightly undulating, covered by vegetation and also by agricultural plantation like tea gardens. Away from this zone towards the southern part i.e., central belt, it has flat topography with 1–2 % slope. This land is relatively free from flood inundation. Along the river Brahmaputra there are some flood affected areas and some swampy areas also.

The major rivers that traverse this district are Panchnai, Belsiri, Jia Gabharu, Dipota, Jia Bhoroli, Ghiladhari, Bardikari, Bargang and Burai. These rivers are perennial in nature and are tributaries of the Brahmaputra. These rivers are originated from Arunachal hills located at the northern side of the district. There are number of small tributaries in the district. All those small tributaries are seasonal in nature. Because of the loose texture of soil in the Arunachal hills, the sediment flow rate in most of the rivers is very high. There are several low-lying and waterlogged areas in the district. The waterlogged areas are locally known as 'Beel'. The major waterlogged areas of the district are Borchalla, Rowmari, Borakota, Khoirabeel, Sree-beel, Deghali, Dhand, Rongapani, Borkura, Salmara, Gonalmari, Kalikocha, Seo-beel, Garoimari, Kharoibeel Mohloti etc. These are major natural water reservoirs of the district.

CLIMATE

The southwest monsoon has considerable influence on this region. The region also comes under the influence of western disturbances during winter months. Mountain ranges to the north protect the valley from the flow of dry cold winds during the winter months and also provide conditions conducive for heavy rainfall during monsoon period. Average annual rainfall is around 2000 mm. Unlike other parts of the country, temperature during hot weather season (March to May) in this region is not high due to frequent cloudiness and rain. The weather is, however, very humid. Average sunshine duration is four hours in monsoon season, 6 to 7 hours in pre- and post-monsoons and 7 to 8 hours during winter. Heat and cold waves are very rare in this part. There is not much difference in temperature between the hot weather and monsoon seasons. Temperatures are highest during July/August in spite of the rains. The total annual rainfall is about 1422 mm in 127 total rainy days, the maximum and minimum temperatures are 37.8°C (September) and 8.9°C (January) and the maximum and minimum relative humidity are 99% (November) and 30% (April) respectively as recorded in NERIWALM agro-met station. The relative humidity rarely goes below 75% in summer season. The high rainfall in the State keeps the soil moist, and bases are removed from the surface owing to heavy leaching.

METHODOLOGY

The water and soil samples were collected from twelve selected river basins of Sonitpur district during the period from October, 2000 to August, 2002. In each of the river basins four groundwater sampling points (STW) were selected for water sample collection. The water table fluctuation was also monitored on monthly basis up to August, 2002. The soil macronutrient parameters namely, potassium, phosphorus, organic carbon, pH of soil were also analyzed for the monsoon and non-monsoon periods between October, 2000 to August, 2002. These samples were analysed to find out the periodical changes in iron content, and the total iron intakes in water and soil samples.

IRON CONTENT IN GROUND WATER

The seasonwise iron content (pre-monsoon, monsoon and post-monsoon) measured in different river basins during the year 2001 are presented in Table 1. From Table 1, it can be observed that the sampling points, which are located nearer to the river Brahmaputra and to the other small rivers, contained comparatively high iron content (ranging from 4.63-22.92 ppm), while the water samples located far off from the rivers contained relative low concentration of iron (ranges from 8.24 to 10.35 ppm). The groundwater flow towards the river Brahmaputra and towards other small rivers may be the probable cause of deposition of iron and high iron concentration in the nearby areas of the rivers.

In all the river basins of the district the variation of iron content of groundwater samples during the monsoon 2001 was found slightly lower than the pre-monsoon of the same year. However, these variations of iron content are found within the range of 1.00 ppm except in Dipota and Gavaru river basin. The variation of iron content in these two basins had gone up to 2.88 ppm. There may be some effect of rainfall on the iron content, which is evident from the results of monsoon samples and the pre-monsoon samples.

Table 1. Change in iron content present in water samples collected from different river basins

Name of the river basin	*Sample collection points (STWs)*	*Iron content in pre-monsoon (Mar-May)*	*Iron content in monsoon (June-Sept.)*	*Iron content in post monsoon (Oct-Dec)*	*Sunk depth of STW from the ground (m)*	*Approximate distance from Brahmaputra river (km)*	*Approximate distance (km) from rivers shown in column 1*
Ghiladhari	stw-1	14.41	13.49	13.26	13.64	8	3
	stw-2	2.28	1.57	1.23	24.50	17	1
	stw-3	2.22	2.07	2.24	14.00	12	3
	stw-4	6.79	5.71	5.35	15.25	6	5
Jamuguri	stw-1	5.23	4.83	4.63	23.33	12	5
	stw-2	0.28	0.25	0.32	23.00	22	7
	stw-3	0.79	0.74	0.86	24.00	13	3
	stw-4	0.33	0.31	0.31	22.50	18	12
Jia Bharali	stw-1	0.24	0.18	0.21	17.27	12	7
	stw-2	9.02	7.29	6.94	15.50	9	8
	stw-3	6.79	6.62	6.87	16.25	10	5
	stw-4	20.03	15.62	16.15	16.00	6	12
Dipota	stw-1	21.76	19.25	18.28	19.69	7	2
	stw-2	10.35	8.63	8.24	19.50	9	3
	stw-3	15.55	12.85	12.36	20.25	6	2
	stw-4	12.17	10.81	10.12	20.00	8	3
Stream	stw-1	0.80	0.81	0.82	18.18	35	11
	stw-2	6.51	6.31	6.34	18.25	8	5
	stw-3	7.30	7.07	7.04	19.25	9	12
	stw-4	4.34	4.19	4.14	20.00	5	7
Gavaru	stw-1	11.39	12.08	11.99	15.76	13	5
	stw-2	12.76	10.48	10.24	18.50	12	4
	stw-3	18.65	15.77	15.57	18.25	8	4
	stw-4	4.30	4.25	4.29	16.00	5	3
Dhansiri	stw-1	7.04	6.83	6.57	22.73	5	3
	stw-2	22.80	20.63	20.25	20.50	3	4
	stw-3	8.60	8.17	8.02	20.25	17	5
	stw-4	14.75	13.60	13.23	22.00	5	6
Chengelijan	stw-1	9.93	7.72	7.98	19.69	15	5
	stw-2	22.92	22.76	22.81	18.00	8	3
	stw-3	2.05	1.70	1.68	16.50	20	22
	stw-4	12.00	0.97	1.13	17.25	18	15
Buroi	stw-1	60.20	4.78	4.60	13.64	22	3
	stw-2	4.82	4.68	4.76	14.50	20	1
	stw-3	2.49	0.88	1.23	14.00	16	7
	stw-4	6.53	6.40	6.45	12.50	8	5
Mijikajan	stw-1	1.15	0.75	0.46	15.15	18	10
	stw-2	13.46	7.03	6.67	15.25	10	5
	stw-3	1.22	1.00	1.12	14.50	13	7
	stw-4	0.47	0.41	0.72	16.00	12	2
Burigong	stw-1	1.09	1.00	1.28	14.24	15	8
	stw-2	3.63	3.37	3.36	14.00	10	2
	stw-3	8.91	8.62	9.13	15.50	8	6
	stw-4	7.64	7.20	7.28	16.00	6	7
Sakojan	stw-1	1.15	0.93	0.88	23.33	22	2
	stw-2	7.725	6.54	6.27	24.50	13	5
	stw-3	0.73	0.50	0.44	22.50	20	7
	stw-4	1.20	1.06	1.14	20.00	25	11

Table 2. Status of plant nutrients in soil of different river basins

Name of the river basins	*Avail P (kg/ha)*			*Avail K (kg/ha)*			*Organic Carbon (%)*		
	Apr, 2001	*Aug, 2001*	*Dec, 2001*	*Apr, 2001*	*Aug, 2001*	*Dec, 2001*	*Apr, 2001*	*Aug, 2001*	*Dec, 2001*
Ghiladhari	26.34	6.67	68.16	149.1	70.56	250.61	1.98	1.55	0.63
Jamuguri	480.07	46.02	108.43	499.06	259.84	253.12	1.37	1.04	0.74
Jia Bharali	187.39	62.64	180.18	136.22	253.99	163.69	1.29	1.75	0.88
Dipota	2082	2.66	72.13	112	75.04	185.04	1.2	1.5	0.65
Stream	57.26	41.32	32.65	217.28	120.96	209.92	1.44	1.85	0.94
Gavaru	271.62	56.27	45.16	186.12	138.43	176.96	1	1.25	0.65
Dhansiri	114.99	89.6	41.24	89.34	146.92	151.2	1.02	1.09	0.81
Chengelijan	150.95	173.9	109.01	184.95	303.52	221.1	1.3	0.75	1.44
Buroi	247.25	149.19	87.18	537.83	271.04	311.36	1.32	1.39	0.58
Mijikajan	972.43	77.38	168.64	181.46	408.8	358.4	1.88	1.37	1.73
Burigong	75.82	39.2	154.53	390.6	185.92	564.48	1.1	1.26	1.14
Sakojan	86.12	23.13	224.66	209.07	140	329.81	1.67	1.7	1.41
Mean	193.31	72.94	99.31	137.73	142.68	244.21	1.19	1.17	0.97

IRON CONTENT IN SURFACE AND SUB-SURFACE SOIL

Soil analysis (Table 3) indicates that soils of Sonitpur district of Assam are acidic in nature and fairly rich in organic carbon. The content of total iron, available phosphorous and potassium are relatively high in most of the tested soil samples of the district. Analysis of surface and sub-surface soil samples

Table 3. pH of the surface and sub surface soils

Name of the river basins	*pH of Soil*					
	30 cm depth			*60 cm depth*		
	Apr, 2001	*Aug, 2001*	*Dec, 2001*	*Apr, 2001*	*Aug, 2001*	*Dec, 2001*
Chengelijan	4.83	5.68	5.50	5.05	5.60	5.15
Buroi	5.40	5.43	5.35	5.33	5.85	5.38
Mijikajan	5.30	4.85	5.28	5.48	5.67	5.23
Burigong	4.75	5.25	5.65	5.35	5.55	5.65
Sakojan	4.93	5.70	4.93	4.80	5.23	5.33
Ghiladhari	5.55	6.10	6.05	5.88	5.90	5.93
Jamuguri	5.45	5.43	5.45	5.08	5.35	5.55
Jia Bharali	5.00	5.53	4.98	5.20	5.75	5.93
Dipota	5.40	5.83	5.35	4.90	5.51	5.88
Stream	5.40	5.92	5.10	5.30	5.47	5.23
Gavaru	4.98	4.93	5.08	5.25	5.18	5.30
Dhansiri	5.25	5.28	5.65	4.98	5.45	5.85
Mean	5.12	5.10	4.87	5.22	5.49	5.03

Source: Tables 1, 2 and 3 have been prepared on the basis of information published in the paper "Iron Status of Shallow Tube Wells and Recycled Water Irrigated Soils and Its Impact on Availability of Plant Nutrients" authored by Singh, A.K., Dutta, B. and Nath, M. (2003), *Jour. Ecology, Environment and Conservation,* **9 (2):** 199-206.

collected from all the river basins for the period April through December 2001 had shown a wide variation in iron content. Higher value in these soils might be due to use of iron-rich groundwater as irrigation water and flow of soluble Fe^{2+} along flow lines from adjacent highlands.

Data of April 2001 indicated that the concentration of total iron varied from 409 to 867 mg/kg in the sub-surface soil depth ranges from 30 cm to 60 cm. However, data of August, 2001 for the same location showed that the concentration of iron decreased drastically in both surface and sub-surface soils. On average, percentage decrease of total iron is nearly 36. Data of December, 2001 revealed that the concentration of iron again enhanced and reached almost near to the value observed during April, 2001. The use of ground water during October through December 2001 might have enhanced the iron content in the soil. This could be substantiated by data observed on the increase in total iron concentration in the soil samples collected in groundwater irrigated area. It was also reported that the iron content significantly increases in the soils of Assam during non-monsoon season (Baruah and Baruah, 2000). In some of the areas total iron decreases progressively with soil depths. The surface soils are sufficiently rich in total iron. In most of the sols of the sandy area it was found that lower part contains less total iron (30-60 cm) in comparison to non-groundwater irrigated area. This distribution of total iron in lower portion of soil profile of groundwater irrigated field indicated that the influence is low in greater depth.

STATUS OF PLANT NUTRIENTS AND IMPACT OF USE OF IRON-RICH GROUNDWATER

Low values of available phosphorous were observed in some of the groundwater sampling points, and it had shown a declining trend. These may be because of possible conversion of K into sparingly soluble double salt of K_2SO_4 and $FeSO_4$ (Singh et al., 2003).

Singh et al. (2003) mentioned that plants grown in iron rich soils often show P and K deficiency. Potassium deficient plants release large amount of root exudates, which cause more activity of the rhizosphere flora, demanding more of O_2 in their neighbourhood. This eventually causes reduction of oxidized compounds, by its high uptake and antagonism with other nutrients at the root absorption sites. This leads to serious nutritional imbalance and the crop may succumb in extreme cases. The pH of sub-surface soil also decreased from 5.22 to 5.03. This could be due to excess irrigation and leaching of basic cations from upper horizon of soil profile. In most of soils, phosphorus and potassium content had also decreased due to increase in soil iron.

CONCLUSION

The study showed that high iron content in the soils of Sonitpur district is mainly due to higher accumulation of iron from ground water extracted through Shallow Tube Wells. The water is rich in soluble iron and acidic pH (<5.5). The distribution of iron in upper portion of soil profile has been found more than the lower layer of soils.

The study indicated that use of iron-rich groundwater for irrigation for a long time would increase the iron content and the concentration of iron oxide in the soil. These oxides may increase cohesiveness of the soil layers that may lead to development of hardpan. It may also affect the soil texture, structure and soil porosity and thereby may effect on drainage system of the soil. The plant nutrients namely N, P and K, which are found declining, are required in sufficient amount for healthy growth and good yield of crops. In general, excess iron accumulation also induced deficiency of P, K, bases and some micronutrients like Zn, Cu, etc.

The effect of iron-rich groundwater could be minimized by adopting proper crop planning, using water as per crop water requirement and cultivating low water requirement crops. Use of organic manure will increase the organic matter in the soil and will maintain the soil porosity. Deep ploughing of soil will help in mixing of surface soil and sub-surface soil and will reduce the accumulation of iron on the surface and may ultimately help in flowing the iron along with ground water to the nearby rivers or depression areas. The quality of ground water and the irrigated soil should also be regularly monitored/tested for maintaining soil health and for ensuring sustainable yield.

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