Soil Desurfacing–Impact on Productivity and Its Management

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1 Introduction

In India as per estimates about 175 million hectares out of total geographical area of 328 million hectares is subjected to soils erosion and degradation. Desurfacing is a process where earthy material is loosened and removed mechanically or manually from soil surface for some other purposes, such as making bricks, foundations for buildings, rails and roads, and land fill etc., leaving infertile subsoil exposed to surface that are poorly suited for growing crops. Desurfacing affects both on-site damage for soil and crops and off-site damage in the form of accelerated soil and water loss. However, the degree of damage is determined by the soil profile constrains, nature of the soil and its position in the landscape. Desurfacing has been used to simulate soil erosion in several controlled experiments and considerable amount of research work has been done abroad on desurfaced soils (Latham, 1940; Ripley *et al*., 1961; Sadler, 1984; Gollany *et al*., 1991, 1992). Though in some aspects, the removal of top soils from desurfacing is analogous to the loss of top soil by natural erosion but the abrupt loss of soil in desurfacing and the difference in the position of the desurfaced field in the landscape affect the soil productivity immediately rather than the gradual decline in the productivity due to erosion. Restoring the abruptly declined productivity of desurfaced soils is of a great concern for a country like India, where every million hectares of land supports 2.5 million people and by 2000 A.D., it is estimated that this number will go upto 3 million. Forty seven per cent (about 140 mha) of the land is already under cultivation, one of the highest in the world with little or no further possibility of increase in cultivated area.

The objective of this paper is to describe the extent of desurfacing in Haryana (India), its impact on soil productivity and suggestion for their management.

2 Soil productivity

Soil productivity is the capacity of a soil for producing a specified plant or sequence of plants under a physically defined set of management practices (Soil Survey Staff, 1951). Sustaining the productivity of soils has been a worldwide concern and one of the most important research priority of soil and water resource (Larson *et al*., 1981). It is not possible to develop a simple quantitative relationship between topsoil depth and crop production that is applicable to all soils. Generally topsoil removal and the associated changes in productivity are measured by soil physical and chemical relationships and their subsequent impacts on crop yield (Christensen and McElyea, 1985). To quantify soil productivity, Piece *et al*. (1983) modified the numerical index method developed by Neil (1979), using soil parameters, available water capacity, resistance to root growth and development and adequacy of soil pH to a depth of 100 cm and assuming that nutrients are not limiting to plant growth.

The productivity index (*PI*) model used by Pierce *et al*. (1983) is as follows:

$$PI = \sum_{i=1}^{r} (Ai.Ci.Di.\ WF)$$

Where *Ai*, *Ci* and *Di* is the sufficiency of available water capacity, bulk density and pH respectively, *WF* is a weighing factor representing an idealized rooting distribution, and r is the number of horizons in the rooting depths,. *PI* ranges from 0 to 1. Need based location specific database will be of help in evolving suitable management strategies for desurfaced soils.

3 Desureaced soils in haryana

Growing urbanisation in vicinity to Mega City like Delhi and need for more infrastructures have increased the demand for bricks dramatically in recent past. There has been nearly 50 per cent increase in number of brick kilns in Haryana (with only 1.4 per cent India's geographical are) between 1989 to 1991 (Table1). A diagnostic survey in different districts of Haryana from 24 brick kilns revealed brick capacity from 0.8 to 1.4 million per kiln with a land area requirement between 0.8 to 1.0 ha • yr^{-1} • $kiln^{-1}$ for desurfacing to a depth of 75 cm—100 cm. With 1989, as a base, desurfaced area increased from 1990 to 17150 ha nearly 8 fold in mere five years (1989 to 1993).

Surface soil samples (0—15) cm were collected from 15 locations representing desurfaced and adjoining normal soils. Soil samples were analysed for their pH, EC, organic carbon available P and K, bulk density and hydraulic conductivity (selected sites only).

Table 1 Number of brick kilns and estimated desurfaced area (ha) in Haryana

Year	Number of brick kilns*	Desurfaced area (ha)
1989	1244	1990
1990	1506	7568
1991	1990	7568
1992	1999	13965
1993	1991	17150

* Source : Directorate of Food and Supplies, Haryana

4 Desurfacing and soil properties

Organic Carbon: Desurfaced decreased organic carbon from 0.47 per cent to 0.31 per cent. The range of organic carbon was 0.30 — 0.73 per cent and 0.22 — 0.43 per cent in normal and desurfaced soils respectively (Table 2). Gollany *et al.* (1992) also reported decrease in organic carbon for desurfaced soils.

Bulk density: Bulk density values for 0—15 and 15—30 cm depths in desurfaced soil were greater than adjoining normal soil (Table 3). Higher bulk density in desurfaced soil may be associated with decrease in organic matter (Peterson, 1964). Greater bulk density for desurfaced plots than the control inspite of annual tillage and incorporation of plant residues for 20 year period following the desurfacing was reported by Gollany *et al*. (1992) and in other studies by Indorante *et al*. (1981) and Bramble – Brodahl *et al*. (1985).

Table 2 Desurfacing and Organic Carbon in Soil

Soil	Organic Carbon (%)	
	Range	Mean
Normal	0.30 — 0.73	0.47
Desurfaced	0.22 — 0.43	0.31

Table 3 Effect of desurfacing on bulk density and hydraulic conductivity of soil

	Bulk density (Mg m^{-3})		Hydraulic conductivity (cm • hr^{-1})	
Depth	Normal	Desurfaced	Normal	Desurfaced
0—15	1.36	1.59	0.86	0.28
15—30	1.51	1.62	0.53	0.37

Hydraulic Conductivity: Saturated hydraulic conductivity of desurfaced soil was lower (0.28 cm • hr^{-1}— 0.37 cm • hr^{-1}) than normal soil (0.53 cm • hr^{-1} — 0.86 cm • hr^{-1}) in 0—15 and 15—30 cm layers (Table 3). It is attributed to the fact that top soil removal changes the resistance of surfaced aggregates to dispersion from energy of rain drops and surface flow which was also reported by Gollany *et al*. (1991) that the stability of aggregates for 30 and 45cm desurfaced plots was lower than 0cm removal plots (normal), Unstable surface aggregates are easily broken down and transported in suspension (E) Hassanin, (1983) which can lead to the formation of crust that inhibit the movement of water and air into the soil.

Available water holding capacity (AWHC): Gollany *et al*. (1992) reported a highly significant (P <0.001) decrease in AWHC with the decrease in top soil depth. The lower available water content in desurfaced plots may be due to additive effect of the lower organic matter content, deterioration of surface soil structure and the reduction of total porosity.

Particle size and $CaCO_3$: Generally there is an increase in clay and $CaCO_3$ contents with depth from surface. Gollany *et al*. (1992) also found higher clay and $CaCO_3$ content for 30 and 45cm desurfaced plots than the 0cm desurfaced plots. This may be due to incorporation by tillage from the underlying horizon or exposure of lower horizons.

Available nutrients: Desurfacing of soil decreased the available phosphorus and potash and differences persisted even upto 16 yrs after desurfacing (Table 4). Lower organic matter and biological activity may cause lower level of available plant nutrients in desurfaced soils.

Table 4 Effect of desurfacing on soil properties

Soil	EC (1:2)	pH (1:2)	O.C. (%)	Av. P_2O_5 (kg • ha^{-1})	Av. K_2O (kg • ha^{-1})
Normal	0.79	8.1	0.48	8.0	564
Desurfaced (16 yrs)	0.15	8.4	0.34	4.0	384
Normal	0.26	8.8	0.49	6.0	400
Desurfaced (3 yrs)	0.4	8.8	0.22	4.0	240
Normal	0.27	7.9	0.73	8.0	800
Desurfaced (2 yrs)	1.05	8.1	0.30	8.0	320

5 Impact of desurfacing on crop production

Crop Growth: Crop growth was affected by desurfacing of soil. Lower plant population (14—26) of Brassica than normal soil (25—42) was observed (Table 5). Gollany *et al.* (1992) reported delayed plant emergence and reduced corn plant population whereas Carter *et al.* (1985) and Pettry *et al.* (1985) reported a significant reduction in plant height on desurfaced soils.

Yield: Yield reduction were observed in desurfaced soils (Table 6) even though soil fertility differences were removed by fertilizer additions) Gollany *et al*., 1992) and the differences were greater in the wet years (1984 and 1986) on desurfaced plots. Topsoil removal not only lowered yield but also reduced the ability of the crop to respond to favourable conditions, whether better landscape position or increased precipitation during the growing season.

Table 5 Impact of desurfacing on population of Brassica plants at different locations

Location	Plant population (m^{-2})			
	Normal		Desurfaced	
	Range	Mean	Range	Mean
(I)	40—43	42	19—30	26
(II)	17—37	25	10—27	21
(III)	32—57	40	13—21	17
(IV)	18—50	34	10—17	14
(V)	34—57	42	13—19	16

Table 6 Effect of removal of 0, 30 cm and 45 cm topsoil on corn grain yield (Gollany *et al*., 1992)

	Corn grain yield ($Mg \cdot ha^{-1}$)		
Year	0cm	30cm	45cm
1984	8.7	7.1	6.5
1985	9.7	9.1	8.4
1986	9.0	8.2	7.6
1987	9.1	8.0	8.1
1988	5.1	4.3	3.9
LSD (0.05) = 1.2 for treatment comparison within each year			

6 Management of desurfaced soils

Desurfacing is considered detrimental for crop production as sub-soil horizons which are generally rich in $CaCO_3$, high in bulk density and poor in organic carbon, available nutrients, biological activity, available water holding capacity are abruptly exposed. Understanding of the dominant factors that limit crop production is the first step in designing appropriate management systems. The regeneration of soil structure by organic amendments and tillage system or their combination is considered appropriate for the management of desurfaced soils. As available nutrient status is invariably poor in desurfaced soils, use of higher doses (25%—50%) of fertilizers and water input than for normal soils may prove beneficial for crop growth. Alternative uses of desurfaced soils for social forestry, soil waste disposal, farm ponds etc. need to be explored.

7 Conclusions

Soil desurfacing by brick kilns for brick making is on exponential increase and a threat to soil protection and soil productivity. Rapid restoration of soil productivity and management of desurfaced soils is of great concern for country like India and warrants due attention from all concerned.

References

Bramble-Brodahl, M., Fosberg, M.A., Walker, D.J. and Falen, A.L. (1985). Changes in soil productivity related to changing topsoil depth on two Idaho Palouse soils.p. 18-27. In Nat. Symp.erosion and soil productivity, ASAE Publ. 8-85. ASAE.St.Joseph, MI.

Carter, D.L., Berg, R.D. and Sanders, B.J. (1985). The effect of furrow irrigation erosion on crop productivity. Soil Sci. Soc. Am.J. 49: 207-211.

El-Hassanin, A.S. (1983). Physical, chemical and mineralogical characteristics of soil vs. erodibility. Ph.D. diss.. Oklahoma State Univ., Stillwater (Diss.abstr.83-25807).

Gollany, H.T., Schumacher,T.E., Evenson, P.D., Lindstrom, M.J. and Lemme, G.D. (1991). Aggregate stability of an eroded and desurfaced Typic Argiustoll. Soil Sci.Soc.Am.J. 55 : 8110816.

Gollany, H.T., Schumacher,T.E., Lindstrom, M.J., Evenson, P.D., and Lemme,G.D. (1992). Top soil depth and desurfacing effects on properties and productivity of a Typic Argiustoll. Soil Sci. Soc.Am.J. 56: 220-225.

Indorante, S.J., Jansen, I.J. and Boast, C.W.. (1981). Surface mining and reclamation : Initial changes in soil character. J.Soil Water Cons. 36 : 347-350.

Larson, W.E., Walsh, L.M., Stewart B.A. and Boelter, D.H., eds. (1981). Soil and Water resources : Research priorities for the nation. Soil Sci. Soc. Am., Madison, Wisc.

Latham, E.E. (1948). Relative productivity of the A horizon of Cecil sandy loam and the B and C horizons exposed by erosion. J.Am. Soc. Agron. 32 : 950-54.

Neill, L.L. (1979). An evaluation of soil productivity based on root growth and water depletion. M.S. thesis Univ. Mo., Columbia.

Peterson, J.B. (1964). The relation of soil fertility to soil erosion. J.Soil Water Cons. 19 : 15-18.

Pettry, D.E., Wood, C.W. and Soileau, J.M. (1985). Effect of topsoil tickness and hirozonation of a virgin coastal plain soil on soybean yields. p. 66-74. In Natl. Symp. Erosion and soil productivity. ASAE Publ. 8-85. ASAE, St. Joseph, MI.

Pierce, F.J., Larson, W.E.., Dowdy, R.H. and Graham, W.A.P. (1983). Productivity of soils : Assessing long-term changes due to erosion. J.Soil Water Const. 38 : 39-44.

Ripley, P.O., Kalbfleishch, W., Boeuget, S.J. and Copper, D.J. (1961). Soil erosion by water, damage, prevention, and control. Ca. Dep.Agri.Publ. no. 1083. Ottawa, ON.

Sadler, J.M. (1984). Effects of topsoil loss and intensive ropping on soil properties related to the crop production potential of a Podzolic Grey Luvisol. Can.J.Soil Sci. 64 : 533-543.

Soil Survey Staff (1951). Soil survey maqnual. Agr. Handbk. No. 18. U.S. Dept Agr., Washington, D.C.