

Physico-Chemical Status of Soil between Khadwa to Amnota, Sewa River Catchment, Kathua District, J & K State

AMITA FOTEDAR AND ANIL KUMAR RAINA

*Department of Environmental Science, Jammu University
Jammu 180001, India*

Abstract

Four stations were selected in Sewa river catchment, district Kathua, J & K for soil studies for 2 years on monthly basis. Geologically and from pH studies, the soils have revealed acidic character. The soils are mostly clay-loam in texture. Climatically, Sewa catchment for most of its parts is barren and soil moisture is accounted for from snow cover and frequent rains for most of the months of the year. Moisture ranges between 2.2 to 20.4% in all profiles and results in high ingress of water. The loss of nutrition among SiO₂, Al₂O₃, TiO₂, Fe₂O₃, CaO, MgO, Na₂O and K₂O and MnO by chemical analysis was found for TiO₂, Fe₂O₃, CaO, MgO and no major fluctuation was revealed for SiO₂, Na₂O and K₂O. Al₂O₃ and MnO get added to composite soils because of excessive erosion, usually common in most of the catchments in the Himalayan terrain. These studies show that soils of catchment area were moderately to highly degraded and prone to soil erosion, landslides and rock falls—leading ultimately to loss of nutrients essential for maintaining the fertility of the soil. The catchment areas should properly be forested, planted with long rooted grass and vetiver grass to control erosion. Various land management practices, such as mixed cropping, inter-cropping, strip cropping, rotational cropping, mulching, application of organic manures will go a long way to reduce soil erosion and conserve sub-soil moisture effectively.

Key words : Soil of Sewa river catchment, Kathua district, Erosion, Measures, Nutrition loss.

The soil is a natural body of mineral and organic constituents, differentiated into horizons of variable depth, which differs from the material below in morphology, physical make-up, chemical properties, composition and biological characteristics (Joffe 1949). Soil, a live and dynamic component of ecosystem, is one of the important natural resources required for the growth of land plants, the essential supply of water and the nutrients for the plants are available from it. The physical and chemical characteristics of the soil determine the type of vegetation which can be supported by it. The top layer of the soil is a vital component, since all the nutrients required by the plants are present in this layer. It is the source of 13 elements out of 16 elements essential for the plant growth. The 12 out of these 13 elements originate in the parent rocks from which it is derived. If the soil is well managed, its fertility is not only renewable but also improvable. If not, then the soil can be permanently damaged or irretrievably lost. Forest soils serve as a media for the sustenance of forest vegetation. The state of Jammu and Kashmir has in all seven types of soils, namely Udalfs, Orthents, Ochrepts, Ochrepts-

Orthents, Ochepts-Orthents-Udalfs, Udolls and soils under glaciers and snow caps. The Sewa river catchment has the Ochrepts type of soil (Fotedar 2006).

The knowledge of physico-chemical composition of the soil and its variation during the different parts of the year is pre-requisite for the proper utilization and management of soil. Since no study has been carried out in respect of soils of Sewa catchment so far, it is thus important to collect the primary data about soils in different profiles. The data need to be in respect of texture, chemical composition, soil moisture, pH, high and low altitude variation because of erosion and loss of nutrition, all these were studied in detail in the present paper. The four stations in the Sewa catchment were included in the present study, namely Khadwa, Chandel, Drabal and Amnota, all situated in Kathua district, J & K state.

(The authors are highly thankful to the Head of the Department of Environmental Sciences, Jammu University, Jammu for giving the laboratory facilities for the analytical work used in this paper).

Table 1. Mean monthly percentage values of soil texture of four stations in the Sewa catchment, Kathua district, J & K from January 2002 to December 2004. All the readings represent the average of 2 years.

Stations	Texture separates	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average
Khadwa (1)	Coarse sand	13.7	9.3	16.7	16.2	13.0	10.0	13.4	15.8	12.8	11.2	15.1	15.1	13.5
	Fine sand	20.6	15.8	11.9	10.4	12.0	11.3	15.9	16.1	19.0	20.0	23.2	17.9	14.2
	Silt	29.9	34.8	35.2	35.4	45.8	38.8	31.0	26.5	19.8	29.8	21.9	29.0	34.0
	Clay	17.8	19.9	18.5	20.5	15.2	27.0	19.1	17.1	13.8	17.9	18.6	24.1	19.1
	Loam	18.0	20.2	17.7	17.5	14.0	12.9	20.6	24.5	34.6	21.1	21.1	13.5	19.2
Chandel (2)	Texture class	Clay-loam	Clay-loam	Clay-loam	Clay-loam	Clay-loam	Clay-loam	Clay-loam	Clay-loam	Clay-loam	Clay-loam	Clay-loam	Clay-loam	Clay-loam
	Coarse sand	12.0	10.5	10.4	12.2	12.0	10.1	13.2	11.7	8.7	9.1	9.2	9.3	10.7
	Fine sand	16.3	14.6	11.4	10.6	12.5	12.5	15.1	16.2	12.6	12.1	16.3	18.1	14.0
	Silt	34.9	38.8	43.6	44.6	41.1	42.6	36.3	26.5	23.7	28.6	38.8	28.4	35.7
	Clay	18.2	20.7	19.9	16.9	19.8	19.1	16.9	19.4	19.1	20.0	18.7	28.4	19.8
Drabal (3)	Loam	18.6	15.4	14.7	15.7	14.6	15.7	18.5	26.2	35.9	30.2	17.0	15.8	19.8
	Texture class	Clay-loam	Clay-loam	Clay-loam	Clay-loam	Clay-loam	Clay-loam	Clay-loam	Clay-loam	Clay-loam	Clay-loam	Clay-loam	Clay-loam	Clay-loam
	Coarse sand	12.8	12.9	12.2	13.5	12.5	9.6	13.5	12.5	11.2	8.3	9.0	14.2	11.9
	Fine sand	17.5	9.9	11.4	9.4	12.7	10.9	16.0	15.2	13.9	12.8	18.4	16.8	13.8
	Silt	35.0	36.6	39.9	41.5	41.2	45.9	35.8	27.2	25.8	32.0	37.9	30.7	35.7
Amnota (4)	Clay	15.8	19.4	22.1	18.0	18.1	16.0	20.5	17.1	15.6	21.0	19.0	18.3	18.4
	Loam	18.9	21.2	15.0	17.5	15.5	17.6	14.0	28.0	33.5	25.5	15.7	20.0	20.2
	Texture class	Clay-loam	Clay-loam	Clay-loam	Clay-loam	Clay-loam	Clay-loam	Clay-loam	Clay-loam	Clay-loam	Clay-loam	Clay-loam	Clay-loam	Clay-loam
	Coarse sand	13.5	15.9	17.1	13.7	11.5	12.5	12.0	10.2	9.9	11.2	15.2	12.5	12.9
	Fine sand	20.8	19.3	10.9	16.3	16.6	16.2	16.5	21.7	15.0	20.0	23.2	19.3	17.9
	Silt	29.0	27.9	35.8	28.2	31.8	21.7	28.6	33.2	27.2	29.8	21.9	19.0	27.8
	Clay	18.7	19.0	19.2	19.7	23.3	20.9	15.6	18.9	17.2	17.9	18.6	14.6	18.6
	Loam	18.0	17.9	17.0	22.1	17.0	28.7	27.3	16.0	30.7	21.1	21.1	34.6	22.6
	Texture class	Clay-loam	Clay-loam	Clay-loam	Clay-loam	Clay-loam	Clay-loam	Clay-loam	Clay-loam	Clay-loam	Clay-loam	Clay-loam	Clay-loam	Clay-loam

Methods

Soil samples were collected from four different sampling stations of Sewa watershed representing the higher elevations (*in-situ* i.e. higher elevation in the watershed area) and the stations below the drainage lines near the river banks at correspondingly lower elevations on monthly seasonal basis. Samples collected from higher elevations were named as 'higher elevation (*in-situ*) soil samples,' and the one which were collected from the stations near the river banks at correspondingly lower elevations were named as 'composite soil samples'. For collecting the soils at the higher elevation i.e. the *in-situ* soil samples, first the overburdened accumulated soils consisting of humus, litter, lots and pots of forest residues, were removed by scaling and digging upto 0—15 cm from the surface and then around 100 g of soil samples were collected in the polythene bags. Similarly, com-

posite soil samples were collected at the termination of gullies, near the banks of Sewa river. The sampling of soil was done in this way in order to assess the loss of nutrients.

Soil texture of the samples was determined according to structural triangle method after asserting the percentage of various soil components viz., coarse sand, fine sand, silt, clay and loam by sieving the sample through electrically operated sieve set having sieve mesh numbers 25, 53, 72, 120, 200 and bottom pan. Soil moisture was determined by gravimetric method. Soil sample of known weight was dried in oven at 105 C for 24 hours. The percentage moisture was calculated by the loss of weight of the sample. Soil pH meter—Hanna was used for recording the pH of the soil samples. For this, 1 : 2 soil water suspensions were prepared and then the pH was recorded. The pH was further confirmed in the laboratory by Phillip pH meter.

Table 2. Mean monthly values of physico-chemical parameters of soil collected from higher elevated (*in-situ*) and composite samples of station 1 (Khadwa) from January, 2002 to December, 2004. All the readings represent the average of 2 years.

Months	Soil moisture (%)	Soil pH	SiO ₂ (%)	Al ₂ O ₃ (%)	TiO ₂ (%)	Fe ₂ O ₃ (%)	CaO (%)	MgO (%)	Na ₂ O (%)	K ₂ O (%)	MnO (%)
<i>Higher Elevated (in-situ) Soil Samples</i>											
Jan	17.7	6.9	7.12	13.20	0.42	5.57	2.28	1.30	2.79	4.30	0.04
Feb	15.0	7.0	74.14	13.22	0.00	4.63	2.28	1.37	2.80	4.33	0.04
Mar	12.4	6.8	74.64	13.32	0.42	4.56	2.15	1.30	2.78	4.24	0.03
Apr	6.4	6.4	74.66	13.33	0.44	4.57	2.20	1.32	2.80	4.27	0.04
May	8.9	6.6	74.68	13.34	0.43	4.58	2.25	1.34	2.82	4.30	0.05
Jun	9.4	7.0	75.38	13.20	0.54	5.56	1.24	1.54	2.81	3.30	0.04
Jul	10.5	6.7	75.40	13.21	0.56	3.58	1.25	1.55	2.82	3.33	0.05
Aug	16.5	6.9	75.42	13.22	0.58	3.54	1.28	1.56	2.83	3.36	0.06
Sep	12.1	6.5	75.38	13.16	0.20	3.58	1.20	1.23	2.76	4.31	0.04
Oct	16.7	6.9	75.40	13.18	0.40	3.58	1.24	1.24	2.78	4.32	0.04
Nov	8.9	7.0	74.10	13.20	0.36	3.51	2.24	1.28	2.78	4.27	0.04
Dec	20.4	6.9	74.10	13.18	0.36	3.51	2.24	1.28	2.78	4.27	0.04
Average	12.9	6.8	74.89	13.23	0.41	4.14	1.73	1.35	2.79	4.05	0.04
<i>Composite Soil Samples</i>											
Jan	14.7	6.3	63.09	23.10	0.50	3.72	1.67	1.18	1.32	2.12	0.06
Feb	12.0	5.9	63.11	23.11	0.51	3.74	1.68	1.19	1.33	2.14	0.07
Mar	10.4	7.0	65.00	21.11	0.46	3.70	1.63	1.30	1.33	2.11	0.08
Apr	7.4	6.8	65.10	21.12	0.48	2.76	1.67	1.32	1.34	2.12	0.07
May	8.9	6.4	64.50	21.13	0.50	2.82	1.71	1.34	1.35	2.13	0.07
Jun	9.8	6.4	65.01	21.07	0.47	2.75	1.0	1.38	1.37	2.21	0.08
Jul	10.5	6.7	65.02	21.08	0.48	2.76	1.67	1.40	1.36	2.22	0.08
Aug	16.5	6.9	65.20	21.09	0.49	2.77	1.74	1.42	1.35	2.23	0.07
Sep	12.1	6.5	64.14	22.12	0.30	1.68	1.64	1.18	1.27	2.06	0.04
Oct	14.7	5.8	64.15	22.00	0.32	1.70	1.65	1.20	1.30	2.08	0.05
Nov	7.9	0.9	64.16	21.88	0.34	2.72	1.66	1.22	1.33	2.10	0.05
Dec	17.4	6.9	63.10	23.09	0.49	2.70	1.66	1.17	1.31	2.10	0.04
Average	11.85	6.5	64.31	21.82	0.44	2.51	1.66	1.27	1.33	2.13	0.06

Seven elemental oxides were determined by the following methods from 'A' solution and 'B' solution according to Shapiro and Brunnock method (1956). Al₂O₃ was analyzed volumetrically using EDTA and zinc sulfate (Shapiro and Brunnock 1956). TiO₂ was determined calorimetrically using ferric ammonium sulfate, KMnO₄ and ammonium thiocyanate (Shapiro and Brunnock 1956). Total iron was determined calorimetrically using tartaric acid, P-nitrophenol, 1—10 phenanthroline and hydroxylamine hydrochloride (Shapiro and Brunnock 1956).

CaO and MgO were determined volumetrically by EDTA method (Vogel 1962 and APHA 1998). Na₂O and K₂O were analyzed using GR grade Na and K

salts on flame photometer (EEL-model). MnO was estimated calorimetrically using potassium periodate (Vogel 1962).

Geology. The area from north to south falls in Pre-Cambrian terrain. In the extreme south, tertiary rocks bind the area. The area is highly folded, faulted and metamorphosed due to two granitic intrusions, one in north-west as Kaplas Granite of Bhaderwah and second in the south-west as Dalhousie Granite. Besides, two important thrusts, namely Murree Thrust in the south and Panjal Thrust in the north are responsible for formation of anticlines and synclines causing plications in the rocks. Bhaderwah-Chamba is an example of such a syncline

Table 3. Mean monthly values of physico-chemical parameters of soil collected from higher elevated (*in-situ*) and composite samples of station 2 (Chandel) from January 2002 to December 2004. All the readings represent the average of 2 years.

Months	Soil moisture (%)	Soil pH	SiO ₂ (%)	Al ₂ O ₃ (%)	TiO ₂ (%)	Fe ₂ O ₃ (%)	CaO (%)	MgO (%)	Na ₂ O (%)	K ₂ O (%)	MnO (%)
Higher Elevated (<i>in-situ</i>) Soil Samples											
Jan	16.0	7.0	66.02	15.24	0.70	5.56	2.40	1.56	2.20	4.37	0.01
Feb	15.3	7.0	66.01	15.25	0.72	5.58	2.41	1.57	2.21	4.39	0.01
Mar	9.6	6.9	67.10	15.33	0.68	5.40	2.40	1.54	2.18	4.39	0.01
Apr	2.5	6.8	67.12	15.34	0.72	5.44	2.41	1.57	2.20	4.39	0.07
May	3.2	6.9	67.14	15.35	0.76	5.48	2.42	1.60	2.22	4.39	0.09
Jun	3.7	7.0	67.00	16.44	0.78	5.20	2.40	1.50	2.16	3.30	0.06
Jul	7.9	7.0	67.10	16.46	0.80	5.24	2.41	1.57	2.22	3.39	0.02
Aug	15.2	6.8	67.20	16.48	0.82	5.28	2.42	1.62	2.28	3.48	0.08
Sep	7.8	6.7	66.08	15.00	0.58	5.44	2.36	1.51	2.17	4.30	0.07
Oct	10.5	6.5	66.10	15.03	0.60	5.46	2.37	1.52	2.18	4.36	0.01
Nov	15.5	6.6	66.12	15.07	0.62	5.44	2.38	1.53	2.19	4.42	0.01
Dec	14.6	6.5	66.00	15.23	0.68	5.54	2.39	1.55	2.19	4.35	0.02
Average	10.15	6.8	66.58	15.51	0.70	5.42	2.39	1.55	2.20	4.12	0.03
Composite Soil Samples											
Jan	11.0	5.9	65.14	18.22	0.53	5.43	2.10	1.46	2.10	4.15	0.03
Feb	11.3	5.9	65.15	18.24	0.52	5.44	2.11	1.47	2.11	4.18	0.03
Mar	9.6	6.4	65.22	18.50	0.51	5.42	2.10	1.40	2.08	4.14	0.04
Apr	2.4	6.9	65.24	18.49	0.53	5.44	2.11	1.47	2.10	4.15	0.05
May	2.2	0.1	65.26	18.51	0.55	5.46	2.12	1.54	2.12	4.16	0.05
Jun	3.7	7.1	65.33	19.08	0.55	5.40	2.15	1.46	2.26	3.10	0.05
Jul	7.9	6.9	65.37	19.10	0.56	5.45	2.16	1.47	2.27	3.16	0.06
Aug	15.2	6.4	65.41	19.12	0.57	5.50	2.17	1.48	2.28	3.22	0.06
Sep	7.0	6.8	65.12	18.10	0.51	5.41	1.90	1.43	2.06	3.90	0.03
Oct	10.5	6.9	65.13	18.20	0.52	5.42	2.00	1.42	2.10	4.00	0.05
Nov	15.0	6.6	65.14	18.30	0.53	5.43	2.10	1.44	2.14	4.10	0.06
Dec	14.1	5.9	65.13	18.20	0.54	5.42	2.09	1.45	2.09	4.12	0.07
Average	11.5	6.2	65.50	18.50	0.53	5.41	2.00	1.44	2.19	4.03	0.04

and the rocks have been referred to as Bhaderwah Slates. Panjal Thrust passes east-west above Ramban and Sincha Formations to the south of Gatti area. Sewa para gneiss is overlain conformably by phyllite-slate sequence of late-pre-cambrian Salkhala Group. The present area of study falls strictly in late-pre-cambrian Bhaderwah Formation of Salkhala Group of rocks. These rocks are acidic in character and constitute mostly granitic and reworked metamorphosed sediments slightly containing more ferromagnesian minerals soils (Dhar et al. 1996, Fotedar 2006).

Results and Discussion

Physical Parameters

At station 1 (Khadwa), coarse sand varied from

a minimum value of 9.3 to 16.7% and the average being 13.5%. Fine sand fluctuated between 10.4 to 23.2% with an average value of 14.2% (Table 1). Silt concentration varied from 21.9 to 45.8% with an average of 34.0%. Clay concentration ranged between 13.8 to 27.0% with an average being 19.1%. Loam concentration fluctuated between a minimum value of 12.9% and a maximum value of 34.6% with an average value of 19.2%. The texture class is clay-loam.

At station 2 (Chandel), coarse sand varied from a minimum of 8.7 to 13.2% with an average value of 10.7%. Fine sand fluctuated between 10.6 to 18.1% with an average value of 14.0%. Silt concentration varied between 23.7 to 44.6% with an average value

Table 4. Mean monthly values of physico-chemical parameters of soil collected from higher elevated (*in-situ*) and composite samples of station 3 (Drabal) from January 2002 to December 2004. All the readings represent the average of 2 years.

Months	Soil mois- ture (%)	Soil pH	SiO ₂ (%)	Al ₂ O ₃ (%)	TiO ₂ (%)	Fe ₂ O ₃ (%)	CaO (%)	MgO (%)	Na ₂ O (%)	K ₂ O (%)	MnO (%)
Higher Elevated (<i>in-situ</i>) Soil Samples											
Jan	17.1	5.7	64.70	14.30	0.90	5.90	2.52	3.69	1.7	5.90	0.03
Feb	11.0	5.7	64.72	14.35	0.91	5.92	2.54	3.70	1.76	5.92	0.03
Mar	8.5	6.0	65.08	15.28	0.72	5.87	2.50	3.40	1.72	5.84	0.02
Apr	8.5	6.9	65.10	15.30	0.78	5.88	2.51	3.50	1.74	5.87	0.02
May	5.7	7.0	65.12	15.32	0.84	5.89	2.52	3.60	1.76	5.90	0.04
Jun	4.5	7.0	65.58	15.24	0.68	5.88	2.48	2.40	1.73	5.08	0.03
Jul	7.4	6.9	65.60	15.28	0.0	5.89	2.50	2.42	1.75	5.09	0.05
Aug	16.0	6.6	65.62	15.32	0.72	5.90	2.52	2.44	1.77	5.10	0.06
Sep	10.8	6.8	68.68	14.08	0.80	5.88	2.38	1.90	1.68	4.88	0.05
Oct	13.8	6.9	68.70	14.10	0.83	5.90	2.40	2.00	1.70	4.89	0.07
Nov	6.6	6.6	68.72	14.12	0.86	5.92	2.42	2.10	1.72	4.90	0.08
Dec	14.3	5.9	64.68	14.25	0.89	5.88	2.50	3.8	1.72	5.88	0.06
Average	10.35	6.5	66.02	14.74	0.80	5.16	2.48	2.90	1.73	5.89	0.05
Composite Soil Samples											
Jan	11.1	5.3	64.64	20.32	0.03	3.91	1.54	2.24	0.69	1.18	0.04
Feb	14.0	7.2	64.65	20.33	0.03	3.92	1.53	2.26	0.71	1.20	0.04
Mar	9.6	6.6	60.00	19.08	0.14	3.80	1.58	1.74	1.73	3.18	0.10
Apr	8.5	7.0	63.12	19.10	0.13	3.90	1.0	1.76	1.74	3.19	2.13
May	5.7	7.0	66.12	19.12	0.12	3.00	1.62	1.78	1.7	3.20	0.16
Jun	4.5	6.7	65.25	19.12	0.15	3.89	1.55	1.75	1.7	3.94	0.26
Jul	9.4	6.9	6.27	19.22	0.14	3.90	1.56	1.77	1.76	3.9	0.24
Aug	18.0	7.1	65.29	19.32	0.13	3.91	1.57	1.79	1.78	3.96	0.36
Sep	11.8	6.9	63.70	18.10	0.24	3.87	2.20	1.18	1.70	3.88	0.20
Oct	13.8	6.8	63.75	18.05	0.79	2.88	2.30	1.20	1.72	3.89	0.19
Nov	8.6	6.7	63.80	18.00	0.80	2.89	2.32	1.22	1.74	3.90	0.32
Dec	15.3	6.6	64.30	20.31	0.43	2.90	1.53	2.22	1.48	3.05	0.20
Average	10.85	6.7	64.18	19.17	0.27	3.56	1.75	1.74	1.48	3.05	0.20

of 36.7%. Clay concentration ranged between 16.9 to 28.4% with an average value of 19.8%. The texture class is clay-loam.

At station 3 (Drabal), coarse sand varied from a minimum value of 8 to 14.2% and the average being 11.9%. Fine sand fluctuated between 9.4 to 18.4% with an average value of 13.8%. Silt concentration varied between 27.2 to 45.9% with an average value of 35.7%. Clay concentration ranged between 15.6 to 22.1% with an average value of 18.4%. Loam concentration fluctuated being a minimum value of 14.0% and maximum value of 33.5% and the average being 20.2%. The texture class is clay-loam.

At station 4 (Amnata), coarse sand varied from a

minimum value of 9.9 to 17.1% with an average value of 12.9%. Fine sand fluctuated between 19.9 to 23.2% with an average value of 17.9%. Silt concentration varied from 19.0 to 35.8% and the average being 27.8%. Clay concentration ranged between 14.6 to 23.3% with average value of 18.6%. Loam concentration fluctuated between a minimum value of 16.0% and a maximum value of 34.6% and the average being 22.6%. Texture class is clay-loam.

Soil Moisture

At station 1 (Khadwa), soil moisture varied from a minimum value of 6.4% to a maximum value of

Table 5. Mean monthly values of physico-chemical parameters of soil collected from higher elevated (*in-situ*) and composite samples of station 4 (Amnota) from January 2002 to December 2004. All the readings represent the average of 2 years.

Months	Soil moisture (%)	Soil pH	SiO ₂ (%)	Al ₂ O ₃ (%)	TiO ₂ (%)	Fe ₂ O ₃ (%)	CaO (%)	MgO (%)	Na ₂ O (%)	K ₂ O (%)	MnO (%)
Higher Elevated (<i>in-situ</i>) Soil Samples											
Jan	13.0	5.3	66.12	19.30	0.40	5.92	1.59	0.34	1.36	3.31	0.06
Feb	10.3	5.7	66.14	19.32	0.42	5.93	1.60	0.36	1.37	3.79	0.07
Mar	9.6	6.0	67.10	17.09	0.48	5.85	1.58	0.29	1.60	3.92	0.06
Apr	5.4	6.9	67.13	17.10	0.50	5.92	1.60	0.32	1.62	3.93	0.06
May	3.2	7.0	67.18	17.11	0.52	5.99	1.62	0.35	1.64	3.94	0.07
Jun	4.7	7.0	65.58	19.20	0.36	5.86	1.58	0.29	1.70	3.93	0.05
Jul	8.9	6.9	65.60	19.23	0.37	5.87	1.60	0.30	1.72	3.94	0.06
Aug	15.2	6.6	65.62	19.26	0.38	5.88	1.62	0.31	1.74	3.95	0.07
Sep	17.8	6.8	67.00	18.38	0.48	5.90	1.56	0.40	1.22	3.88	0.05
Oct	10.5	6.7	64.10	18.40	0.50	5.92	1.58	0.41	1.24	3.90	0.03
Nov	15.5	6.6	67.20	18.42	0.52	5.94	1.60	0.32	1.26	3.92	0.04
Dec	9.6	5.9	66.10	19.28	0.38	5.91	1.58	0.34	1.35	3.92	0.03
Average	10.30	6.4	66.48	18.50	0.44	5.90	1.59	0.34	1.48	3.89	0.05
Composite Soil Samples											
Jan	10.0	7.1	65.10	19.0	0.32	3.86	1.55	0.33	1.31	3.80	0.02
Feb	9.3	5.8	65.12	19.10	0.33	3.88	1.57	0.34	1.33	3.81	0.04
Mar	8.6	5.6	85.18	20.00	0.40	3.86	1.57	0.30	1.50	3.91	0.03
Apr	5.5	7.0	65.20	20.10	0.35	3.87	1.58	0.34	1.60	3.90	0.04
May	3.2	7.0	65.22	20.20	0.30	3.88	1.59	0.38	1.70	3.92	0.05
Jun	4.7	6.7	65.48	19.20	0.36	3.87	1.58	0.32	1.69	3.90	0.04
Jul	8.9	5.8	65.50	19.22	0.37	2.88	1.60	0.34	1.0	3.91	0.04
Aug	8.2	7.0	65.52	19.24	0.38	2.90	1.62	0.36	1.71	3.92	0.05
Sep	17.8	6.8	66.16	19.20	0.35	2.91	1.55	0.35	1.21	3.87	0.05
Oct	10.5	5.7	66.18	19.22	0.37	2.92	1.57	0.40	1.22	3.89	0.06
Nov	12.5	7.0	66.20	19.24	0.39	2.84	1.59	0.45	1.23	3.91	0.07
Dec	9.6	7.1	65.08	18.90	0.31	2.8	1.56	0.32	1.32	3.79	0.07
Average	9.06	6.5	65.49	19.38	0.35	3.44	1.57	0.35	1.46	3.87	0.05

20.4% in higher elevation and minimum value of 7.4% to a maximum value of 17.4% in case of composite soil samples (Tables 2 to 4). At station 2 (Chandel), soil moisture ranged between 2.5 to 15.5% in case of higher elevation soil and between 2.2 to 15.0% in case of composite soils samples. At station 3 (Drabal), it fluctuated between 4.5 to 17.1% in higher elevation soil and 4.5 to 18.5% in composite soil samples. At station 4 (Amnota), Soil moisture ranged between 3.2 to 17.2% for higher elevation and composite soil samples. Amnota in the Sewa catchment is known for landslides. The watershed is devoid of forest cover and the intensity of water ingress is sufficient to bring about mass wastage. The moisture con-

tent at toe and crown portion of the slide is same because of the mechanism of drainage flow from top to bottom of the slide.

Soil pH

At station 1 (Khadwa) soil pH fluctuated between 6.4 to 7.0 for higher elevation and 5.8 to 7.0 in composite soil samples. At station 2 (Chandel) at this station, values ranged between 6.5 to 7.0 for higher elevation and 5.9 to 7.1 for composite soil samples. At station 3 (Drabal) soil pH ranged between 5.7 to 7.0 in higher elevation and 5.3 to 7.0 for composite soil samples. At station 4 (Amnota). The soil pH

ranged between 5.3 to 7.0 for higher elevation and 5.8 to 7.1 for composite soil samples.

With regard to textural classification of soils of Sewa catchment, the soils belong to clayey to clayey-loam in texture for all the four stations. Soil pH in the present study ranged between 5.0 to 7.3 for higher elevation soils and 5.3 to 7.2 for composite soil samples. This revealed that the soils of Sewa catchment are generally acidic in nature. This is in accordance with the normal observed pattern by almost all the forest workers throughout the world. The soil pH reflects both, the chemical properties of the mineral soils and of the organic residue deposited as litter (Wazir 1984). However, along the longitudinal profiles for stations 1 to 4, pH did not show much fluctuation except that from slightly acidic to slightly alkaline favored the breaking of silicate chain and aiding the denudation (Wedepohl 1978). Also, burial metamorphism in Salkhala group of rocks, occurring in Sewa catchment is an additional factor causing excessive erosion due to breaking of silicate chain (Dhar et al 1996).

Soil moisture contents varied from a minimum value of 2.5% to a maximum value of 20.40% in higher elevation soil samples and a minimum value of 2.2% to a maximum value of 18.0% in composite soil samples. The ability of forest soils to retain water depends upon the amount of silt and clay present. The greater the amount, the greater is the soil moisture content. However, the soil moisture content did not show any fluctuation present in all the four stations in the Sewa catchment.

Chemical Parameters

The concentration of silica in composite soil samples, in all the four stations, was less at almost all stations as compared to higher elevation soil samples, which shows that the area of study has suffered from extensive erosion. Silica is rich in acidic soils as has been reported by Nesbitt and Young (1982), so under favorable pH and metamorphism, the acidic rocks correspond to high values of silica in the soils of Sewa catchment. Along the longitudinal profiles from station 1 (Khadwa) to station 4 (Amnota), silica recorded high values at Khadwa as compared to rest of the stations. The reason for this is that Khadwa is surrounded by granitic rocks which are acidic in na-

ture and silica is rich in acidic rocks. Aluminium oxide was found to be higher in composite soils than *in-situ* soils. Aluminium contents get added up in the composite soils, where intensity of erosion is more. The soils got weathered to a large extent and this has resulted in more clayey type of composite soil rich in aluminium content. This observation is supported by studies of Wedepohl (1978).

According to longitudinal profile, TiO_2 in soils of Sewa catchment was lower in composite soils as compared to *in-situ* higher elevation soils. This indicates more of erosion suffered by the rocks of Sewa catchment. This influence is supported by the study of Nesbitt and Young (1982) as TiO_2 is considered one of the best indicators to assess the rate of weathering. In the present study, ilmenite has been best carrier of TiO_2 which has impoverished in composite soils with prolonged course of weathering.

Calcium oxide ranged between 1.20 to 2.54% in higher elevation soils and between 1.60 to 2.30% in case of composite soils. The source for calcium in the soil appears to be from the weathering of calcareous materials in the catchment areas. The amount of calcium is quite low as compared to the available references in many of the soil profiles. Champion and Seth (1968) recorded 3.9 to 34.2 meq % for chir pine (*Pinus roxburgii*) and cedar soils in Kullu and Himachal Pradesh, respectively. Puri and Gupta (1951) noticed considerably high concentration of calcium (33.7 to 72.3% meq) in the top layers of the soil profiles in Kullu bearing coniferous communities. An insufficiency of calcium permits the accumulation of undesirable ions in plants. The loss of calcium in the catchment of Sewa in the present case is undesirable.

Mg is important component of chlorophyll pigment and its deficiency in general can cause chlorosis in plants. MgO ranged between 0.29 to 3.69% in higher elevation and 0.30 to 2.26% in composite soil samples. These values are in accordance with the values reported by Wazir (1984) in the Bhaderwah soils in the north of the present area of study. The Mg ions in excess produce harmful effects in isolation, but in the natural forest soils, these effects are neutralized by the amount of calcium present in these soils (Puri and Gupta 1951, Ray Chaudhury and Datta 1964, Champion and Seth 1968, Wazir 1984). The overall relation of Mg is positive with that of Ca,

however, Mg in forest soils is usually from 1/5th to 1/3rd of Ca (Wilde 1958). In the present study, Mg was recorded higher than this ratios. Mg in the composite samples on an average is lesser than *in-situ* samples by a margin of 2%.

Sodium content of Sewa catchment ranged between 1.36 to 2.80% in higher elevation soils and 0.69 to 2.28% in composite soils. Soils in the present study contain normal amounts of sodium percentage.

Potassium percentage ranged between 3.30 to 5.92% in higher elevation (*in-situ*) soils and 1.18 to 4.16% in composite soils. Ray Chaudhury and Datta (1964) found that exchangeable potassium ranged from 1.10 to 15.46% of HCl soluble potassium. Along the longitudinal profile from Khadwa to Amnota, sodium and potassium did not show much fluctuation.

Mn shows a lot of fluctuation in both higher elevation soils and in lower elevation soils. The average Mn concentration in all the four stations comes to 0.04% in higher *in-situ* samples, while in composite samples, the average moves up to 0.09%. It reveals that in the longitudinal profile from Khadwa to Amnota, Mn gets considerably added up in the composite samples. This is consistent with the extensive studies done by Horowitz (1974) in down water drained soil profiles, which he ascribes to most of Mn getting concentrated in down drainages by fine grained sediments by the mechanism of adsorption. Similar adsorption and concentration increasing in low profiles has been noticed in Jajjar Nalla, Udampur, J & K by Fotedar and Loan (2004) and Tikoo (2004) in a tributary of Chenab in J & K.

Fe₂O₃ percentage in higher elevation soils of Khadwa (station 1) was found to be 4.14 on average basis and in composite soil of same station, Fe₂O₃ was found 1.59% less. At Chandel (station 2), Fe₂O₃ was found 5.41 in higher elevation soil but in composite soil also the same concentration was found depicting no loss, no gain in nutrition. In Drabal (station 3) profile, Fe₂O₃ in *in-situ* soil samples was found to be 5.89% but in composite samples it was 2.33% less. In Amnota (station 4), Fe₂O₃ in *in-situ* soil sample was found to be 5.90, but in composite sample it was 2.46% less. Thus there is an overall loss in nutrition from 2.3 to 2.5%.

In conclusion, the loss of nutrition of four element oxides has taken place in Sewa catchment, namely TiO₂, Fe₂O₃, CaO and MgO which can be

mitigated by improving the soil by modern silvicultural methods using adequate farm yard manures or compost. Other methods for improving the quality of soils are given below.

The government and local communities should check enormous erosion occurring in the area (Goel et al. 1968). Diversion of land suitable for sustainable farming to non-farming uses should be checked. The stoniness in all the transects persists due to high intensity of erosion in the area of study. The stones can be removed to make the soil worth fruit cultivation. There exists a huge promise for planting fruit trees in the whole area. The climate and soil are both congenial for starting fruit industry. Modernized farming and use of manures is necessary to make soils fertile for three crops (rice, wheat and maize) that are mainly cultivated on repose slopes, on both sides of river Sewa. Long rooted grass and vetiver grass should be used as a soil builder in the watershed areas. In many Himalayan terrains, vetiver grass is being used successfully for checking erosion (Rao 2002, Lavania 2004). Afforestation in the catchment area is needed to combat erosion. Forests in barren areas should be started on regeneration principle. It will check erosion and will screen all the contaminants from entering into the solution of the Sewa river, thus protecting riverine ecology. It is necessary to construct a series of staggered contour trenches on slopes, series of stone check dams in gullies and plantation of ecologically suited soil builder species (Fotedar 2006). Besides, various land management practices may be applied such as mixed cropping, intercropping, strip cropping, rotational cropping, mulching, application of organic manures, appropriate residue management, which will reduce soil erosion and conserve sub-soil moisture effectively.

References

- APHA. 1998. *Standard method for the examination of water and wastewater*. 20th edition). Am. Pub. Hlth. Assoc., Washington, USA.
- Champion H. G. and H. K. Seth. 1968. *Forests of India*. Govt. India, Publ. Div., New Delhi, India, pp. 104.
- Dhar B. L., A. K. Raina, B. K. Fotedar and R. Singh. 1996. Petrology of Doda-Granites, Jammu, Lesser Himalaya. *Ind. J. Nepal Geol. Soc.* 13 : 49–56.
- Fotedar A. 2006. *Ecological studies of river Sewa and its catchment (J & K)*. Ph. D. thesis. Jammu Univ., Jammu, India.

- Fotedar B. K. and B. A. Loan. 2004. Physico-chemical studies of Jajjar nallah waters, district Udhampur, Jammu Himalaya. Sem. Geohazards of North-West Himalaya. Abstract. 9 to 11 Oct, 2004, Jammu Univ., Jammu, India.
- Goel K. N., M. L. Khanna and R. N. Gupta. 1968. Effect of degree and length of slope and soil type on plant nutrient losses by water erosion in the alluvial tracts of UP. *J. Soil and Water Conser. in India* 16 : 1—6.
- Horowitz A. 1974. The geochemistry of sediments from the Northern Reykjanes Ridge and the Iceland-Faeroes Ridge. *Marine Geol.* 17 : 103—122.
- Jofee. 1949. Definition of soil. P. 5. In T. D. Biswas and S. K. Mukherjee (eds.). *Textbook of soil science*. Tata McGraw Hill Publ. Co. Ltd., New Delhi, India.
- Lavania U. C. 2004. Vetiver system ecotechnology for environmental protection and sustainable development. *Curr. Sci.* 86 : 11—14.
- Nesbitt H. W. and G. H. Young 1982. Early proterozoic climates and plate motions inferred from major element chemistry of lutites. *Nature* 299 : 715—717.
- Puri G. S. and A. C. Gupta. 1951. Himalayan conifers II. The ecology of humus in conifer forest in Kulu Himalaya. *Ind. For.* 77 : 124—129.
- Rao Jeevan K. 2002. Pp. 23—26. In Soil erosion and conservation. *Environ. and People*.
- Ray Choudhury S. P. and N. P. Dutta. 1964. Phosphorus and potassium status of Indian soil. *ICAR Rev. Ser. Bull. No.* 36 : 43.
- Shapiro L. and W. W. Brunnock. 1956. *Rapid analysis of silicate rocks (revised)*. Circular 165 USGS Bull. 1936-C, pp. 19—56.
- Tikoo V. J. 2004. *Geological aspects of environmental degradation along the National Highway-1A Between Jammu and Banihal, J & K state*. Ph. D. thesis. Jammu Univ., Jammu, India.
- Vogel I. A. 1962. *A textbook of quantitative inorganic analysis*. 3rd edition.
- Wazir P. K. 1984. *Physico-chemical studies of soils from Bhandarwah Forests, Jammu*. M. Phil. Dissert. Jammu Univ., Jammu, India.
- Wazir P. K. 1989. *Soil nutrients in relation to grazing and vegetation of Jammu (J & K)*. Ph. D. thesis. Jammu Univ., Jammu, India.
- Wedepohl K. H. 1978. *Handbook of geochemistry*. Springer Verlag Heidelberg.
- Wilde S. A. 1958. *Forest soils, their properties in relation to silviculture*. The Ronald press Co., New York, USA.