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RELATIONSHIP BETWEEN SODIUM MAGNESIUM AND CALCIUM IN UNDER-GROUND IRRIGATION WATER OF A BRACKISH WATER TRACT

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A survey of underground irrigation water of a brackish water affected tract in Agra district of Uttar Pradesh revealed Na^{+}—Mg^{++}—Ca^{++} type waters. An increase in salinity of water was associated with increase in the concentration of the ions, however relative increase of magnesium was more than sodium and calcium. About 5 per cent of water samples were dominated with magnesium over sodium. Out of the remaining waters dominated with sodium, a large number (30 per cent) showed Na/Mg ratio between 2—3 Only 2 per cent water samples were dominated by calcium over sodium and from remaining sodium dominated waters 26 per cent contained 6—10 times sodium as compared to calcium. About 94 per cent samples were dominated by magnesium over calcium and 1/3rd of these samples analysed 2—3 times more magnesium than calcium. Hence the ratio between Na/Mg and Mg/Ca were approximately of the same order.

Presence of total soluble salts or electrical conductance (EC) and sodium adsorption ratio (SAR) continue to be the yard stick to judge the quality of irrigation water. Out of the cations contributing towards salinity of irrigation water, the amount of potassium present is very small and the preponderance of sodium, calcium and magnesium has been established beyond any doubt. An assumption that calcium and magnesium being divalent behave alike has been used for computing SAR by Richards (1954) and subsequent workers. A large number of reports reveal that calcium differs from magnesium with regard to exchange behaviour, specific adsorption sites (Beckett, 1965), plant growth and soil physical properties (Bernstein and Hayward, 1958; Heinmann, 1959). Magnesium dominated irrigation waters and reported to be more hazardous than calcium dominating irrigaiton waters (Paliwal et al 1975) It appears therefore, necessary that relative proportion of sodium to calcium and sodium to magnesium might be of considerable significance for predicting effect of saline waters on soil physico chemical properties and plant growth. The present study is an attempt towards this direction.

MATERIAL AND METHODS

A survey of under ground irrigation water was conducted in brackish water affected tract of Agra district in Uttar Pradesh covering eight blocks namely, Bichpuri, Akola, Baroli Ahir, Kheragarh, Jagner, Saiyan, Fatehpur Sikri and Kiraoli. Number of samples

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collected from a block were based on its size and were randomly distributed all over the block area. Four hundred and thirty-one water samples (216 from tubewells and 215 from wells) were collected and analysed for pH, EC, Ca^{++} Mg^{++} Na^{+} K^{+} $CO_3^{=}$ HCO_3^{-} Cl^{-} and $SO_4^{=}$ (Richards, 1954) Various cationic ratios worked out from chemical composition of these water samples have been discussed.

RESULTS AND DISCUSSION

Na^{+} Mg^{++} and Ca^{++} vs Salibity.

The detailed chemical analysis of these water samples reported by Narain et al. (1976) revealed electrical conductance varying from 0.6 to 34.3 with an average value of 7.1 mmhos/cm. The SAR of these waters ranged between 1.1 to 78.5 (mean 12.8). Sodium was the dominant cation which was followed by magnesium or calcium. Thus, the cationic composition of these waters was Na^{+}-Mg^{++}-Ca^{++} or Na^{+}-Ca^{++}-Mg^{++} type. Potassium was present in small amount irrespective of salinity grade of irrigation water.

With increase in salinity of waters, there was increase in concentration of Na^{+} Mg^{++} and Ca^{++} (Narain et al. 1976) The contribution of sodium, magnesium and calcium towards salinity varied from 51 ro 68, 21 to 28 and 8 to 18 per cent, respectively. The contribution of sodium towards salinity increased upto 2 to 4 EC of waters (Fig. 1), with a simultaneous decrease in per cent contribution of magnesium and calcium upto these salinity ranges. In water samples above this salinity; the contribution of sodium and calcium was decreasing while that of magnesium was increasing. In case of extremely saline waters having EC more than 20 there was a sharp decrease in sodium contribution and increase in that of magnesium This indicated that relative proportion of magnesium with increased insalt content of waters above 4 mmhos/cm conductivity.

Na/Mg, Na/Ca and Mg/Ca ratios vs Salinity :

The Na/Ca and Na/Mg ratios of these irrigation waters indicated (Fig. 2 an increase in these ratios upto 2-4 mmhos/cm of EC of irrigation water. With further increase in salinity of water, there was decrease in Na/Mg ratio while in the Na/Ca ratio continued to increase upto 20 Ec and dropped later on This shows that with increase in the salinity of water above 4 mmhos/cm, relative increase of magnesium with respect to sodium is more than calcium. A sharp fall of Na/Ca ratio above 20 mmhos/cm conductivity may be attributed due to considerable decrease in sodium in this range rather than any remarkable increase of calcium (Fig. 1), Mg/Ca curve revealed a continuous increase in the ratio with increase in salinity confirming magnesium domination in water samples over calcium. In most of the irrigation waters magnesium was more than calcium excepting few samples possessing low salinity. The magnesium content was 1 to 3 times that of calcium content all over the salinity ranges of irrigation water.

Na/Mg, Na/Ca and Mg/Ca ratios vs frequency distribution of samples:

Frequency distribution diagram with regard to Na/Mg revealed (Fig.3) that about 30 per cent of water samples contained 2-3 times sodium than magnesium and about 74 per cent water possessed Na/Mg ratio lesser than 4. The curve shows that number of the water samples increased upto 2-3 Na/Mg ratio and decreased than after particularly beyond 10 to 20 ratio. Most of the water samples (95 percent) revealed the Na/Mg ratio lesser than10. Blockwise frequency distribution (Table 1) shows that about 5 per cent of irrigation water possessed Na/Mg ratio less than 1 indicating the dominance of magnesium over sodium in these waters. Of remaining samples 69 per cent waters revealed Na/Mg ratio 1 to 4 and 26 per cent more than 4. about 5 per cent irrigation waters also classed in the category of Na/Mg ratio$>$10. The maximum percentage of water samples (9.4) dominated by magnesium (having Na/Mg(ratio $<$1) were found in the block Baroliahir while minimum (1 2 per cent) in Fatehpur Sikri block. This was inversely related to the salinity problem of irrigation waters in these blocks Thus, the waters of low salinity were dominated by magnesium while in higher salinity waters the sodium occupies the place of dominant cation. In all the blocks maximum percentage of water samples about 45 to 70 possessed Na/Mg ratio between 1to 3.

About 70 per cent of waters possessed Na/Ca ratio (Fig.3) lesser than 10 and only 24 per cent less than 4. Maximum number of waters (26 per cent) contained sodium 6 to 10 times m re than calcium. About 88 per cent water samples showed Na/Ca ratio lesser than 20. The frequency distribution of Na/Ca ratio (Table 1) shows that only 2 per cent irrigation water were dominated by calcium and rest (about 98 per cent) were having more sodium than calcium About 22 per cent water samples contained sodium 1 to 4 times more than calcium and 19 per cent of the samples revealed 4 to 6 times sodium over calcium. About 70 per cent waters possessed Na/Ca ratio less than 10.

Fig. 3 depicts that only 6.5 per cent of water samples were having Mg/Ca ratio$<$1, there by dominated, by calcium. Rest of water samples (93.5 per cent) showed presence of more magnesium than calcium. About 86.5 per cent of the samples possessed Mg/Ca ratio between 1 to 5 and 7 per cent of samples had more than 5. Thus, 1/3 of water samples had magnesium 2 to 3 times more than calcium content. Such magnesium dominated waters have also been reported in Rajasthan (Paliwal et al. 1975) and from western Uttar Pradesh (Tripathi et al. 1973; Narain et al. 1976).The blockwise frequency distribution of irrigation waters with respect to Mg/Ca ratio is given in table 1. The magnesium hazard in irrigation water has been calculated in those cases where magnesium is more than calcium (Paliwal et al 1975) and expressed as % Mg hazard = No. of water samples having Mg > Ca × 100/ total no. of water samples. Maximum magnesium hazard was recorded (Table 1) in the blocks Bichpuri and Saiyan where all the samples showed dominance of magnesium over calcium. Excepting the Baroliahir and Jagner blocks atleast 90 per cent of underground irrigation waters possessed a potential magnesium hazard. In Baroliahir and Jagner 11 to 22 per cent of water samples were found to have more calcium than magnesium. Therefore water of these blocks revealed low magnesium hazard. About 98 per cent waters of Bichpuri block have Mg/Ca ratio in between 1 to 5. In case of Saiyan and Jagner 79 and 90 per cent, respectively were grouped in this category. Magnesium hazard in other blocks was in the order: Kheragarh > Kiraoli > Akola > Fatehpur Sikri > Baroliahir.

A comparison of Na/Ca, Na/Mg and Mg/Ca ratio curves (Fig. 3) indicated that the ratio of Na/Mg is lower than Na/Ca and hence the Na/Ca curve is shifted away from the ordinates But Na/Mg and Mg/Ca frequency curves run more or less parallel to each other. This indicates that the ratio between Na/Mg is approximately of the same order and magnitude as that of Mg/Ca.

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Table 1 Block—wise per cent frequency distribution of underground irrigation waters with regard to cationic ratios.

Class	Bich-puri (39)	Akola (29)	Baroli-ahir (53)	Khera-garh (55)	Jagner (40)	Saiyan (52)	Fateh-pur Sikri (86)	Kiraoli (77)
				Na/Mg ratio				
0-1	7.7	3.5	9.4	—	5.0	5.8	1.2	9.1
1-2	30.8	31.0	24.6	27.3	27.5	30.8	10.5	26.0
2-3	38.5	27.6	27.6	27.3	27.5	32.7	40.7	22.1
3-4	10.3	13.8	13.2	16.4	17.5	7.7	19.8	16.6
4-6	7.6	10.4	11.3	12.7	15.0	7.7	14.0	11.7
6-10	5.2	7.0	15.1	10.9	10.0	7.7	8.1	9.1
10-20	—	—	1.9	3.6	—	3.9	2.3	2.6
20-30	—	3.5	1.9	—	—	1.9	2.3	—
>30	—	3.5	1.9	1.8	2.5	1.9	1.2	3.9
				Na/Ca ratio				
0-1	—	—	3.8	1.8	5.0	—	—	5.2
1-2	5.1	3.5	7.6	1.8	10.0	1.9	3.5	2.6
2-3	10.3	3.5	15.1	7.2	20.0	1.9	11.6	5.2
3-4	15.4	3.5	13.2	3.6	2.5	15.4	5.8	10.4
4-6	41.0	24.1	9.4	20.0	25.0	21.2	12.8	13.0
6-10	18.0	27.5	22.7	21.8	22.5	27.0	40.7	20.8
10-20	7.7	24.1	15.1	29.1	7.5	21.2	12.8	24.7
20-20	2.6	10.3	7.6	7.3	7.5	3.9	9.3	7.8
>30	—	3.5	5.7	7.3	—	7.7	3.5	10.4
				Mg/Ca ratio				
0-1	—	6.9	11.3	1.8	22.5	—	8.1	3.9
1-2	35.9	6.9	34.0	16.4	47.5	13.5	20.9	24.7
2-3	53.9	27.6	26.4	38.2	17.5	36.5	39.5	26.0
3-4	7.7	27.6	11.3	21.8	10.0	28.9	24.4	19.5
4-6	2.6	20.7	13.3	20.0	—	17.3	5.8	19.5
6-10	—	10.4	1.9	1.8	2.5	1.9	1.2	3.9
10-20	—	—	1.9	—	—	—	—	—
20-30	—	—	—	—	—	1.9	—	1.3
>30	—	—	—	—	—	—	—	1.3

Figures in paranthesis indicate number of samples.

Fig. 1 PERCENT CONTRIBUTION OF CATIONS TOWARDS TOTAL SALINITY

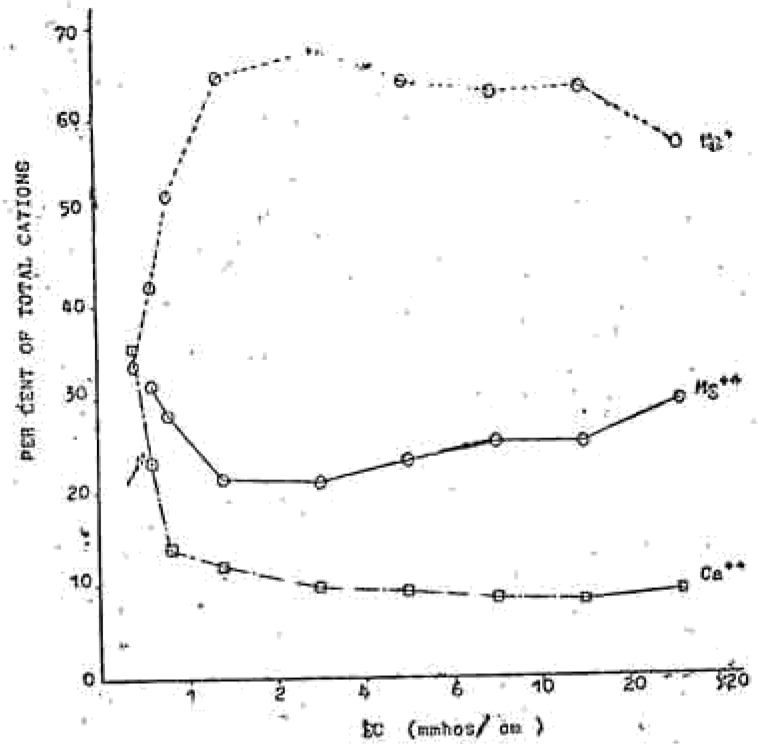

Fig. 2 Na/Ca, Na/Mg AND Mg/Ca RATIOS IN RELATION TO SALINITY OF UNDERGROUND IRRIGATION WATER

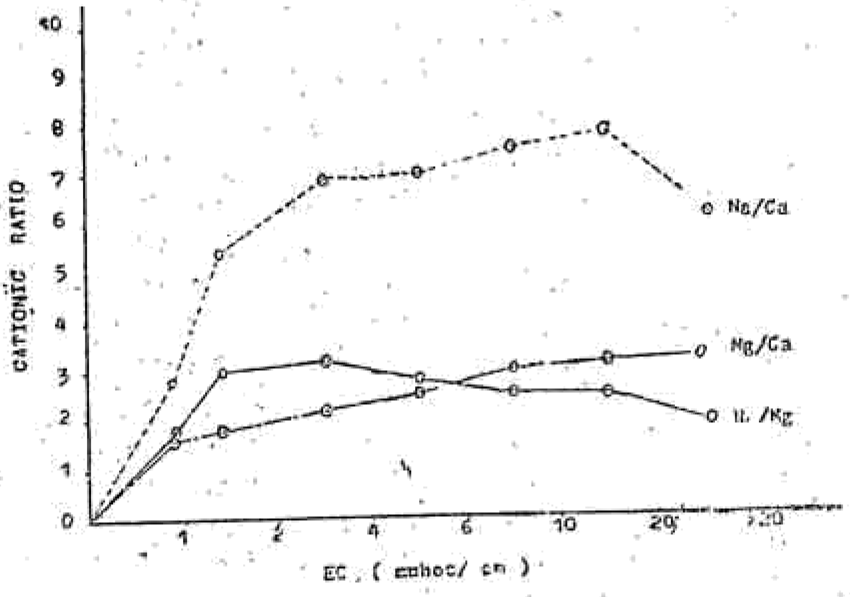

Fig. 3. FREQUENCY DISTRIBUTION OF UNDER-GROUND IRRIGATION WATER IN RELATION TO DIFFERENT CATIONIC RATIOS