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Research Article

PEDOLOGICAL PERSPECTIVE OF RAVINE EROSION SITES WITH IN GIRD REGION OF MADHYA PRADESH

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Abstract: Erosion is a common feature in Gird region of Madhya Pradesh, rendering large expanses of arable land, uncultivable and uninhabitable. Erosion in the area was classified into two types: Deep erosion (Chambal Ravine), medium (Kunwari and other tributaries of Chambal and Yamuna) and minimum erosion (Agriculture field). The current study aimed at providing insight into physical and chemical properties of soil that promote soil erosion and determine the ravine/gully formation type. Field studies were conducted at 3 sites (2 eroded and 1 Minimum- eroded). Physical (particle size distribution, structure stability and dispersibility), and chemical (pH, exchangeable cations, total-C, and total-N) properties of soil samples collected from the sites were analyzed in the laboratory. The results showed High infiltration rate and higher soil dispensability resulted to loss of heavy soil mass due to fragile soil structure and hollow out at the soil layer of stream floor might induce the fall down of the above soil mass successively are major factors contributing to the formation of deep and medium type of ravine erosion. Soils of the eroded sites and the non-eroded sites differed mainly on the basis of soil structure stability, water infiltration rate, and soil dispersibility and low organic carbon content in eroded soil. Susceptibility of soil layers to erosion also depended on the magnitude of ESP and sand content.

Keywords: Soil Management, Physical and chemical properties of soil, erosion, ravine, soil dispersion, soil structure

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Introduction

Land is most precious natural resource. The existence of mankind depends on land resources. Its unscientific use for immediate gains without considering the long term sustainability, leads to land degradation. India is endorsed with a rich diversity of natural resources. However, the need for food and nutritional security is increasing due to expanding population and narrowed capital land availability. The present population of India is expected to stabilize at about 1.7 billion by 2050. This would result in further significant reduction of per capita resource availability of land, water, forest and other form of natural resources. The annual food grain requirement is likely to reach 350 million tons by the year 2050, which is to be met out from the land resources. Therefore, quality of land need to be maintained to enhanced and sustain higher productivity with minimum land degradation rates have to be effectively controlled. Erosion is the process by which the soil or rock formation is loosened and carried away by wind, water, freeze and thaw or biological activities [1]. The word ravine denotes gullied land containing network of gullies running more or less parallel to each other along the nearby river flowing much lower than the surrounding table lands. The channels or gullies range in depth from 3 to 30 m and only contain water during and immediately after precipitation events [7]. Gully erosion in this region is caused by water. Gullies and ravines form an extensive net work along Gomati, Yamuna, Chambal, Betwa, Sindh, Ken and Mahi rivers and their tributaries in Uttar Pradesh, Madhya Pradesh, Rajasthan and Gujarat states. These result not only in loss of non-renewable land and soil resources but also lead to other processes destructive to National Economy such as floods in rivers, siltation of water reservoirs and consequent loss in their storage capacity, damage to railway lines, roads and other public properties[9]. Out of 329.0 million ha geographical area of the country, nearly 147.75 million ha is subjected to various types of degrees of degradation. Of this about 93.68 million ha is severely eroded [8].These ravines are constantly damaging the valuable fertile land. In the districts of Chambal region of Madhya Pradesh namely Morena, Sheopur and Bhind out of geographical area of about 16.5 lakh ha, out of which about 3.50 lakh ha is ravenous, which is about 20 % of their total geographical area and is increasing year after year. Gully erosion in the area is classified into deep ravine (Chambal Ravine) and medium ravine (mainly kunwari/sindh and other tributaries of Ymuna and Chambal)

Materials and Methods

Study sites

There two experimental sites for deep and medium ravine were selected in the Morena District which are located between 23°15' to 26°45' N – latitude and 70° 30' E – longitude with an altitude ranging from 150 to 240 m and the third site at Collage of Agriculture, Gwalior 22°03' N – latitude and 76°54' E – longitude with minimum soil erosion. The climate is characterized as semi-arid and extremely hot during May-June and extremely cold during end of December to January. This area is categorized under Gird Agro-climatic zone. The maximum temperature in summer month varies from 40 to 49ºC. The mean maximum and minimum temperature in summer was 39.0 and 21.2ºC, respectively. The monsoon sets in during last week of June. Most of which falls during last June to middle of September with mean annual rainfall of area is about 730 mm. Forty five (45) soil samples were collected from three ravine sites of Morena on the bank of (Chambal and Kunwari River) and one from Gwalior (College of Agriculture field) districts (15 samples from each site) from different depth (five depths) during March to April 2015. After collection, the samples were brought to Soil Science laboratory, College of Agriculture, Gwalior and samples were air dried, crushed and sieved through 2 mm plastic sieve. The following Physical properties and Chemical properties were determined during the study.

Table-1 Physical properties of soils of three erosional site

Depth (cm)	Particle size distribution			Dispersible Silt+clay	Dispersible Ratio	PD g/cm^3
	Sand (%)	Silt (%)	Clay (%)			
1	2	3	4	5	6	7
P1: Chambal Ravine						
0 -15	51.33	20.50	28.17	50.40	0.88	02.61
15 –30	52.33	20.73	26.93	44.39	0.83	02.65
30 –60	57.83	23.50	21.33	42.41	0.79	02.70
60 –80	55.17	21.67	20.50	43.84	0.81	02.62
80-100	59.00	20.50	20.50	46.22	0.79	02.64
P2: Kunwari Ravine						
0 – 15	43.60	22.83	33.57	48.54	0.86	02.69
15 – 30	44.53	24.23	27.90	43.57	0.80	02.69
30 – 60	48.43	24.67	26.90	44.26	0.82	02.63
60 – 80	50.77	23.47	25.77	40.34	0.78	02.65
80-100	51.27	24.23	24.57	47.61	0.81	02.67
P3: College field Gwalior						
0 – 15	42.20	23.90	33.77	21.73	0.37	02.66
15 – 30	42.00	24.73	33.27	19.90	0.34	02.67
30– 60	45.40	22.00	32.60	19.86	0.36	02.70
60 – 80	46.50	24.70	28.80	23.60	0.43	02.61
80-100	47.00	26.10	27.23	23.30	0.43	02.68
Mean	49.15	23.18	27.45	37.33	0.67	02.65
SD	05.40	01.74	04.52	11.75	0.21	0.08
CV	10.98	07.51	16.46	31.47	31.63	03.38

Table-2 Chemical properties of soils of three erosional site

Depth (cm)	pH (1:2)	EC (dSm^{-1})	Total C (%)	Total N(%)	Exchangeable CationCmol(p$^+$)kg^{-1}				CEC {cmol(p+)kg^{-1}}	ESP %
					Ca	Mg	K	Na		
1	2	3	4	5	6	7	8	9	10	11
P1: Chambal Ravine										
0 -15	08.10	0.42	01.18	0.21	07.30	04.70	03.06	01.23	16.63	07.99
15 –30	08.20	0.44	01.18	0.18	08.06	03.52	01.28	01.56	14.70	08.03
30 –60	08.40	0.48	01.16	0.17	06.36	03.20	02.72	02.76	15.13	07.80
60 –80	08.47	0.49	01.06	0.16	06.50	03.40	01.50	01.02	13.91	07.93
80-100	08.63	0.52	01.02	0.14	05.93	02.12	02.34	02.32	12.94	08.80
P2: Kunwari Ravine										
0 –15	08.23	0.43	01.31	0.26	06.20	04.80	01.98	03.40	16.43	08.10
15– 30	08.37	0.43	01.25	0.17	06.89	03.90	01.99	02.25	15.73	08.33
30– 60	08.37	0.45	01.19	0.17	07.20	03.10	02.01	02.15	14.67	08.60
60 – 80	08.47	0.42	01.14	0.15	06.70	02.40	02.75	01.95	14.37	08.60
80-100	08.47	0.49	01.08	0.14	06.55	03.70	01.93	01.12	13.60	08.89
P3: College field Gwalior										
0 – 15	07.60	0.43	01.75	0.31	12.70	09.30	03.70	03.50	29.90	06.43
15– 30	07.53	0.50	01.72	0.26	12.20	09.10	02.60	02.95	28.30	06.63
30– 60	07.50	0.45	01.66	0.22	11.50	08.50	03.80	03.90	26.52	06.93
60 – 80	07.60	0.45	01.62	0.14	09.70	07.50	03.60	01.85	24.67	07.30
80-100	07.50	0.37	01.48	0.15	08.90	06.20	02.10	03.62	20.83	07.37
Mean	08.09	0.45	01.32	0.18	08.54	05.65	03.41	03.28	18.55	07.84
SD	0.42	0.03	0.25	0.05	02.29	02.46	0.73	0.94	05.87	0.77
CV	05.21	08.57	19.31	27.74	26.87	43.56	21.48	28.84	31.64	09.83

Physical properties

Particle size distribution of sand, silt and clay was determined by hydrometer methodas described by bouyoucos [1]. Soil analysis was performed by shaking soil in water with sodium hexameta phosphate. Structure stability of soil aggregates was compared among the soil samples in the laboratory. Air dried soil particles with the size between 0.5 and 2 mm were placed on a 0.5 mm sieve; excess amount of distilled water was added drop by drop to submerge the soils. Five min after soil submergence, excess water was absorbed by tissue paper from the bottom of the screen. The soil structure was then compared with that of air dry soil samples. Particle density was demined Soil dispersibility was evaluated by a without use of chemicals.

Chemical properties

Soil pH was determined by using glass electrode pH meter using 1:2 soil water suspensions. Electrical conductivity (Ec) supernatant liquid of the soil suspension formerly used for pH determination was used for the determination of electrical conductivity by conductivity meter, total carbon (total-C), and total nitrogen (total-N) were determined.

Total C in soil samples were determined using the Total Organic Carbon (Elemental), and Total nitrogen is determined (Modified kjeldahl method), cation exchange capacity CEC was determined by centrifuging the soil with 1N sodium acetate (pH 8.2) in centrifuge tubes till supernatant is clear using Heavy duty centrifuge, 5-7'revolution per minute. After removal of excess of sodium acetate by centrifuge with 95 percent ethanol till supernatant gets an EC of 55-40 dSm^{-1} at room temperature the absorbed sodium was then replaced by ammonium using 1N ammonium acetate (pH 7.0) solution and the sodium concentration in the leachate was determined by flame photometer [6], ESP was computed on the basis of exchangeable cation *viz*. Na^+ and CEC of soil which were determined as per the method described by Richards [6]. Exchangeable sodium percentage(ESP) was computed by using following formula:

$$ESP \quad = \frac{Na + \ (me/100g\ soil)}{CEC\ (mili\ equivalent/100g\ soil)} \times 100$$

Exchangeable sodium and potassium were determined by leaching the soil with 1 N ammonium acetate (pH 7.0) sodium and potassium in the leachate were determined by using flame photometer [5]. Exchangeable calcium and magnesium were determined by leaching the soil with 1 N KCL triethanolamine buffer solution (pH 8.2) and titrating the leachate with standard Ethylene diamine tetra acetic acid(EDTA) solution [5].

Statistical analysis

Chemical and physical properties of soil samples collected from the first five layers from the ground surface of the soil profiles at the four sampled sites were subjected to statistical analysis.

Results and Discussion

Particle size distribution

Particle size distribution significantly (P>0.05) varied between and within sites [Table-1]. Sand fractions of Deep ravine site at village Aisha, Medium erosion / Ravine site at village on bank of Kunwari, and College field sites ranged from 51.33 to 59%; 43.60 to 51.27%; and 42 to 47%, respectively. The lower layers had significantly (P > 0.05) higher sand content than the lower upper layers. The soil at ravine site was sandy clay loam in all the layers, with the clay fraction ranging from 21 to 27%. The clay content of the layers significantly varied from one layer to the other. The texture of the soil at Kuwari site was sandy loam throughout the layers with clay fraction ranging from 24 to 34.5%. The soil at college field was generally loamy with the clay fraction ranging from 24 to 35.3%. The wide range of sand fraction at this site was due to the multiple depositions of soil materials by alluvial processes, Furthermore; the sand fraction was significantly larger in the ravine site in 3rd and 5th layers than in the 2nd and 4th layers; which suggested the deposition. At Kunwari ravine site soil samples from 1st to 3rd layers remained in original structure and at College field site soil sample from all layers remained in original soil structure. The samples to submergence showed different reaction to the submergence. The soil sample from ravine site of 2nd to 5th layer was destructed to smaller particles [10].

Stability of soil structure

Stability of soil structure varied between each soil profile at the three erosion sites. The soil samples collected from the 2nd to 5th layers at Ravine site became fragile when submerged in water soil samples from the 1st layers retained original structures. At Kunwari Ravine site soil samples from 1st to 3rd layers retained original structure and at college field site soil sample from all layers retained original soil structure. The samples were to submergence showed different reaction to the submergence. The soil sample from ravine site of 2nd to 5th layer was destructed to smaller particles

Soil dispersibility

Thesoil dispersibility at high erosion site (Chambal Ravine) and medium erosion site (Kunwari Ravine) was higher than the less erosion site of college of Agriculture field. Soil dispersibilty was high in first and last layer of Chambal and Kunwari ravine. The higher soil dispersibility was due to the lower organic content in the soil [Table-1].

Particle density

Almost identical values were obtained for the particle density, ranged between 2.34 to 2.59 g/cm^3 [Table-1] with a mean value of 2.63g/cm^3.Lower magnitude of the coefficient of variation(<15%)suggested uniformity in the mineralogical make up in the soils of alluvial plains. The textural composition (mechanical composition) of the soils varied from sandy loam to sandy clay loam in Chambal ravine, Kunwari ravine, and sandy clay nature in Gwalior college field.

Cation Exchange Capacity

The cation exchange capacity varied from 12.43 to 16.63, 13.60 to 16.43 and 20.83 to 29.90 cmol $(p^+)kg^{-1}$ in highly erosion site (Chambal ravine), medium erosion site (Kunwari ravine) and minimum erosion site (College field), respectively [Table-2].CEC was found to increase from Chambal ravine to Kunwari ravine and reached maximum at college field. The lower CEC at higher erosion site (Chambal ravine) attributed to the lower clay content as compared to the medium erosion site (Kunwari ravine) and minimum erosion site (College field) there is significant positive correlation (r^2 =0.695*) exist. Considering the soil of all layer. The CEC of soils decreases from surface to sub surface horizon in all the three sites and is due to decrease in clay content with depth.

Exchangeable sodium percent (ESP %)

Exchangeable sodium percentage was computed on the basis of exchangeable cations *viz.* Na^+ and cation exchange capacity of soil. It is clear from the results that the ESP was noticed less than 15% in all the layers of different pedons. Maximum ESP (8.89%) was noticed with deepest layer of medium erosion site (Kunwari ravine) where minimum (6.43%) in surface layer of minimum erosion site at college of agriculture field. The ESP ranged from 7.8 to 8.8, 8.10 to 8.09 and 6.43 to 7.37 in highly eroded (Chambal Ravine), medium erosion at (Kunwari Ravine) and minimum erosion site (College field) respectively [Table-2]. The data indicated that there was no significant variation in all three group soils of study area. It was observed from the data there no particular trend with respect to depth at Chambal ravine site, while at Kunwari ravine and college field the ESP values increased along with the depth .The results shows that ESP at erosion site (Chambal Ravine) was maximum followed by Kunwari ravine and College field.

Exchangeable cations

The exchangeable cations calcium, magnesium, sodium and potassium status were presented in [Table-2]. The distribution of exchangeable calcium was studied in different soil erosion sites and notice that values of 7.3, 6.20, 12.70 cmol $(P^+)kg^{-1}$ at surface in and5.93, 6.35, 7.6 cmol $(P^+)kg^{-1}$ at deepest at deep ravine (Chambal), medium ravine (Kunwari) and College of Agriculture (Gwalior, respectively). The distribution of exchangeable calcium in different pedon of deep and medium ravine indicated no consistent trend with increase in depth, while minimum erosion site (College of Agriculture.) site the distribution of exchangeable calcium in different pedon shoes a decreasing trend with increase in depth. The exchangeable magnesium was recorded in range of 2.12 to 4.7, 2.3 to 4.8 and 5.2 to 9.3 $cmol(P^+)kg^{-1}$ at different depth of deep erosion site (Chambal ravine). Medium erosion site (Kunwari Ravine) and less erosion site (college field) respectively. The maximum exchangeable Mg content was observed in the surface of less soil erosion site, where as minimum 2.12 in the deepest layer of high erosion site (Chambal ravine). The distribution of exchangeable magnesium at medium erosion (Kunwari ravine) and minimum erosion site (College field) shows the decreasing trend with increasing the depth, where as no consistency at high erosion site (Chambal Ravin).The exchangeable sodium was studied in different soil profile at different type of soil erosion site and found that the there is not consistent in the exchangeable sodium with the increasing of depth at Chambal ravine and college field site. Whereas decreasing trend in exchangeable sodium were noticed with increasing in depth at medium soil erosion site (Kunwari ravine). The maximum exchangeable sodium was recorded 3.4 and 3.5 cmol $(P^+)kg^{-1}$ surface layer of Kunwari ravine and College field site, respectively. Exchangeable potassium was recorded in the range of 1.28 to 3.80 $cmol(P^+)kg^{-1}$ at different depth. However, in surface its content was from 1.98 to 3.70 cmol $(P^+)kg^{-1}$.

Maximum exchangeable K content was observed in college field Gwalior whereas minimum in Kunwari ravine. The distribution of exchangeable potassium indicated no consistent trend with increase in depth.

Soil physical and chemical properties and the erodibility deep and medium ravine of study sites

The particle size distribution in [Table-1] and [Table-2] showed that the deep ravine of Chambal sites has a significantly higher sand content in comparison to medium erosion site (Kunwari Ravine) and College field (minimum eroded). The medium erosion (Kunwari Ravine) site contained significantly higher sand fraction in some but not in all layers indicating texture was not only factor influencing erosion. However sediment with high sand or silt contents erode more easily than those with lower sand and silt contents [3]. Soil structures in the lower layers at the highly eroded Ravine site followed by medium eroded Kunwari Ravine sites were very fragile with easy destruction by water in comparison with the upper layer. Destruction of soil structure induced considerable soil dispersion in those soil layers. Markedly large soil dispersion of Chambal Ravine and Kunwari Ravine soil sample explained from the high ESP. Dispersion is facilitated by a large number of water molecules associated with each micelles and with the absorbed Na+ ions. Highly hydrated monovalent Na^{+} ions are not highly held by the micelles enhancing clay dispersion [2].

Conclusion

The pedagogical prospective represents a support for estimating soil properties for assessment of spatial variability. The methodology adopted in the present study is suitable for identifying the areas with varying degree of erosion and production potential of Chambal and Kunwari ravine. The study reflect that the ravine site at Kunwari were alkaline in nature with moderate exchangeable sodium percentage. The structure was fragile with higher dispersion ratio. The erodibility of soil was affected by sand content specially inkunwari sites, which represent wide variation in soil particle fraction due to multiple deposition of soil material by alluvial process. The cation exchange capacity decreased from surface to subsurface layers, magnitude of organic carbon was decreased in order of Chambal ravine >Kunwari ravine > Gwalior College field.

Application of research: The present research work demonstrates the capability of ravine land to capture ultimate land use for food production, which is necessary for optimum and sustainable utilization of land resources and prevention of further undesirable deterioration of Chambal ravines.

Research Category: Soil Science

Abbreviations:

TOC- Total organic carbon
CEC- cation exchange capacity
rpm- Revolutions per minute
ESP- Exchangeable sodium percentage
me- milliequivalent
KCL- potassium chloride
EDTA- Ethylene diamine tetra acetic acid
Total N- total Nitrogen
Total C – total carbon

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