

DISTRIBUTION OF ELEMENTS IN SOME ARIDISOLS DEVELOPED ON QUATERNARY SEDIMENTS

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ABSTRACT

Seven pedons of Aridisols, developed on aeolian and alluvial plains, and formed during early Holocene to early Pleistocene in western Rajasthan were studied for the total elemental composition, their distribution and association of elements with each other and also with soil constituents. Results showed that Si was the most predominant element followed by Al, Fe, Ca, Mg, Na, K, Mn, Zn and Cu. The content of Al, Fe, Mg, Cu and Zn was found to increase in soils with increasing age of the landforms. The Aridisols developed on older landforms showed a higher concentration of Fe, Al, Mn, Mg, Cu and Zn in the B horizon of the profiles than A and C horizon, whereas these were uniformly distributed in soils developed on Holocene aged landforms. Correlation matrices revealed a variance control of finer fraction on the content of Al, Fe, Mg, and K.

INTRODUCTION

Aeolian and alluvial plains are the dominant landforms of the arid region of Rajasthan (Ghose et al., 1977) formed during quaternary. Varying degrees of pedogenic manifestations in the soil cover of these landforms substantiate the archaeological (Agrawal et al., 1978) and geomorphological (Singh and Ghose, 1977) evidences for the age of their evolution (Choudhari, 1987). During soil profile development, pedomorphological weathering leads to the differentiation in respect of content of secondary products and pattern in distribution of constituent elements with soil depth (Hodgson, 1963; Dankert and Drew, 1970; Evans and Adams, 1975). Varying degrees of weathering and transformation of clay minerals in soils developed from quaternary deposits of western Rajasthan were studied earlier (Choudhari and Dhir, 1982) but information on pattern of distribution of elements in soils developed from quaternary deposits is not known so far. Hence, the results of the elemental composition, their distribution and association with each other in some Aridisols developed on varying aged landforms are reported in this paper.

MATERIAL AND METHODS

Soil samples from each of the horizon of soils developed on varying aged landforms (Table 1) were collected for this study. Site characteristics and properties

of soils were reported earlier (Choudhari, 1987). Air dried 100-mesh passed soil samples were taken for total elemental analysis. Residue of sodium carbonate fusion and also of HF-HClO₄ digestion (Jackson, 1958) were dissolved in HCl. In the extract Fe, Mn, Cu, Zn, Ca, and Mg were determined by atomic absorption spectrophotometer Varion Techtron AA 120. Na and K were determined by flame photometer, whereas Si and Al by colorimetry (Jackson, 1958).

Table 1. Soils and age of the landforms

Landform	Landform Unit	Age of the landform	Soil series	Pedon No.
Aeolian plain	Dune	Early Holocene	Dune	1
	Inter-dune	Early Holocene	Shergarh	2
	Coarse textured plain with dunes	Latest Pleistocene	Chirai	3
Alluvial plain	Accumulative upland	Mid-Pleistocene	Gajsinghpura	4
	Accumulative lowland	Mid-Pleistocene	Asop	5
	Flat land	Early Pleistocene	Pipar	6
	Flat plain	Early Pleistocene	Pali	7

RESULTS AND DISCUSSION

Distribution of elements

Silica, the most abundant element in soils, was highest in the Holocene age soils than other. Aluminium, which was next in abundance, varied between 6 to 16%, followed by Fe (3 to 6.4 % Fe₂O₃), CaO (0.9 to 4.8%), Na₂O (1.2 to 2.8%), MgO (1.0 to 2.7%), K₂O (0.75 to 1.97%), Mn (560 to 1000 ppm), Zn (53 to 141 ppm) and Cu (36 to 94 ppm). Further, in Holocene age soils, there was little evidence for any change in composition with depth, whereas the contents of Al, Fe, Mg, Cu and Zn increased with depth and also with increasing age of the landforms from latest Pleistocene to early Pleistocene. However, the contents were maximum in the B horizon of the soils (Fig. 1). Silica showed a concentration in the soils (Fig. 1) which could be due to translocation of elements released during weathering of the minerals, and thence the relative abundance of quartz in surface. Moreover, the weathering of quartz is very low (Jackson and Sherman, 1953) as compared to other minerals. Beside this, the concentration of Al, Fe, Mg, Mn, Cu and Zn in B horizon of older surface could either be due to enhanced weathering or illuviation of elements along with the finer particles as structural components (Dankert and Drew, 1970) or as coatings (Tan, 1982) or as discrete oxide particles (Kalbasi and Racz, 1978). It is also interesting to note that the content of Al, Fe, Mg, Zn, and Cu increased in B horizon with increasing age of the landforms. Hodgson (1963) and Yaalon et al. (1974) reported a concentration of trace elements in B horizon of many soils and attributed to the advanced weathering.

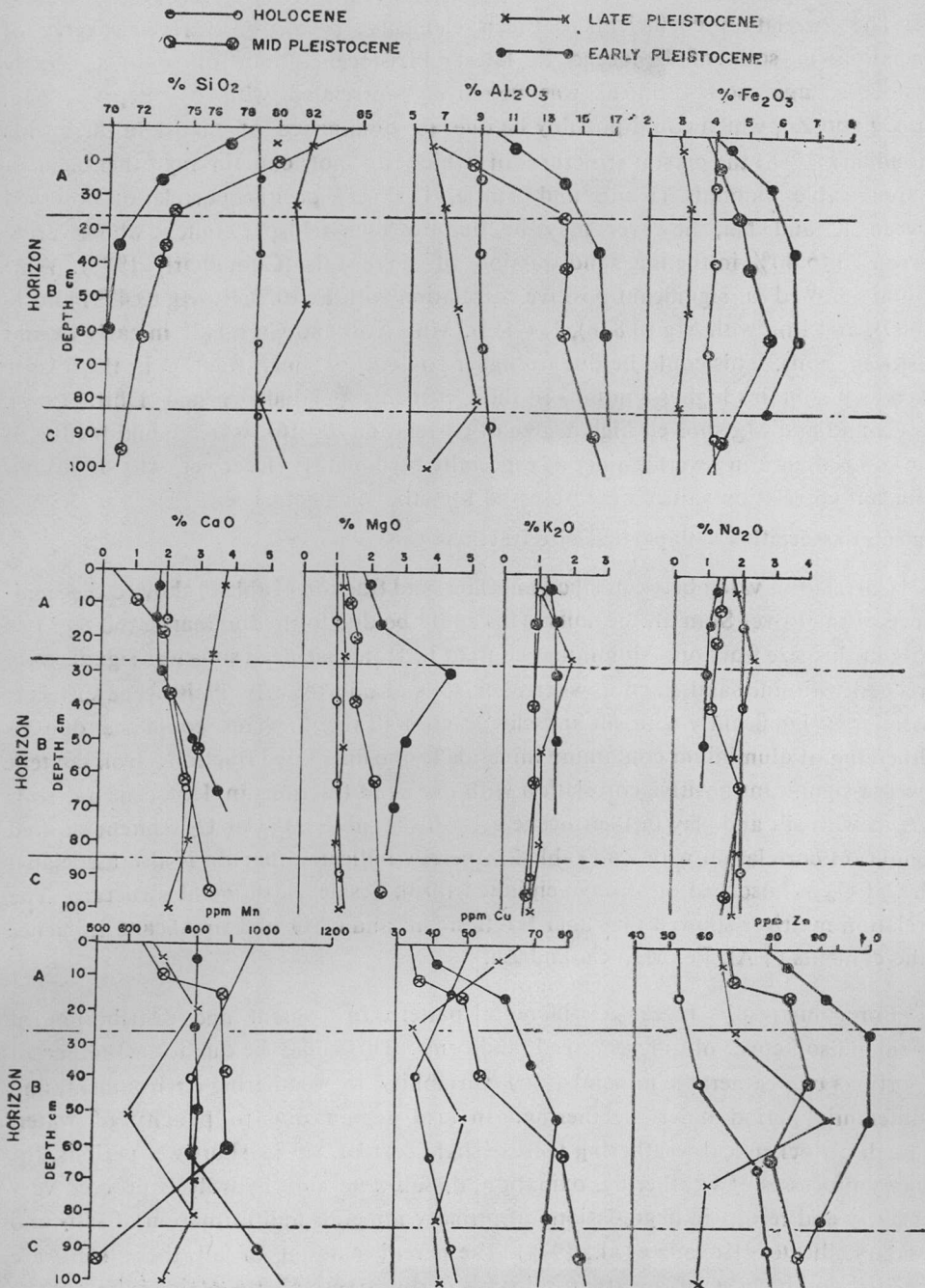


Fig. 1. Distribution pattern of elements in Aridisols in different horizons

Elemental associations

The correlation coefficients between elements revealed a variable degree of associations in soils of Holocene to latest Pleistocene and of mid to early Pleistocene age soils. Silica was negatively correlated with Al, Fe, Ca, Mg, Mn, Cu and Zn, which could possibly be due to dominance of quartz in these soils (Choudhari, 1988) the crystal structure of which do not contain any other element in appreciable amounts (Kaith and Tuttle, 1952). A positive correlation observed between K and Na, however may be due to high feldspar content which varied between 30 to 40% in the fine sand fraction of these soils (Choudhari, 1988). Aluminium showed a significant positive correlation with Fe (0.763), Mg (0.479) and K (0.409), and iron with Mg (0.826), K (.451), Mn (.416) and Cu (.442) in early to mid Pleistocene soils. This could be due to higher content of finer fraction in the former soils which contains higher amounts of these elements (Choudhari and Dhir, 1982). The Ca and Mg showed high degree of correlation (0.616), which could be due to their co-occurrence in several minerals especially carbonates (Deer et al., 1966) No significant correlation values were observed for other elements.

Elemental association with particle size fractions

Correlation value between silica and fine sand fraction (Table 2) showed the significance of sand over Si in all the soils. This could be due to predominance (60-80%) of quartz in this size fraction. Aluminium content in Holocene aged soils was significantly correlated with fine sand fraction whereas in soils of mid to early Pleistocene surfaces, it correlated significantly with silt and clay fraction (Table 2). This could be due to weathering of aluminium containing minerals to the finer sized fractions. Iron content showed a significant positive correlation with fine sand fractions in Holocene age soils where as with silt and clay in Pleistocene age soils (Table 2). CaCO_3 content showed a significant correlation with Zn (Table 2), thereby indicated that Zn is also associated with CaCO_3 as adsorbed or as coprecipitated form, beside in mineral structure. The correlation matrices showed that finer fraction (silt and clay) had significant influence on the contents of Al, Fe, Mg, Cu and Zn.

Foregoing results reveal a differential pattern in content and distribution of elements in soil cover of different aged landforms. This could be due to (a) different proportions of weatherable minerals, (b) variability in weathering environment, and (c) differential period under weathering. In arid region due to paucity of water, although pedochemical weathering is to a slight extent, yet in short wet periods, the ordinary processes of weathering, oxidation, dissolution and hydrolysis proceed very intensively and result in degradation of primary minerals and formation of salts and secondary silicates (Kovada et al., 1979). The parent material of all these soils are comprised dominantly of resistant minerals and nearness of the plains rules out the first two causes of differentiation of elements in soils. Therefore the differential period under weathering seems to be the factor for differentiation. The distinct variation in

Table 2. Correlation coefficient (r) matrix of fractions and elements content in aeolian and alluvial plain soils

Soil fractions	SiO ₂	Al ₂ O ₃	Fe ₂ O ₃	CaO	mgO	K ₂ O	MnO	Na ₂ O	Cu
Aeolian plain soils									
Fine sand	.896	.384	.665	-.535	-.702	-.205	.402	.489	-.164
Very fine sand	.114	-.454	-.687	.385	.404	.339	-.331	-.399	.243
Coarse silt	-.192	-.134	-.428	.275	.567	.386	-.136	-.186	-.160
Fine silt	-.043	-.406	-.463	.391	.537	.365	-.467	-.214	-.173
Coarse clay	.053	-.425	-.677	.509	.276	.272	-.453	-.367	-.075
Fine clay	-.222	-.195	-.263	.284	.860	.646	-.264	-.413	.278
CaCO ₃	-.484	-.124	-.351	.925	.702	-.191	-.250	-.561	.142
Alluvial plain soils									
Fine sand	.446	-.591	-.661	-.039	-.622	-.409	-.034	-.565	-.474
Very fine sand	.284	-.391	-.182	-.054	.001	-.456	.016	.586	-.343
Coarse silt	-.127	.438	-.600	-.140	.613	.201	.260	-.327	.128
Fine silt	-.326	.657	.813	-.114	.811	.280	.126	-.308	.359
Coarse clay	-.544	.671	.609	.195	.588	.088	.021	-.556	.227
Fine clay	-.468	.270	.305	.354	.558	-.412	-.364	.104	.278
CaC ₃	-.800	.118	-.391	.990	-.181	.705	-.668	-.179	.266

Significance at .1 = .360; at 0.01, 537 and at .001 = 0.652