The Stability And Weathering Of Soil Minerals In Various Geomorphic Units In The Northeastern Region Of Uttar Pradesh

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ABSTRACT

Seven pedons were used in a methodical investigation of the weathering and stability of soil minerals of various geomorphic units in the northeastern region of Haryana. The soil minerals were arranged in order of stability, or alternatively, the weatherability of each mineral was forecast using the thermodynamic model that Rai and Lindsay (1975) developed to make generalizations about the behavior of soils, i.e., the physical properties in relation to the types of clay minerals present to evaluate the effects of different environmental conditions on the soil formation process. Plotting the mineral solubility lines in terms of activities of the species common to the minerals under discussion was done using the equation of the chemical species as they relate to the equilibrium constants. Equations demonstrating the link between log (Al+3) and –log (H SiO) for the minerals were created, and stability diagrams were built, in accordance with the methodology described by Rai and Lindsay in 1975.The stability order of various minerals in the study area, derived from the models, was grouped in stability groups (increasing order) for the purpose of weathering stability of primary minerals under various environments: low albite, anorthite, muscovite, microcline, quartz; low albite, anorthite, microcline; muscovite, quartz; anorthite, low albite, microcline, muscovite, quartz; Low albite, muscovite, anorthite, microcline, quartz; muscovite, low albite, anorthite, microcline, quartz. Secondary mineral stability was less variable, with kaolinite, illite, and chlorite having the highest order of stability among the minerals in the various geomorphic units.

Keywords*: Mineral weathering,stability,geomorphicunits,Haryanasoils*

INTRODUCTION

The most valuable natural resource in each country and the foundation of industry is its soil. The great majority of four essential human needs—food, fuel, fiber, and shelter—come from soil. Thus, a prerequisite for agricultural planning and development initiatives is a deep understanding of the soil. In order to estimate the general degree of soil weathering and its natural nutrient (soil fertility) reserve for wise use, soil minerals can be ranked in order of stability.With the

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aforementioned in mind, a methodical investigation on the weathering and stability of mineral soils from various geomorphic units in the northeastern regions of Haryana was conducted.Rai and Lindsay's (1975) thermodynamic model was utilized to forecast the weathering and stability of the minerals in the research region.

MATERIALSANDMETHODS

The research region is mostly the districts of Panchkula, Ambala, Yamuna Nagar, and Kurukshetra in the state of Haryana. It is located between 76o31' to 76o35'Elongitude and 30o03' to 30o57'Nlatitude (Fig.1). Except for the steep regions, most of this region is covered with quaternary deposits.Shiwalik Foothills are low lying hill ranges in the northeastern half of the study area. The Indo-Gangatic alluvial plains, which were created by the deposition of alluvial material in the recent Pleistocene, occupy the southern portion.The area's overall terrain is flat in the lower half and undulating in the higher half. The region mostly slopes north to south. There are two rivers in the area: the Yamuna and the Ghaggar.The region has a subtropical, semi-arid, continental, and monsoonal climate with strong seasonal fluctuations, scorching summers and chilly winters, and erratic rainfall.The area's rainfall is extremely irregular and inconsistent.The average annual rainfall is between 578 and 1486 mm, with July through September accounting for 70% of the total.
The hardness, cleavages, coefficient of expansion, first crystal fractures, and solubility in a particular environment are only a few of the many variables that affect a mineral's stability (Boul et al., 1980; Haseman and Marshall, 1945).Visual interpretation of FCC (band 2, 3, and 4) and IRS-1B satellite images at a 1:250,000 scale was done utilizing picture components and ground reality.
Following comprehensive field surveys, 1:250,000 geomorphic and soil association maps were created. Twenty-two pedons were identified based on the geomorphic soil connection developed in the region; seven of these pedons were selected (Fig. 2) for the current weathering stability investigation. Following conventional protocols, the physico-chemical characteristics of the pedon sites were investigated (Jackson, 1975).

In order to predict weathering and stability of minerals, the Rai and Lindsay (1975) thermodynamic model was used to prepare stability diagrams for primary and secondary aluminosilicate minerals. Equations demonstrating the relationship between log (Al^{+3}) and –log (H_4SiO_4) using Gibb's standard free energy formation (Go) for the minerals under different environments were used. Various minerals from the research region, gathered from the models, were categorized.

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RESULTSANDDISCUSSION

Tables 1 and 2 provide comprehensive details and pertinent physical-chemical characteristics of the experimental pedons.Colors of pedons 2, 4, and 7 ranged in color from yellowish brown to dark yellowish brown with values and chromas ranging from 2 to 6.Pedons 1, 3, and 6 on the other hand ranged in color from reddish brown to dark reddish brown. The color of the Pedon 5 ranged from dark brown to yellowish brown. These may have different colors because of differences in their parent material, organic materials, geometric units, and drainage conditions.

The soils of Shiwaliks pedons 2 and 3 were mediumtomoderatelyheavytextured(loamtoclayloam) and pedon 1 was light textured (loamy sand to sandy loam), where as that of the alluvial plains (pedons 6, 7) were found light to moderately heavy textured (sandy loam to clay loam). The structure of soils of the study area (Shiwalik hills top & slope, piedmont plains and alluvial plains) were weak to medium, fine to coarse, sub-angular blocky.

Pedons 1 and 5 had slightly acidic to neutral soils (6.0–7.35), pedons 2, 3, and 4 had moderately alkaline soils (7.8–8.3), while pedons 6 and 7 had severely alkaline soils (8.3–9.4). The surface horizons of pedon 1 (1.20%), medium in pedons 3, 6, 0.51%, and pedon 7 (0.64%) had greater levels of organic carbon (OC), whereas pedon 2 (0.14%) and pedon 5 (0.35%) had lower levels. With the exception of pedons 5 and 7, the OC dropped with depth in every pedon. It was discovered that the CEC in pedalons 1, 4, and 5 was lower (3.10–9.70) than in pedalons 2, 3, 6, and 7 (9.30–26.80).

The study area's mineral weathering and stability were forecast using the thermodynamic model created by Rai and Lindsay in 1975. The mineral solubility lines were shown in terms of the activities of the species that are the montominerals under discussion using the chemical species' equations related to the equilibrium constants.Eqquations illustrating the link between log (Al+3) and –log (H4SiO4) for the minerals were produced, and stability diagrams were created, in accordance with the methodology of Rai and Lindsay (1975) (Fig. 3-6).

For weathering and stability of primary and secondary minerals under different environments, the stability orders of different minerals of the study area (Fig. 3-6) obtained through the models (curves) were

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Table1.Generalinformationabouttheexperimentalpedons

Horizon	Depth (cm)	Colour moist	Texture	pH (1:2)	EC(1:2) dS/m	O.C. (%)	CEC cmol (p+) kg	ExchangeableCations(cmol(p+)kg^{-1})			
								Ca^{++}	Mg^{++}	Na^{+}	K^{+}
Pedon-1 ShiwalikHill Top:LoamySk eletal,Typ icUdorthent											
AI	0-18	5 YR 2/2	SiL	6.40	0.53	1.20	9.70	5.25	3.80	0.12	0.42
CI	18-41	5YR3/3	SL	6.70	0.36	0.81	6.30	2.80	3.00	0.10	0.38
CII	41-90	5YR4/6	SL	6.60	0.36	0.40	3.95	2.50	0.80	0.08	0.22
Pedon-2ShiwalikHillSlope:Fineloamycalcareous,TypicUdorthent											
A1	0-41	10YR4/3	CL	8.45	0.37	0.14	14.49	8.00	5.60	0.19	0.13
AC	41-70	10YR4/3	L	8.25	0.44	0.15	9.61	7.70	1.60	0.12	0.09
CI	70-90	10YR4/4	SCL	8.55	0.35	0.27	14.71	8.10	5.70	0.24	012
CII	90-127	10YR4/4	SCL	8.50	0.34	0.10	13.43	10.60	2.84	0.51	0.07
Pedon-3ShiwalikHill(Slope):LoamySkeletal,calcareous,TypicUdorthent											
AI	0-13	10YR3/3	S	7.85	0.85	0.56	15.20	7.00	7.40	0.15	0.38
CI	13-48	10YR3/3	S	8.15	1.70	0.09	26.80	6.10	20.10	0.31	0.16
CII	48-86	10YR4/3	S	8.20	1.00	0.05	22.80	10.30	11.20	0.40	0.32
Pedon-4ShiwalikHillValley:Coarseloamy,calcareous,TypicUdipsamment											
AI	0-23	10YR3/3	S	8.40	0.39	0.19	7.83	4.10	3.20	0.12	0.084
AC	23-53	10YR3/3	S	8.65	0.31	0.11	6.70	4.20	2.10	0.12	0.096
C	53-106	10YR4/3	S	8.65	0.29	0.10	6.70	4.00	2.40	0.11	0.072
2C	106-190	10YR4/2	SL	8.70	0.28	0.06	9.20	5.80	3.0	0.14	0.110
Pedon-5UpperPiedmontPlain:Coarseloamy,TypicUdipsamment											
Ap	0-29	10YR4/3	S	6.50	0.26	0.35	3.90	2.30	1.30	0.12	0.055
CI	29-57	7.5YR4/4	S	6.70	0.18	0.10	3.10	1.80	1.00	012	0.048
CII	57-89	7.5YR4/4	S	6.80	0.15	0.13	3.80	2.50	1.00	0.08	0.042
Pedon-6ActiveFloodPlainGhaggar:Coarseloamy,calcareous,TypicUstorthent											
Ap	0-26	7.5YR3/2	SCL	8.05	0.94	0.51	15.00	12.10	2.00	0.26	0.29
CI	26-54	5YR3/3	SL	8.90	0.59	0.21	12.00	9.10	2.00	0.22	0.13
CII	54-86	5YR3/3	SL	8.85	0.52	0.13	10.90	7.00	1.50	0.12	0.12
2CI	86-112	7.5YR4/4	SL	8.90	0.47	0.10	10.20	8.00	1.00	0.18	0.12
2CII	112-190	5YR4/4	SL	8.10	0.46	0.10	13.10	5.00	7.00	0.40	0.15
3C	190-240	5YR4/4	LS	8.80	0.44	0.09	9.30	5.70	2.50	0.84	0.12
Pedon-7OldAlluvialPlainGhaggar:Fineloamy,calcareous,FluventicHaplustept											
Ap	0-17	10YR4/4	SL	8.30	0.71	0.64	11.27	8.50	2.50	0.24	0.25
AB	17-28	10YR4/3	SCL	8.60	0.44	0.21	11.10	7.00	3.50	0.20	0.29
B2I	28-50	7.5YR4/4	SCL	8.80	0.39	0.33	15.30	11.10	3.00	0.38	0.22
B2II	50-82	7.5YR4/4	SCL	9.00	0.40	0.28	16.40	10.00	5.00	1.02	0.13
B2III	82-121	5YR3/4	SCL	9.10	0.55	0.13	13.00	6.90	4.00	1.76	0.18
BC	121-134	5YR4/4	SL	9.10	0.29	0.12	12.75	8.00	3.50	0.72	0.14
C	134-165	10YR4/3	SL	9.15	0.31	0.10	12.30	6.00	4.50	0.82	0.12
2C	165-210	5YR3/4	SCL	9.15	0.38	0.08	16.30	10.50	4.00	1.16	0.18

grouped in five categories (in increasing order of their stability)

1. Lowalbite,anorthite,muscovite,microcline, quartz
2. Lowalbite,anorthite,microcline,muscovite, quartz
3. Anorthite,lowalbite,microcline,muscovite, quartz

Lowalbite,muscovite,anorthite,microcline,

1. Muscovite,lowalbite,anorthite,microcline, quartz

Yadav (1999) andAhuja *et al.* (1993) reported the difference in the stability order of primary and secondarymineralsduetodifferentsoilenvironments *i.e.* pH, drainage, physiographic position and mineral composition. Thestabilityofsecondarymineralsvariedlesser

Table3.Weatheringandstabilityofprimaryandsecondaryminerals

GeomorphicUnits	Pedon No.	Depth (cm)	Stabilityofprimaryminerals (increasingorder)	Stabilityofsecondaryminerals (increasingorder)
Shiwalik hills(Top)	1	0-18	Anorthite,lowalbite,microcline,muscovite,quartz.	Chlorite,illite,kaolinite
Shiwalikhills(Slope)	2	0-41	Muscovitelowalbite,anorthite,microcline,quartz.	Chlorite,illite,kaolinite
Shiwalikhills(Slope)	2	70-90	Anorthite,lowalbite,muscovite,microcline,quartz	Chlorite,illite,kaolinite
Shiwalikhills(Slope)	3	0-13	Anorthite,lowalbite,muscovite,microcline,quartz	Chlorite,illite,kaolinite
Shiwalikhills(Slope)	3	13-48	Lowalbite,muscovite,anorthite,microcline,quartz	Chlorite,illite,kaolinite
Shiwalikhills(Valley)	4	0-23	Lowalbite,anorthite,muscovite,microcline,quartz	Chlorite,kaolinite,illite.
Shiwalikhills(Valley)	4	23-53	Anorthite,lowalbite,muscovite,microcline,quartz	Chlorite,illite,kaolinite
Piedmontplains(Upper)	5	0-29	Lowalbite,anorthite,microcline,muscovite,quartz	Chlorite,illite,kaolinite
Piedmontplains(Upper)	5	29-57	Anorthite,lowalbite,microcline,muscovite,quartz.	Chlorite,illite,kaolinite
Activefloodplains(Ghaggar)	6	0-26	Lowalbite,anorthite,muscovite,microcline,quartz	Chlorite,illite,kaolinite
Activefloodplains(Ghaggar)	6	26-54	Lowalbite,anorthite,muscovite,microcline,quartz	Chlorite,illite,kaolinite
Oldfloodplains(Yamuna)	7	0-17	Lowalbite,anorthite,microcline,muscovite,quartz	Chlorite,illite,kaolinite
Oldfloodplains(Yamuna)	7	134-165	Lowalbite,anorthite,muscovite,microcline,quartz	Chlorite,illite,kaolinite

andorderofstabilityofmineralsindifferentgeomorphic units is given inTable 3 in increasing order as chlorite, illite, and kaolinite. The stability of minerals was influenced by mineralogical composition and geomorphic positions.RaiandLindsay(1975)constructedthestability diagram for different primary and secondary minerals and reported that pH from 6.0 to 8.0 did not change the relative stability of the primary minerals.According to them secondary clay minerals are more stable under alkaline environments than under acidic environments. Themostsubstantialincreaseinstabilitygoingfroman acidic to an alkaline environment was for chlorite

CONCLUSIONS

The models produced five main orders (in increasing order) based on the weathering stability of primary minerals: low albite, anorthite, muscovite, microcline, quartz; low albite, anorthite, microcline; muscovite, quartz; anorthite, low albite, microcline, muscovite, quartz; low albite, muscovite, anorthite, microcline, quartz; muscovite, low albite, anorthite, microcline, quartz; muscovite, low albite, anorthite, microcline, quantz.Secondary mineral stability varied less, with chlorite, illite, and kaolinite having the highest order of stability among the minerals in the various geomorphic units.In comparison to the piedmont plains (upper), active flood plains,

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shiwalik hills (tops & slopes), and old alluvialplains, theseveralratios and other characteristics, coupled with the stability result, showed that the soils of the valley, recent flood plains, and ancient alluvialplains were more weathered and pedologically better developed.

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