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Evaluation of Salinity, Sodicity and Fertility Indices of Soils of South-Eastern Jodhpur (Rajasthan), India

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Abstract

The periodically diagnosis and subsequent management of salinity, sodicity and fertility status of the soils is of vital significance. The detailed systematic information about these aspects is not yet available for this tract which is essential for sustainable natural resource management. Therefore, an urgent need was felt for extensive and well planned study of soils both in the field and laboratory was conducted to evaluate salinity, sodicity and fertility indices of both irrigated and unirrigated cultivated soils of south eastern part of Jodhpur district of Rajasthan during December, 2021. One hundred sixty five composite soil samples (0-15 cm depth) from fields irrigating with tube wells/open wells water and sixty three composite soil samples (0-15 cm depth) from adjacent unirrigated fields were collected. Underground water for irrigation in the study area were good (40.66%), marginally saline (29.67%), saline (1.10%), high SAR saline (26.92%) and highly alkali (1.65%) types. The computed values of salinity and sodicity indices were 1.96, 2.86 and 1.06, 2.49 for irrigated and unirrigated soils of study area, respectively. The calculated values of fertility index for organic carbon, available phosphorus and potassium were 1.08, 1.37 and 2.50 for irrigated and 1.00, 1.17 and 2.16 for unirrigated soils, respectively. On the basis of soil and water characteristics studied it can be inferred that poor fertility, very slight salinity and moderate sodicity of soils and marginally saline, saline, high SAR saline and highly alkali underground water for irrigation were the principle constraints affecting crop production in the study area.

Key words: Salinity and sodicity indices, Irrigated and unirrigated soils, Underground water

Introduction

Soil salinity is one of the largest global challenges in the arid and semi-arid regions that severely affect agricultural production (El hasini *et al*., 2019). Soil salinity already covers 20 percentages of the total cultivated and 33 percentages of the irrigated agricultural land worldwide (Srivastava and Kumar, 2015). At global level, out of the total 810 m ha salt affected soils, 376 m ha area comes under salinity and 434 m ha area comes under sodicity. In India, 6.73 m ha and in Rajasthan, 1.18 m ha of land is affected by salinity and sodicity (Sharma *et al.,* 2014). Salt affected soils occur to a lesser or greater extent in all the districts of the state, however, their nature is location specific. The main contributing factors for soil salinization are the highly impregnated salty layer in the soil profile, saline ground water coupled with high water table depth, seepage from canals and other water bodies causing a rise in water table, restricted surface and subsurface drainage and intrusion of sea-water into main land. In addition to these, considerable part of cultivated land is subjected to secondary and seasonal salinization due to irrigation with ground water of poor quality.

Availability of N, P, K, secondary and micronutrients may induce better germination of seeds and have better growth and development of roots may make the plants more capable of tolerating salt stress, particularly at the later stage of their growth. Plants also tend to absorb some quantities of salt constituents from soil solution and adjust their leaf-water potential and their quantities by developing internal resistance against salinity/sodicity. The diagnosis of salinity, sodicity and fertility status of soil and water resources along with their nutritional enrichment is of vital significance.

The detailed systematic information is not yet available about salinity, sodicity and fertility indices of the soils of the study area, which is essential for sustainable natural resource management. Therefore, an urgent need was felt for extensive and well planned study both in the field and laboratory to suggest appropriate management practices for better utilization of soils of this tract. Keeping all these point in view, the present investigation was undertaken with the following objectives: (i) Characterization and mapping of soils in the south eastern part of Jodhpur district (ii) To determine the salinity, sodicity and fertility indices of the soils and (iii) To suggest the appropriate measures for better utilization of soils of the study area.

Materials and Methods

Study area

The study area (south-eastern part of Jodhpur district) were lied in the agro-climatic zone IA (Arid North Western Sandy Plain) and IIB (Alluvial Plain of Luni Basin) in western part of Rajasthan which situated at 26°0' to 27°37' N latitude and 72°55' to 73°55' E longitude and semi-arid climate. Jodhpur district comprising of 15 tehsils *viz.,* Jodhpur, Balesar, Bawari, Bap, Bhopalgarh, Bilara, Lohawat, Luni, Osian, Phalodi, Piparcity, Shergarh, Denchu, Bapini and Tinvari. The location of the sites from where soil samples collected are marked in Fig. 1.

Data collection

One hundred sixty five sites in eighty eight villages of Bapini, Osian, Bawari, Tinvari, Jodhpur and Luni tehsils of south eastern part of Jodhpur district of Rajasthan were selected for soil sampling and one hundred sixty five geo referenced composite soil samples (0-15 cm depth) from cultivated fields irrigated with the tube wells/ open wells water and sixty three composite soil samples (0-15 cm depth) were also be collected from adjacent unirrigated fields with the help of auger during December, 2021. Approximately 0.5 kg soil was collected from each site in properly labeled polythene bags. Samples were air-dried, ground and passed through 2 mm sieve and store in labeled bags for analysis work. In general, sodium and chloride was found to be the most abundant cation and anion in underground water for irrigation in the study area. The range and mean values of pH, EC, SAR, RSC and SSP in underground water for irrigation was 7.04-8.73 (7.79), 0.30-16.89 (4.34) dS m^{-1}, 2.24-30.04 (9.06),

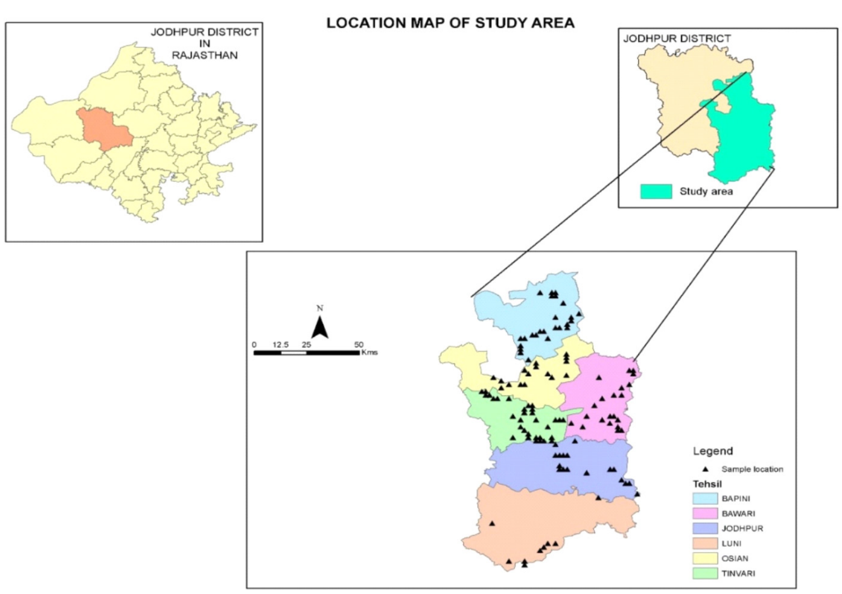

Fig. 1 Map showing sample collection sites

nil- 7.07 (0.21) me L^{-1} and 57.19-69.83 (64.76), respectively.

Data analysis

The collected soil samples were analyzed for pH, EC (1:2 soil water suspension), organic carbon, available phosphorus and potassium by using standard methods. Salinity, sodicity and fertility indices of soils were calculated by the methods suggested by Muhr *et al.* (1965) and Seth (1967) (Table 1, 2 and 3).

$$\text{Salinity index} = \frac{\text{\% of samples testing normal} \times 1 + \text{\% of samples testing tending to become saline} \times 2 + \text{\% of samples testing saline} \times 3 + \text{\% of samples testing highly saline} \times 4}{100}$$

$$\text{Sodicity index} = \frac{\text{\% of samples testing normal} \times 1 + \text{\% of samples testing sodic} \times 2 + \text{\% of samples testing very sodic} \times 3 + \text{\% of samples testing highly sodic} \times 4}{100}$$

$$\text{Fertility index} = \frac{\text{\% of samples testing low} \times 1 + \text{\% of samples testing medium} \times 2 + \text{\% of samples testing high} \times 3}{100}$$

Results and Discussion

Data presented in table 4 indicated that the soil pH value of south eastern part of Jodhpur district were ranged between 7.64 to 9.55 with the mean value of 8.70 and 7.52 to 9.36 with an average value of 8.47 for irrigated and unirrigated soils, respectively. The soil pH of study area varied from normal to highly alkaline. Accumulation of bases especially Na^+ under low rainfall conditions seems to be the primary reason for alkaline soil reaction. Similar results was also reported by Meena *et al.* (2006) and Gosavi and Chaudhari (2016).

The electrical conductivity of irrigated soils varied from 0.03 to 4.80 with an average value of 0.51 dS m^{-1}, while of unirrigated soils varied from 0.03 to 2.24 with the mean value of 0.30 dS m^{-1}.

Table 1. Limits for salinity and alkalinity groups (Muhr *et al.,* 1965)

Groups	Electrical conductivity (dS m^{-1} of 1:2 soil water suspension)	Classification	pH (1:2 soil water suspension)	Classification
A	<1.0	Normal	<8.0	Normal
B	1.0-2.0	Tending to become saline	8.0-8.5	Alkaline
C	2.0-3.0	Saline	8.5-9.0	Very alkaline (soil tending to become alkaline)
D	>3.0	Highly saline	>9.0	Highly alkaline

Table 2. Rating chart of salinity and alkalinity indices (Seth, 1967)

Index	Rating for salinity	Rating for alkalinity
<1.5	No salinity problem	No alkalinity problem
1.5-2.5	Mild salinity problem	Slight alkalinity problem
2.5-3.5	Moderate salinity problem	Moderate alkalinity problem
>3.5	Sever salinity problem	Sever alkalinity problem

Table 3. Rating chart for fertility groups (Muhr *et al.,* 1965)

Nutrient	Low	Medium	High
Organic carbon (%)	<0.5	0.50-0.75	>0.75
Available phosphorus (kg P_2O_5 ha ^{1})	<20	20-50	>50
Available potassium(kg K_2O ha ^{1})	<125	125-300	>300

The nutrient index <1.50 is low, 1.50 to 2.50 is medium and >2.50 is high

Table 4. Chemical parameters of soils of south-eastern parts of Jodhpur (Rajasthan)

Character	Irrigated soils					Unirrigated soils				
	pH	EC (ds m^{-1})	Organic carbon (%)	Available phosphorus (kg P_2O_5 ha^{-1})	Available potassium (kg K_2O ha^{-1})	pH	EC (ds m^{-1})	Organic carbon (%)	Available phosphorus (kg P_2O_5 ha^{-1})	Available potassium (kg K_2O ha^{-1})
Range	7.64-9.55	0.03-4.80	0.05-0.62	2.26-50.48	171.41-478.14	7.52-9.36	0.03-2.24	0.02-0.44	1.77-37.78	134.73-374.20
Mean	8.70	0.51	0.28	16.89	306.26	8.47	0.30	0.19	11.60	226.06
CV	3.96	137.54	51.34	55.04	19.42	4.22	132.31	62.96	63.94	26.07

The EC values of irrigated soils were higher as compared to unirrigated soils. The high EC values of irrigated soils might be due to irrigation with poor quality irrigation water and low-lying area. Beside this, low level of EC may be due to good drainage condition which favored the removal of released bases with percolating and drainage water. The results of the present investigation were in close conformity with the findings of Singh *et al.* (2012) and Choudhary *et al.* (2019).

The data presented in table 4 and Fig. 3, 4 and 5 revealed that organic carbon, available phosphorus and potassium status of irrigated soils were varied from 0.05 to 0.62 with mean value of 0.28 per cent, 2.26 to 50.48 with mean value of 16.89 and 171.41 to 478.14 with an average value of 306.26 kg ha^{-1} while, for unirrigated soils it were ranged between 0.02 to 0.44 with mean value of 0.19 per cent, 1.77 to 37.78 with an average value of 11.60 and 134.73 to 374.20 with mean value of 226.06 kg ha^{-1}, respectively. The organic carbon content of both irrigated and unirrigated soils had been found low. The low organic carbon content of these soils could be ascribed to occasional addition of organic material, scanty natural vegetation and poor decomposition due to low rainfall and rapid oxidation due to high summer temperature and wind erosion. These results get support from the findings of Kumar *et al.* (2011) and Choudhary (2022). While, the available phosphorus and potassium status of soils of south-eastern part of Jodhpur district was recorded low to medium and medium to high in both irrigated and unirrigated soils, respectively. The lower status of P in the soils might be due to the adoption of intensive cropping systems by the cultivators resulting in absorption of plant nutrients in higher amount. The present results were in close conformity with the findings of Kumar *et al.* (2017) and Mandal and Ghosh (2021).

The computed values of salinity and sodicity indices for irrigated and unirrigated soils were 1.96, 1.06 and 2.86, 2.49, respectively (Table 5). From these indices it can be inferred that both irrigated and unirrigated soils belong to mild salinity moderate sodicity and non-saline slight sodicity problems, respectively. Further, on the basis of pH and EC of irrigated and unirrigated soils of study area were also classified into six salinity and sodicity groups (Table 6 and Fig. 2) as suggested by Sehgal *et al.*(1987).

The majority of irrigated soils (66.66 per cent) fell under the VsM group (very slight salinity and moderate sodicity) whereas, 17.58, 9.70, 2.42, 3.03 and 0.61 per cent soils fell under the V_SSt (very slight salinity and strong sodicity), V_SS (very slight salinity and slight to negligible sodicity), SS (slightly saline and slight to negligible sodicity), SM (slightly saline to moderate sodicity), MS

Table 5. Frequency distribution, salinity and sodicity indices of soils

Parameters	Number of samples under each category	
	Irrigated soils	Unirrigated soils
EC (dS m^{-1})		
<1	140	60
1-2	15	2
2-3	7	1
>3	3	-
Salinity index	1.96	1.06
pH		
<8.0	1	5
8-8.5	50	28
8.5-9.0	85	24
>9.0	29	6
Sodicity index	2.86	2.49

Table 6. Salinity and sodicity hazard groups of soils of south-eastern part of Jodhpur (Rajasthan)

S.No.	Salinity, sodicity hazard groups	Symbol	Number of samples	Per cent of samples in each category
Irrigated soils				
1	V_SS	A	16	9.70
2	V_SM	B	110	66.66
3	VsSt	C	29	17.58
4	SS	D	4	2.42
5	SM	E	5	3.03
6	MS	F	1	0.61
Unirrigated soils				
1	V_SS	A	19	30.16
2	V_SM	B	37	58.73
3	V_SSt	C	6	9.52
4	SS	D	1	1.59

Where, V_SS: Very slight salinity and slight to negligible sodicity; V_SM: Very slight salinity and moderate sodicity; V_SSt: Very slight salinity and strong sodicity; SS: Slightly saline and slight to negligible sodicity; SM: Slightly saline to moderate sodicity; MS: Moderately saline to slight to negligible sodicity

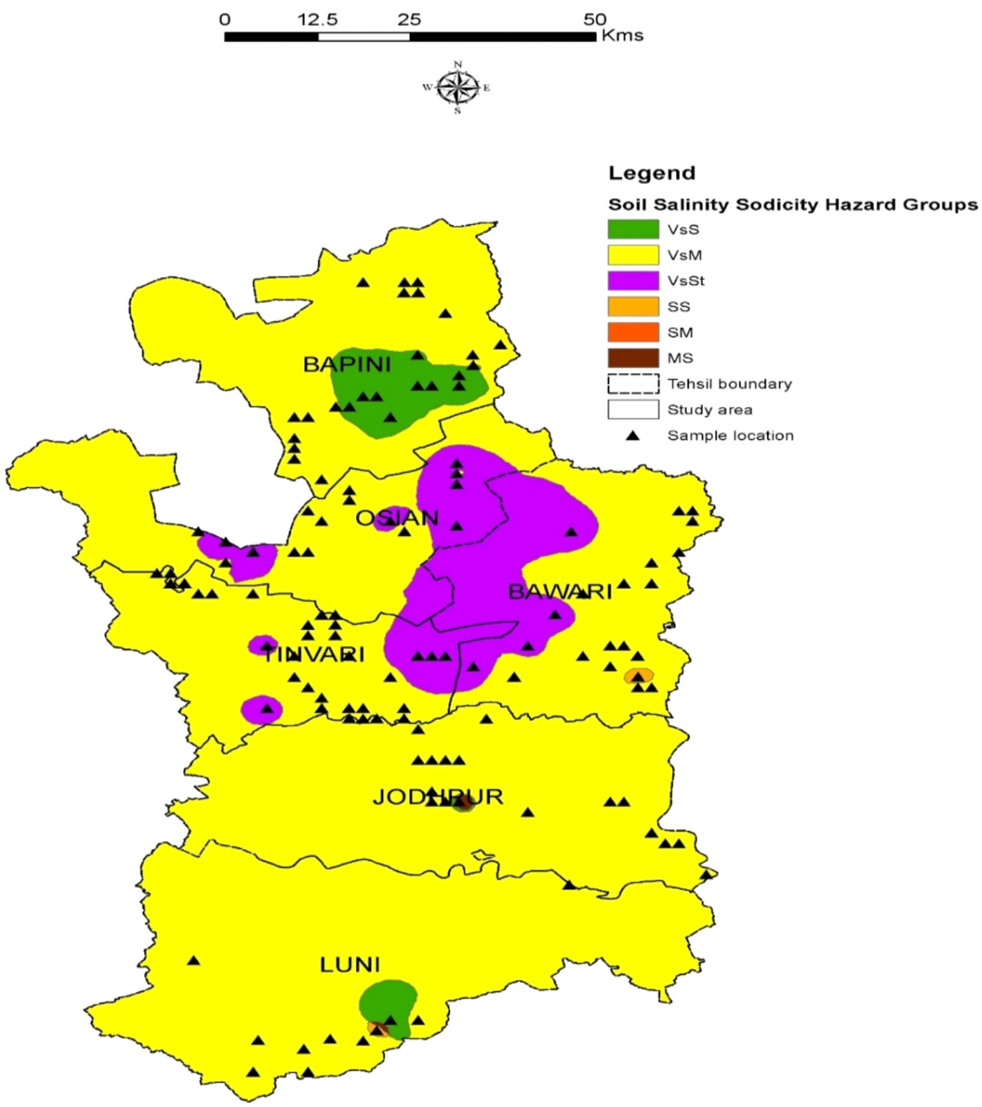

Fig. 2 Showing salinity and sodicity hazard groups of soils of south-eastern part of Jodhpur (Rajasthan)

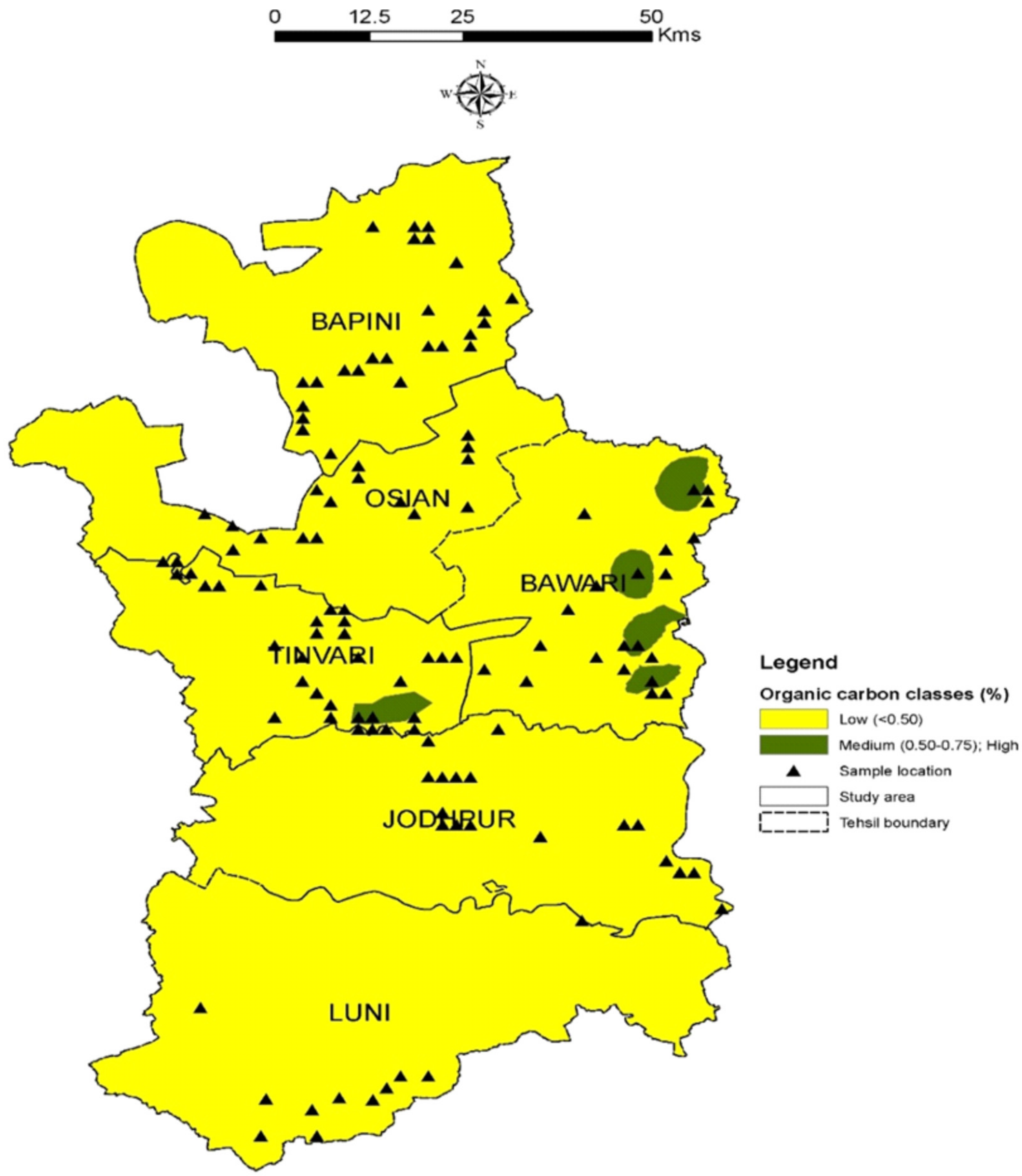

Fig. 3 Organic carbon status of soils

(moderately saline to slight to negligible sodicity) groups, respectively. While, in case of unirrigated soils, about 61.90 per cent soils fell under the V_SM group (very slight salinity and moderate sodicity) and 19.05, 17.46 and 1.59 per cent soils found under the VsSt (very slight salinity and strong sodicity), V_SS (very slight salinity and slight to negligible sodicity) and SS (Slightly saline and slight to negligible sodicity) groups, respectively.

The fertility index for organic carbon, available phosphorus and potassium were 1.08, 1.37 and 2.50 for irrigated soils and 1.00, 1.17 and 2.16 for unirrigated soils, respectively. Further, soils of the study area were found to be low in organic carbon and available phosphorus and medium to high in available potassium (Table 7 and Fig. 3, 4 and 5).

Conclusion

The majority of soils of study area were normal to alkaline in reaction and having mild salinity and slight to moderate sodicity problems. With repeat to fertility, the soils were found low in organic carbon, available phosphorus and medium in potassium. The continuous use of high SAR saline and highly alkali underground water for irrigation may lead to formation of sodic soils. Based on the quality characteristic of underground water for irrigation and soils three management

Table 7. Frequency distribution and fertility index of soils of south-eastern part of Jodhpur (Rajasthan)

Parameters	Number of samples under each category							
	Nutrient status						Fertility index	
	Low		Medium		High		Irrigated soils	Un-irrigated soils
	Irrigated soils	Un-irrigated soils	Irrigated soils	Un-irrigated soils	Irrigated soils	Un-irrigated soils		
Organic carbon (%)	151 (91.52)*	63 (100.00)	14 (08.48)	-	-	-	1.08	1.00
Available phosphorus (kg P_2O_5 ha^{-1})	105 (63.64)	52 (82.54)	58 (35.15)	11 (17.46)	2 (1.21)	-	1.37	1.17
Available potassium (kg K_2O ha^{-1})	-	-	83 (50.30)	53 (84.13)	82 (49.70)	10 (15.87)	2.50	2.16

*Figures in parenthesis represent per cent samples under each categories

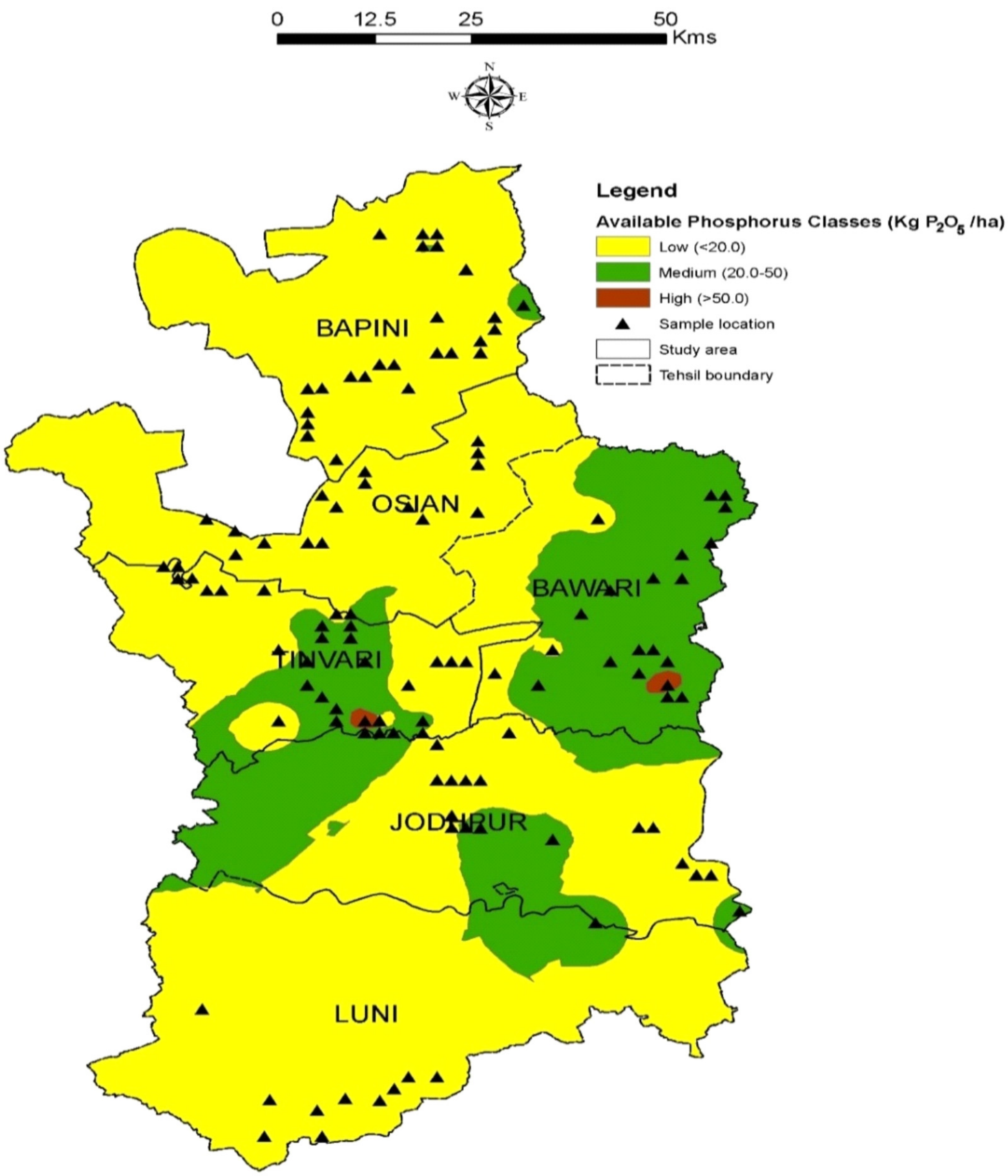

Fig. 4 Available phosphorous status of soils

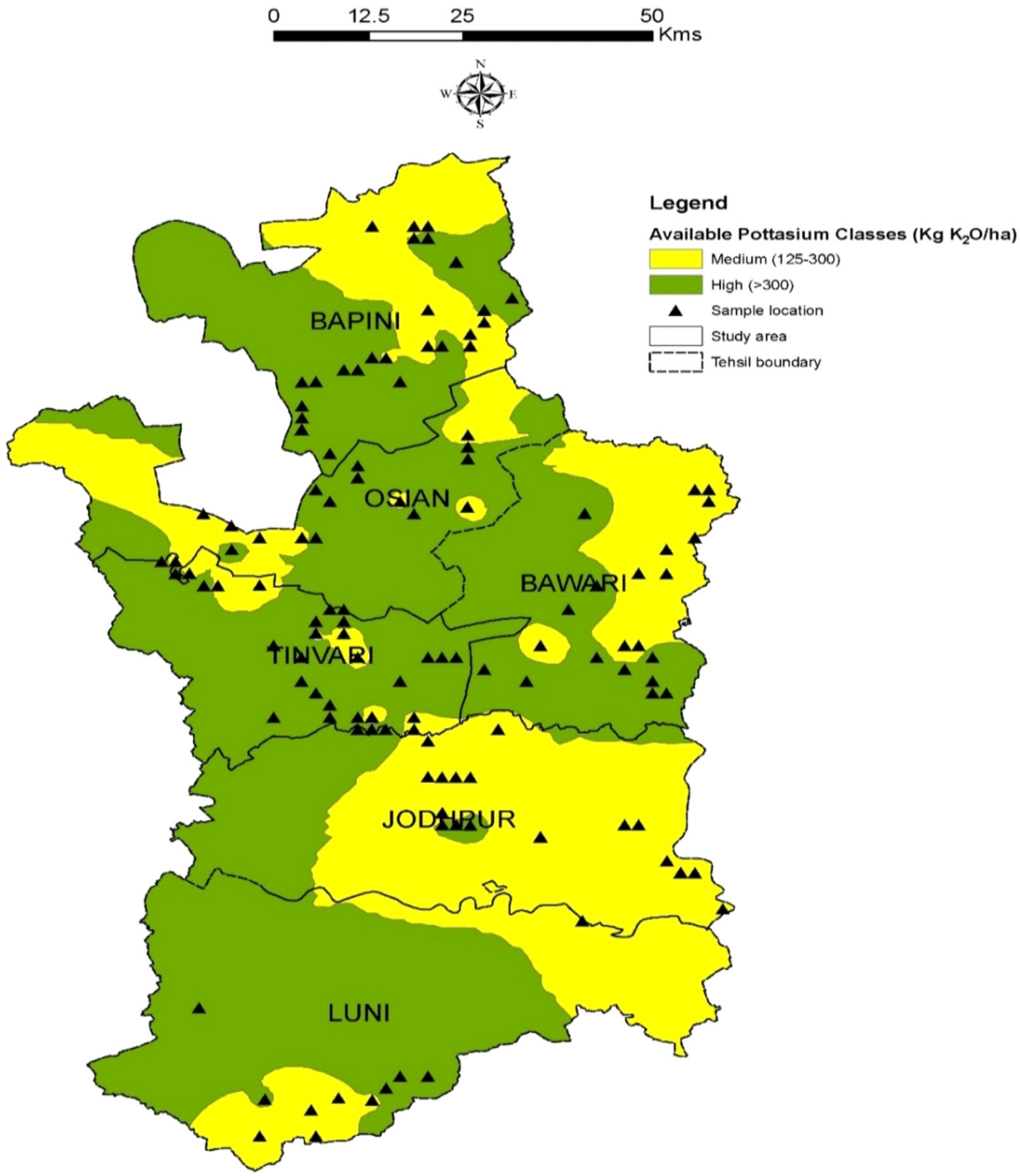

Fig. 5 Available potassium status of soils

units were identified for better utilization of underground water for irrigation and soils of the study area.

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