Research Article

Build-up of Soil Fluoride under Wheat and Mustard Crop Irrigated with Different Categories of Fluoride Water

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Abstract

Based on the fluoride content of 100 water samples collected during inventory survey five categories of water were framed, *viz*. F_1 : < 2.0 mg L^{-1} fluoride, F_2 : 2.1 – 4.0 mg L^{-1} fluoride, F_3 : 4.1 – 6.0 mg L^{-1} fluoride, F_4 : 6.1 – 8.0 mg L^{-1} fluoride and F_5 : > 8.0 mg L^{-1} fluoride. Thereafter, for each category of fluoride water four sites were selected for monitoring the changes in the soil and crops *i.e*. mustard and wheat and also in the quality of groundwater, as a result of use of fluoride waters. The details of twenty sites selected for monitoring work are presented in Table 1&2. In all the twenty sites selected in different villages of Ladnu tehsil, mustard (Pusa bold) and Wheat (Raj 3077) crops were grown in *rabi* season during 2007-08 and 2008-09 as per package and practices for the agro-climatic zone-II (a). Soil and water samples were collected at the time of sowing and harvesting of both the crops during both the years. Yields of both the crops were also recorded. The plant samples of mustard and wheat were collected at 30 DAS and harvest for detailed analysis.

Keywords: Fluoride water, Wheat, Mustard, Build- up

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Introduction

Water is an essential natural resource for sustaining life and environment, however, chemical composition of surface or subsurface water is one of the prime factors on which the suitability of water for domestic, industrial and agricultural purpose depends. Fresh water occurs as surface water and groundwater, though groundwater contributes only 0.6 per cent of the total water resources on earth but it is a major and the preferred source of drinking water in rural as well as urban areas. The demand for water has increased over the years and this has led to water scarcity in many parts of the country. At present about 85 per cent of India's fresh water recourses are being utilized in agriculture and remaining 15 per cent in industrial and domestic sector. Rajasthan, being largest state of India having 10.41 per cent nation's area and 5.5 per cent of country's human population but has low water resources *i.e.* 1 per cent of country's resources. Fluoride is considered to be beneficial for human health if taken in controlled quantity (1.0 - 1.5 mg L^{-1}) preventing dental cavities, but it is also known to cause dental and skeletal fluorosis when its concentration is higher than 3.0 mg L^{-1} in water [1]. The problem of high fluoride concentration in groundwater resource has become an important health related geoevironmental issue in 23 districts of Rajasthan [2-4].

The state has extreme climatic and geographical condition. Rajasthan suffers both the problems of quantity and quality of water. Since last one decade there is growing tendency in the farmers of Rajasthan to dug tube wells and irrigate their crops by sprinkler irrigation. Thus, there is need to generate information regarding characterization of ground water and soil of Ladnu tehsil.

Materials and Methods

An inventory survey of ground water and soils was carried out at villages of Ladnu tehsils of Rajasthan during 2007. Ladnu tehsil of Nagaur district is a part of Agro-climatic zone-II (a) *i.e.* transitional plain of inland drainage of Rajasthan. In the north, it is surrounded by Sujangarh tehsil of Churu district, in the east Dhod tehsil of Sikar district, in the west Jayal tehsil of Nagaur district and in the south Didwana tehsil of Nagaur district. The texture of soils of the area under study varies from sand to sandy loam showing dominance of sand. The climate of Ladnu tehsil is semi-arid with a cool winter from November to March. During this period north-eastern winds prevail and there is occasional

rains. Summer is hot and dry from April to June. In this hot period, strong south-western winds blow causing frequent dust storms. Scattered rains occur during July to September with an average rainfall of 263.3 mm per annum. The rainfall is extremely scattered and variable with severe drought, which is of common occurrence. The temperature ranges from 3 °C to 46 °C and sometimes minimum and maximum temperature goes even up to 0 °C to 50 °C, respectively. An inventory survey of the area had been done, wherein 100 ground water samples were collected. Water sample and composite soil sample from 0 - 30 cm depth was collected from the field which is being irrigated by the tube well. Soil samples were taken with the help of a spade and '*khurpi*' and were collected in polythene bags. Each soil sample (approximately 2.0 kg) was carefully labelled carrying all the relevant details and was brought to the laboratory for analysis. The fluoride content in soil estimated by the using method [5]. The data obtained for different parameters of soil, water and plant analysis were statistically analyzed for correlation and regression using the procedures given by [6].

Results and Discussion

Soil Fluoride Build-up under Wheat Crop

Data regarding soil fluoride build up after first and second year and total build up after completion of study period in wheat crop is presented in **Table 1**. Data revealed that the average soil fluoride build up in wheat crop varied from +0.13 to +1.36 mg kg^{-1} and +0.29 to +1.36 mg kg^{-1} during first and second years, respectively, under different fluoride categories. The maximum soil fluoride build-up of +2.21 mg kg^{-1} and +1.85 mg kg^{-1} was recorded in fluoride category of > 8.0 me L^{-1} during first and second year, respectively. The minimum soil fluoride build-up of +0.11 mg kg^{-1} and +0.14 mg kg^{-1} was observed in < 2.0 mg L^{-1} fluoride category during both the years. Fluoride in vegetables and cereal crop grown in potentially fluoridated area in Dausa district of Rajasthan and reported that maximum fluoride concentration was found in wheat i.e. 14.3 µg g^{-1} where fluoride concentration in water samples was found 6.2 ppm [7]. The grain yield of wheat decreased with increasing level of F in the soil and extent of decrease was from 12.53 to 10.83 g/pot with increasing F levels from 0 to 200 mg kg^{-1} at ESP 5.8 and from 7.11 to 5.59 g pot^{-1} at ESP 56.6 at same F levels [8].

Data regarding total soil fluoride build up after harvest of wheat crop during the study period (2007-08 and 2008-09) revealed that average total soil fluoride build up in varied from 0.32 to 2.11 mg kg^{-1} in the different fluoride categories. The total soil build up varied from 0.20 to 0.47, 0.42 to 0.88, 0.59 to 1.01, 0.78 to 1.45 and 0.80 to 3.28 mg kg^{-1} in fluoride category of < 2.0, 2.1-4.0, 4.1-6.0, 6.1-8.0 and > 8.0 mg L^{-1}, respectively. The maximum total soil build-up of 3.28 mg kg^{-1} was recorded in fluoride category of > 8.0 mg L^{-1} while, the minimum of 0.20 mg kg^{-1} was observed in fluoride category of < 2.0 mg L^{-1}. This implies that the crops grown with fluoride enriched waters can absorb, translocated and accumulated fluoride [9]. Thus, after going through all the data, it can be inferred that increase of fluoride content in water as well as in soil results in increase of fluoride content of plants.

Soil Fluoride Build-up under Mustard Crop

Data regarding soil fluoride build up after first and second year and total build up after completion of study period in mustard crop is presented in **Table 2**. Data revealed that the average soil fluoride build up in mustard crop varied from +0.07 to +0.44 mg kg^{-1} and +0.08 to +0.23 mg kg^{-1} during the first and second years, respectively, under different fluoride categories. The maximum soil fluoride build-up of +0.84 mg kg^{-1} and +0.27 mg kg^{-1} was observed in fluoride category of > 8.0 mg L^{-1} during first and second year, respectively. The minimum soil fluoride build-up of +0.07 mg kg^{-1} in < 2.0 mg L^{-1} fluoride category during first year and +0.06 mg kg^{-1} in < 2.0 mg L^{-1} and 2.1 to 4.0 mg L^{-1} fluoride category during second year.

Data regarding total soil fluoride build up after harvest of mustard crop during the study period (2007-08 and 2008-09) revealed that average total soil fluoride build up in mustard crop varied from 0.12 to 0.49 mg kg^{-1} in the different soil fluoride categories. In different soil fluoride categories the total soil build up varied from 0.09 to 0.16, 0.12 to 0.20, 0.21 to 0.26, 0.28 to 0.34 and 0.38 to 0.65 mg kg^{-1} in fluoride category of < 2.0, 2.1-4.0, 4.1-6.0, 6.1-8.0 and > 8.0 mg L^{-1}, respectively. The maximum total soil build up of 0.65 mg kg^{-1} was recorded in fluoride category of > 8.0 mgL^{-1} while, the minimum total soil build-up of 0.09 mg L^{-1} was observed in fluoride category of < 2.0 mg L^{-1}. These results get support from the findings of [10, 11].

Table 1 Build-up of soil fluoride (mg kg^{-1}) under wheat crop irrigated with different categories of fluoride water

Fluoride category (mg L^{-1})	Village name	First year			Second year			Build-up (two years)
		S*	H*	Build-up	S*	H*	Build-up	
< 2.0	Ratau (a)	0.12	0.24	+ 0.12	0.22	0.36	+ 0.14	0.24
	Ratau (c)	0.56	0.71	+ 0.15	0.67	0.91	+ 0.34	0.35
	Genana (b)	0.37	0.54	+ 0.17	0.43	0.84	+ 0.41	0.47
	Audint (c)	0.58	0.69	+ 0.11	0.51	0.78	+ 0.27	0.20
	Average	0.40	0.54	+ 0.13	0.45	0.72	+0.29	0.32
2.1 – 4.0	Sandas (b)	0.54	0.67	+ 0.13	0.49	0.96	+ 0.47	0.42
	Jhardia (c)	0.58	0.83	+ 0.25	0.62	1.10	+ 0.48	0.52
	Lukas (a)	0.31	0.72	+ 0.41	0.57	1.03	+ 0.50	0.72
	Lukas (b)	0.61	0.86	+ 0.25	0.83	1.49	+ 0.66	0.88
	Average	0.51	0.77	+0.26	0.62	1.14	+0.52	0.63
4.1 – 6.0	Baladoo (a)	0.35	0.79	+ 0.44	0.46	0.95	+ 0.49	0.60
	Baladoo (b)	0.51	0.90	+ 0.39	0.54	1.10	+ 0.56	0.59
	Nimbi Jhodha (a)	0.19	0.50	+ 0.31	0.41	1.05	+ 0.64	0.86
	Nimbi Jhodha (b)	0.64	0.97	+ 0.33	0.81	1.65	+ 0.84	1.01
	Average	0.42	0.79	+0.36	0.55	1.18	+0.63	0.76
6.1 – 8.0	Natas (b)	0.13	0.54	+ 0.41	0.49	0.96	+ 0.47	0.83
	Dujar (c)	0.57	0.93	+ 0.36	0.77	1.35	+ 0.58	0.78
	Bakolia (b)	0.56	1.12	+ 0.56	0.79	1.66	+ 0.87	1.10
	Bakolia (c)	0.87	1.21	+ 0.34	1.12	2.32	+ 1.20	1.45
	Average	0.53	0.95	+0.41	0.79	1.57	+0.78	1.04
>8.0	Sikarali	0.97	3.18	+ 2.21	2.46	4.25	+ 1.79	3.28
	Malgoan (b)	0.64	1.59	+ 0.95	0.49	2.81	+ 1.85	2.17
	Mangalpura	0.51	1.13	+ 0.62	0.66	1.31	+ 0.65	0.80
	Dujar (b)	0.65	2.34	+ 1.69	1.67	2.84	+ 1.17	2.19
	Average	0.69	2.06	+1.36	1.32	2.80	+1.36	2.11

S* = Sowing, H*= Harvesting

Impact of different categories of fluoride waters on quality of wheat and mustard

Plants grown under high fluoride condition may suffer due to interference in the availability and uptake of essential plant nutrients. In addition, the high fluoride concentration in the soils or waters may affect certain physiological processes in plants, which ultimately affects the quality of the crops.

Evaluation of Soil Fluoride Build-Up under Wheat and Mustard

The ability of different soils to adsorb fluoride can be explained as saturation fluoride adsorbing capacity, which indicates that the adsorption of fluoride in soil decreases from humid areas to arid areas and from acid soils to alkaline soils. The present study area is being in semi-arid climate and soils being having alkaline pH have shown less build up or adsorption of fluoride in soil. Further, the fluoride build-up in soil was in accordance to fluoride concentration in irrigation water and the average build up in mustard crop was comparatively less than wheat crop. Owing to application of lesser amount of irrigation water in mustard than wheat crop. These results get support from the findings of [12].

Evaluation of Soil Fluoride Build-up under Wheat and Mustard Crop

- Soils being having alkaline pH have shown low build up or adsorption of fluoride in soil.
- The fluoride build-up in soil was in accordance to fluoride concentration in irrigation water and the average build up under mustard crop was comparatively less than wheat crop. This could be due to application of lesser amount of irrigation water in mustard than wheat crop.

Table 2 Build-up of soil fluoride (mg kg^{-1}) under mustard crop irrigated with different categories of fluoride water

Fluoride category (mg L^{-1})	Village name	First year			Second year			Build-up (two years)
		S*	H*	Build-up	S*	H*	Build-up	
< 2.0	Ratau (a)	0.12	0.20	+ 0.08	0.18	0.28	+ 0.10	0.16
	Ratau (c)	0.56	0.65	+ 0.09	0.60	0.67	+ 0.07	0.11
	Genana (b)	0.37	0.44	+ 0.07	0.40	0.46	+ 0.06	0.09
	Audint (c)	0.58	0.65	+ 0.07	0.60	0.70	+ 0.10	0.12
	Average	0.40	0.48	+0.07	0.44	0.52	+0.08	0.12
2.1 – 4.0	Sandas (b)	0.54	0.62	+ 0.08	0.60	0.66	+ 0.06	0.12
	Jhardia (c)	0.58	0.70	+ 0.12	0.66	0.74	+ 0.08	0.16
	Lukas (a)	0.31	0.39	+ 0.09	0.37	0.46	+ 0.09	0.15
	Lukas (b)	0.61	0.72	+ 0.11	0.70	0.81	+ 0.11	0.20
	Average	0.51	0.60	+0.10	0.58	0.51	+0.08	0.18
4.1 – 6.0	Baladoo (a)	0.35	0.46	+ 0.11	0.42	0.56	+ 0.14	0.21
	Baladoo (b)	0.51	0.65	+ 0.14	0.63	0.75	+ 0.12	0.24
	Nimbi Jhodha (a)	0.19	0.33	+ 0.14	0.31	0.45	+ 0.14	0.26
	Nimbi Jhodha (b)	0.64	0.80	+ 0.16	0.76	0.90	+ 0.14	0.26
	Average	0.42	0.56	+0.13	0.53	0.66	+0.13	0.24
6.1 – 8.0	Natas (b)	0.13	0.30	+ 0.17	0.27	0.45	+ 0.18	0.32
	Dujar (c)	0.57	0.73	+ 0.16	0.68	0.85	+ 0.17	0.28
	Bakolia (b)	0.56	0.75	+ 0.18	0.71	0.90	+ 0.19	0.34
	Bakolia (c)	0.87	1.10	+ 0.23	1.00	1.21	+ 0.21	0.34
	Average	0.53	0.72	+0.18	0.66	0.85	+0.18	0.32
>8.0	Sikarali	0.97	1.21	+ 0.24	1.15	1.35	+ 0.20	0.38
	Malgoan (b)	0.64	0.90	+ 0.26	0.85	1.07	+ 0.22	0.43
	Mangalpura	0.51	0.85	+ 0.84	0.80	1.03	+ 0.23	0.52
	Dujar (b)	0.65	1.10	+ 0.45	1.07	1.30	+ 0.27	0.65
	Average	0.69	1.01	+0.44	0.96	1.18	+0.23	0.49

S* = Sowing, H*= Harvesting

Conclusions

The present study area is being in semi-arid climate and soils being having alkaline pH have shown less build up or adsorption of fluoride in soil. Further, the fluoride build-up in soil was in accordance to fluoride concentration in irrigation water and the average build up in mustard crop was much less than wheat crop.

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