Distribution of Nitrate-N and Soluble Phosphorus in Displaced Wind Erosion Sediments in the Red River Valley

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Soil erosion by wind action is a serious problem in the Red River Valley. Most wind erosion occurs during the winter and spring months when crops are not growing and crop residue cover has been destroyed by excessive fall tillage or removed.

Soils in the Red River Valley are formed from fine and loamy sediments on a level glacial lake plain. Seasonal freezing and thawing, and wetting and drying interact with relatively high organic matter (4-5 percent or more) to form small sized (0.05 to 2.0 mm dia.) aggregates susceptible to wind displacement. Chepil (1945a, b, c) has reported on the processes by which aggregates of fine textured soils are transported.

The displaced sediments generally form dune-like deposits in road ditches, drainage ditches, field depressions and along banks of streams. We have previously reported on the characteristics of these sediments and relationships between sediment characteristics and their calcareousness (presence of free $CaCO_3$) as well as cropping in the field of origin (Cihacek et al., 1992).

The purpose of this report is to show the distribution of nitrate-nitrogen (NO_3-N) and bicarbonate soluble phosphorus (P) found in wind erosion sediments throughout the Red River Valley. Both NO_3-N and P can have an impact on surface and ground water quality in the area of deposition.

Materials and Methods

After several large wind erosion events, we collected sediment samples from dune piles in road or drainage ditches between 19 and 24 May 1988 from 34 sites throughout the Red River Valley. A 2 liter volume of sediment was collected to a depth of about 18 inches below the surface of the sediment pile. A portion of the sediment sample was analyzed for NO_3-N (Gelderman and Fixen, 1988) and soluble P (olsen et al., 1954; Watanabe and Olsen, 1965). Data were plotted by county to see if trends in the NO_3-N or P concentration in the sediments could be related to specific areas of the Red River Valley.

Results and Discussion

Due to drouth conditions across most of the northern Great Plains in 1988, displacement of wind erosion sediments into road and drainage ditches was one of the most severe in recent history (Figure 1). Sediment accumulation

Figure 1. Sediment displaced by wind erosion events fill road and drainage ditches, impede water flow and may impact water quality.

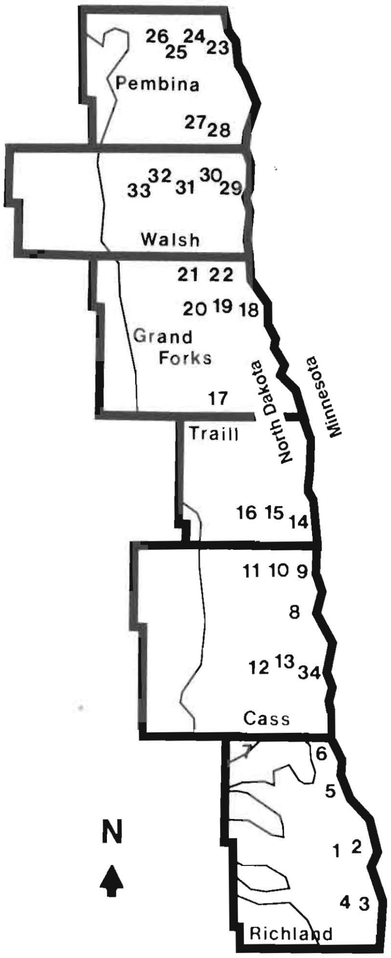

Figure 2. Sampling site locations.

Table 1. Site descriptions and the NO_3-N and P concentration of wind erosion sediment deposits.

Site No.	Soil Series	Sediment Texture	NO_3-N	Soluble P
			ppm	
		Cass County		
8	Fargo/Hegne	Silty clay	79	27
9	Fargo/Hegne	Silty clay loam	72	51
10	Fargo/Hegne	Silty clay loam	45	5
11	Galchutt/Fargo	Clay loam	66	20
12	Fargo	Silty clay loam	44	24
13	Fargo	Silty clay	65	20
34	Fargo	Silty clay	63	19
		Grand Forks County		
17	Arvilla	Fine sand	15	11
18	Bearden/Perella	Silty clay loam	44	18
19	Cashel	Silt loam	219	14
20	Bearden	Silt loam	343	14
21	Bearden	Silt loam	64	14
22	Bearden	Silt loam	111	22
		Pembina County		
23	Bearden	Silty clay loam	149	12
24	Bearden	Silt loam	150	19
25	Hegne/Fargo	Silty clay	92	34
26	Bearden/Glyndon	Very fine sandy loam	58	8
27	Hegne/Fargo	Silty clay loam	37	11
28	Hegne/Fargo	Silty clay loam	113	27
		Richland County		
1	Fargo	Silt loam	14	15
2	Ryan/Fargo	Silt loam	65	26
3	Bearden/Glyndon	Silt loam	64	11
4	Antler/Tonka	Silt loam	89	14
5	Fargo	Silty clay loam	38	25
6	Fargo/Hegne	Silty clay loam	100	23
7	Overly	Loam	150	30
		Traill County		
14	Fargo	Silty clay loam	149	35
15	Bearden/Lindaas	Silty clay	125	14
16	Bearden	Silty clay loam	101	21
		Walsh County		
29	Hegne/Fargo	Silty clay loam	171	19
30	Hegne/Fargo	Silty clay loam	52	19
31	Glyndon	Silt loam	279	19
32	Bearden	Silty clay loam	274	39
33	Overly/Bearden	Loam	66	28

ranged from several inches to several feet deep along the borders of entire fields.

Locations of the sampling sites are shown in Figure 2. The thin line passing through the western edges of the counties in Figure 2 and subsequent figures denotes the western boundary of the Red River Valley in relation to the sampling sites. The sediment textural classes ranged from fine sand to silty clay with silt loam and silty clay loam being the predominant textures (Table 1).

Table 1 also shows the corresponding sediment NO_3-N and P concentrations for each sampling site. Nitrate ranged from 14 to 343 ppm N (avg 105 ppm, standard deviation ± 76 ppm) and P ranged from 5 to 51 ppm (avg 21 ppm, standard deviation ± 9 ppm). Field samples were collected to a depth of 3 inches (7.5 cm) from upwind locations with respect to the sediment sample collection. Enrichment ratios, calculated by dividing the sediment nutrient concentration by the field soil nutrient concentration, were 2.7 and 1.6 for NO_3-N and P, respectively.

The distribution of the samples of NO_3-N concentrations is shown in Figure 3. The lowest concentrations appeared most frequently in Cass and Richland counties. Three counties had average sediment NO_3-N concentration greater than 100 ppm N and three had 100 ppm N or less (Figure 4). Cass, Pembina and Richland counties had county averages of 62, 100 and 74 ppm NO_3-N in the sediment, respectively while Grand Forks, Traill, and Walsh counties averaged 132, 125 and 168 ppm NO_3-N, respectively.

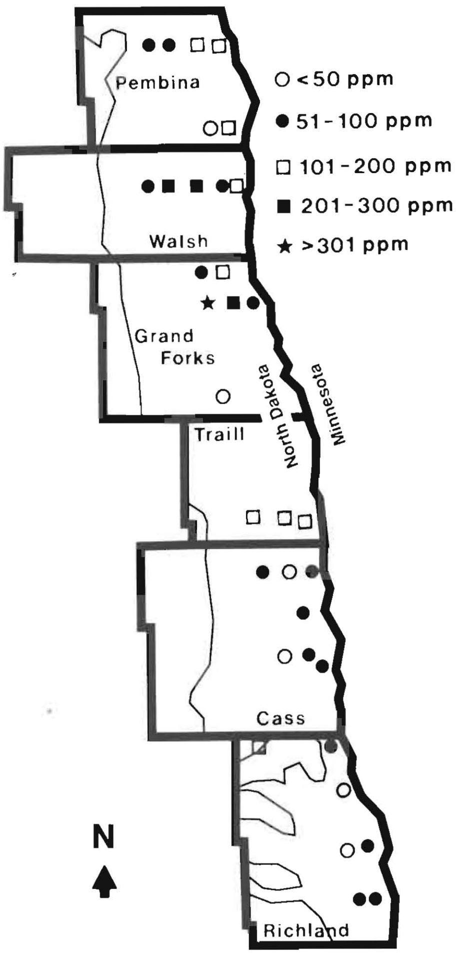

Figure 3. Nitrate-N concentrations in wind erosion sediments by site.

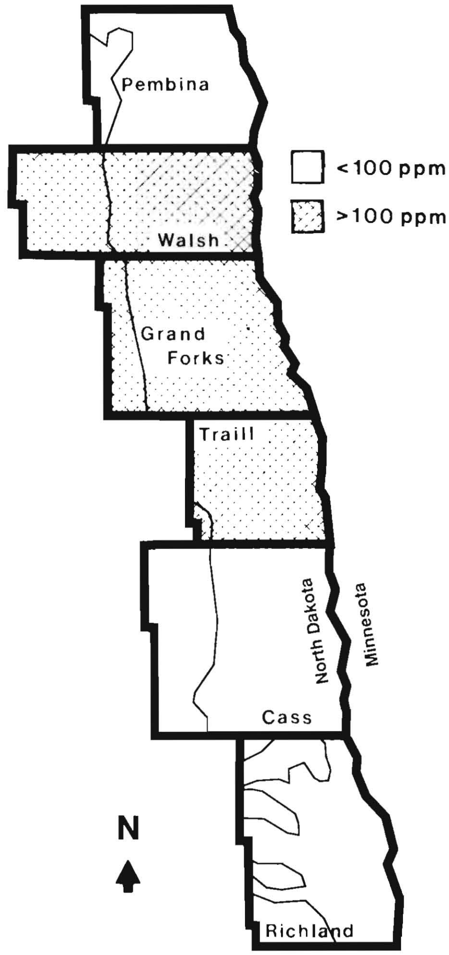

Figure 4. Counties with average NO_3-N levels greater than 100 ppm.

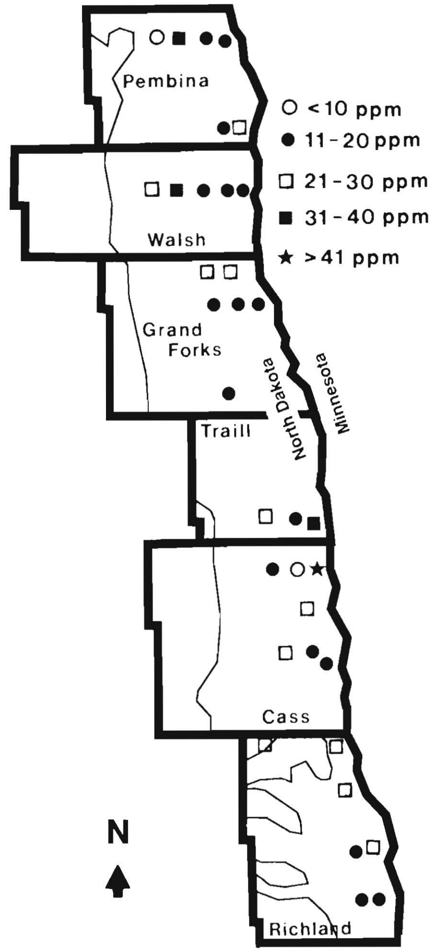

Figure 5. Soluble P concentrations in wind erosion sediments by site.

Phosphorus concentration distributions in the sediments are shown in Figure 5. Phosphorus concentrations appeared to be relatively uniformly distributed throughout the six county area. Only Grand Forks and Pembina counties had average sediment concentrations of less than 20 ppm with 17 and 18 ppm, respectively (Figure 6). Cass, Richland, Traill and Walsh counties all had P averages of greater than 20 ppm with levels of 24, 21, 23 and 24 ppm P, respectively.

We previously reported significant differences in NO_3-N and P between calcareous and non-calcareous sediments (Cihacek et al., 1992). We have also noted that sediments from sugarbeet and small grain fields tend to be higher in NO_3-N than soybean, edible bean or fallow fields and that sediments from small grain and edible bean fields tend to be higher in P. This indicates that soil fertility management may play a key in the amount of NO_3-N or P that are found in wind displaced sediments.

Summary

Nitrate-N and P are found in greater quantities in wind displaced sediments than in field soils after a series of major wind erosion events. The impact of these enriched sediments on surface and ground water quality is not clear. However, these sediments do have a serious impact on the filling of road and drainage ditches and require periodic cleaning of ditches by producers, counties or drainage districts.

If impacts on the quality of surface or subsurface water do occur, these impacts will depend on (a) the quality of the sediment displaced into drainageways; (b) the quantity of displaced sediment; (c) the frequency and quantity of precipitation following wind erosion events; (d) the volume and flow of drainage or stream water; (e) the amount of NO_3-N denitrification and P solubilization and utilization by vegetation in the drainageways; and (f) the rate of groundwater recharge.

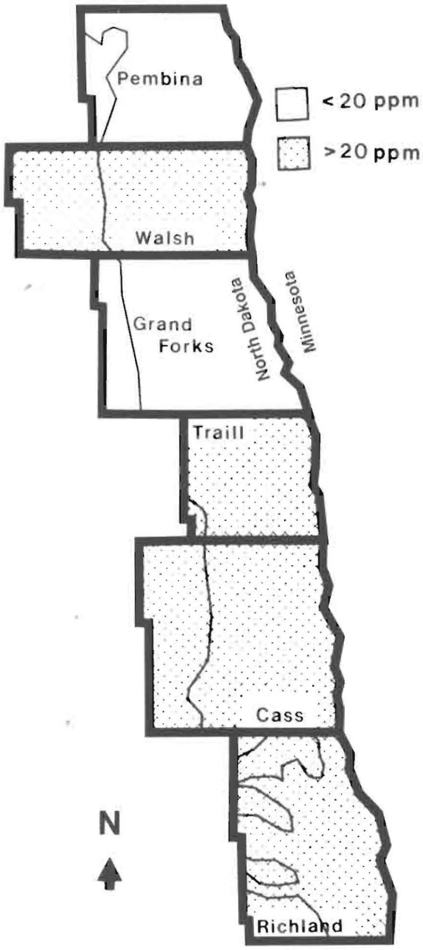

Figure 6. Counties with average soluble P levels greater than 20 ppm.

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References

Chepil, W.D. 1945a. Dynamics of wind erosion. I. Nature of movement of soil by wind. Soil Sci. 60:305-320.

Chepil, W.D. 1945b. Dynamics of wind erosion. II. Initiation of soil movement. Soil Sci. 60:397-411.

Chepil, W.D. 1945c. Dynamics of wind erosion. III. The transport capacity of the wind. Soil Sci. 60:475-480.

Cihacek, L.J., M.D. Sweeney, and E.J. Deibert. 1992. Characteristics of dune sediments displaced by wind erosion events in eastern North Dakota. p. 121-127. In Proceedings of the North Dakota Water Quality Symposium, Bismarck, ND. 25-26 March 1992. NDSU Extension Service.

Gelderman, R.H. and P.E. Fixen. 1988. Recommended nitrate-N tests. p. 10-12. In W.C. Dahnke (ed.) Recommended soil test procedures for the North Central Region. North Central Regional Publication 221 (Revised). North Dakota Agricultural Experiment Station Bulletin 499 (Revised).

Olsen, S.R., C.U. Cole, R.S. Watanabe, and L.A. Dean. 1954. Estimation of available phosphorus in soils by extraction with sodium bicarbonate. USDA Cir. 939:1-19.

Watanabe, F.A. and S.R. Olsen. 1965. Test of an ascorbic acid method for determining phosphorus in water and $NaHCO_3$ extracts from the soil. Soil Sci. Soc. Amer. Proc. 29:677-678.

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