PLAYA WATER QUALITY FOR GROUND-WATER RECHARGE AND USE OF PLAYAS FOR IMPOUNDMENT OF FEEDYARD RUNOFF[1/]

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Playa Water Quality for Ground-water Recharge

The Ogallala aquifer, the only large source of water for all uses in the Texas High Plains, is being rapidly depleted. Failure to supplant this water source, and to optimize the use of existing regional water supplies, will result in drastic curtailment of irrigated agriculture. Water importation is considered by many to be the ultimate solution to regional water supply problems; however, importation is a long-range goal, and more immediate attention should be given to the best uses for available water. One source of water not being fully utilized is runoff that collects in nearly 17,000 playas on the Texas High Plains.

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The playas are natural basins which catch an estimated 2 to 3 million acre-feet of runoff annually from approximately 22 million acres (2). Most of this water is lost by evaporation because little percolation occurs through the very slowly permeable playa bottoms. About 5.5 million acres in the region are irrigated. If all the estimated runoff could be conserved it would furnish nearly 0.5 foot of water for each irrigated acre. However, evaporation rates are high, and fresh runoff in playas cannot be immediately pumped to an already saturated watershed. Thus, maximum conservation of water from precipitation must include an alternative to direct irrigation from the playas. Maximum conservation of all available water in the Texas High Plains (including precipitation) may have to provide for 'water harvesting' from least productive acres, and modification of playas to reduce the areas exposed to evaporation. Recharge of the Ogallala through surface spreading basins (pits) also shows much promise as a tool in water conservation.

Reports from regional studies indicate that playa water is of excellent quality for most uses (5), and, if adequately clarified, it can be used to recharge the Ogallala aquifer through wells (2). A subsequent study of playa water quality changes during impoundment reported similar conclusions (4). Water samples from five playas were analyzed at intervals for 24 days following runoff from a single storm. Playa water was of better quality than Ogallala water for many uses because it had a lower pH, less total dissolved solids, and less nitrate (Table 1). Higher chemical oxygen demand and more suspended solids in playa water can make it less desirable than Ogallala water, but these factors can be corrected by proper treatment.

Impoundment of Feedyard Runoff in Playas

The cattle feeding industry on the Texas High Plains has grown tremendously in just a few years. In September 1970, nearly one million cattle were on feed in the region. Most of the cattle were located in 67 feedyards which had individual capacities of from 5,000 to 90,000 animals. Thirty-six of the yards had individual capacities of 20,000 or more animals. Concentration of so many cattle in small areas has created waste-handling difficulties. One immediate problem facing the feeding industry is the prevention of surface water pollution. Many feedyards on the Texas High Plains have solved this problem by discharging runoff into nearby playas.

Playas are isolated, natural retention basins which prevent runoff to other surface waters. Playa bottoms have low permeability that may become even lower following exposure to feedyard runoff. A report from Kansas stated that addition of feedyard wastes to undisturbed cores of four soils reduced percolation rates to 3 percent of original values (6). The decreased flow rate was attributed, at least in part, to concentration of exchangeable monovalent cations in the surface 0-3 inches of each core.

Although permeability of playa soil may be reduced by feedyard wastes, the potential threat to ground water beneath feedyard playas in the Texas High Plains has not been adequately investigated. Also, some feedyards depend solely on excavated basins for retention of runoff, and recent work on recharge of the Ogallala through basins showed that the exposed material (Pleistocene) was much more permeable than overlying materials (1). Therefore, the use of excavated basins for retention of feedyard runoff may enhance the threat to ground water. A lack of information in the general area of potential pollution by feedyards in the Texas High Plains has generated several preliminary studies.

A report of seepage below a feedyard playa in the Texas High Plains is available (3). Most of the playa was covered with feedyard runoff for from 60 to 120 days. Soil samples were taken at various locations across the playa by 1-foot increments to maximum depths of 13 feet (Figure 1). Only sites No. 1 through No. 8 were covered with feedyard runoff. Soil chemical analyses showed a buildup of nitrate and ammonium in the surface foot at sites No. 1 through No. 8, but only traces were found below the top 2 feet at all sites (Table 2).

Traces of nitrite in the surface foot at the lowest elevations (data not given) indicated that nitrate was reduced to nitrite under very wet, anaerobic conditions. Apparently, substantial quantities of nitrogen were lost from feedyard runoff, and from the playa soil, by such processes as anaerobic reduction of nitrate, fixation of ammonium by organisms, and volatilization of ammonium to the atmosphere. These results indicate that a minimal amount of nitrogen will seep through playa bottoms.

Chloride moves readily in soil water but no buildup was found below a depth of about 4 feet even at the lowest elevations (Table 2). This indicates that runoff constituents impounded for as much as 120 days traveled about 4 feet into the profile. Further downward movement of feedyard wastes would be difficult to predict because it is primarily dependent on frequency and amount of future runoff. This study (3) was an indirect estimation of seepage below a feedyard playa based on soil chemical analysis. Therefore, it was decided to bring large, undisturbed soil cores into the laboratory for a more controlled measurement of seepage potentials.

Partial results are available from the laboratory study of seepage through undisturbed cores of playa surface soil (Randall clay) and through the Pleistocene material underlying the clay[3/]. The Pleistocene is usually exposed when runoff basins are excavated. Using clear Ogallala water, the average permeability (K_t) values for duplicate cores were 0.10 inch/day for the clay and 38 inches/day for the Pleistocene (Figure 2). Since the Pleistocene cores were treated at different times, the K_t values are shown separately in Figure 2. Addition of feedyard runoff to the cores reduced permeabilities to averages of 0.02 inch/day for the clay and 0.06 inch/day for the

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3/ Unpublished data, O. R. Lehman and V. S. Aronovici, USDA, Southwestern Great Plains Research Center, Bushland, Texas.

Pleistocene. Chemical oxygen demand and chloride analyses of core effluent showed that the Pleistocene material transmitted the large amounts of constituents in feedyard runoff (Table 3).

Few, if any, serious salinity problems have arisen in the Texas High Plains due to irrigation with Ogallala water. However, feedyard runoff contains much more dissolved solids than Ogallala and natural playa waters (Table 1). Since salts tend to concentrate in the surface soils of feedyard playas there is a definite soil-salinity hazard if feedyard wastes are pumped from playas to adjacent lands. There is also a possibility that feedyard wastes used for irrigation will percolate deeper through agricultural soils than through playa soils. These potential problems deserve more attention.

Summary

An estimated 2 to 3 million acre-feet of annual runoff in the Texas High Plains could be conserved for beneficial uses. Maximum efforts should be made to conserve ground water and all water available from precipitation.

The use of playas to impound feedyard wastes prevents runoff to other surface waters. Preliminary results indicate that feedyard wastes in playas present no immediate threat to ground water; however, since playa physical properties vary, each playa must be judged on its own merits.

The Pleistocene material underlying most High Plains soils is much more permeable than playa clay. Exposed Pleistocene material therefore poses a greater threat to ground water if it is used to impound feedyard wastes.

Literature Cited

1. Aronovici, V. S., Arland D. Schneider, and Ordie R. Jones. Basin recharging the Ogallala Aquifer through Pleistocene sediments. Proceedings, Ogallala Aquifer Symposium, April 30-May 1, 1970, Lubbock, Texas (in press).

2. Hauser, Victor L., and Donald C. Signor. Water conservation and ground-water recharge research. Tex. Agri. Expt. Sta. Misc. Pub. MP-850. 1967.

3. Lehman, O. R., B. A. Stewart, and A. C. Mathers. Seepage of feedyard runoff water impounded in playas. Tex. Agri. Expt. Sta. Misc. Pub. MP-944. February 1970.

4. Lehman, Oliver R., and Victor L. Hauser. Playa water quality changes with time and effects on clarification. Water Resources Research, Vol. 6. pp. 1420-23. October 1970.

5. Lotspeich, F. B., V. L. Hauser, and O. R. Lehman. Quality of waters from playas on the Southern High Plains. Water Resources Research, Vol. 5. pp. 48-58. 1969.

6. Travis, David O. Effects of feedlot effluent on four Kansas soils. Agron. Abstracts, Amer. Soc. Agron. Detroit, Mich. November 1969.

Table 1.--Water quality comparisons for the Ogallala, playas, and feedyard runoff.

Source	pH	Conductance* (25° C)	NO_3^-	COD	Suspended solids	Cl^-
		mmhos	ppm			
Ogallala	7.5	0.50	5-10	0	0	5
Playas†	7.0 (7.4)	0.12 (0.22)	2 (0.25)	42 (26)	980 (810)	5 (8)
Feedyard runoff‡	8.0	5.8	-	2200	-	1000

*Conductance in millimhos X 640 = approximate dissolved solids in ppm (the factor '640' is less reliable when dissolved solids are 2000 to 3000^+ ppm, or if water has a high Cl^- content).

†Fresh runoff, values in parenthesis are after 24 days of impoundment.

‡Values will vary widely with source and runoff event.

Table 2.--Seepage of nitrogen and chloride below a feedyard playa

Depth	Low Elevations (Sites 1-8) NO_3^--N	Low Elevations (Sites 1-8) NH_4^--N	Low Elevations (Sites 1-8) Cl^-	High Elevations (Sites 9-11) NO_3^--N	High Elevations (Sites 9-11) NH_4^--N	High Elevations (Sites 9-11) Cl^-	Non-feedyard Playa NO_3^--N	Non-feedyard Playa Cl^-
feet	ppm							
1	200*	16	300	1.2	3	90	8	140
2	6	6	250	0.3	3	60	3	110
3	3	5	140	0.1	3	50	3	50
4	1	4	100	0.1	1	20	2	30
5	2	3	40	0.3	1	30	-	-
6	2	3	50	0.1	1	20	-	-

*All values in table are average for number of sites sampled.

ble 3.--Chemical analysis of effluent from undisturbed cores of playa clay and Pleistocene material

Core aterial	Water used	COD	Chloride
		ppm	
laya clay	Ogallala	40	15
	Feedyard	40	25
		*(50)	*(50)
leistocene	Ogallala	40	40
	Feedyard	800	800
		*(40)	*(650)

*After 70 to 100 days of continuous exposure to feedyard runoff.

Figure 1.--Playa soil sampling sites and relative elevations, Randall County Feedyards.

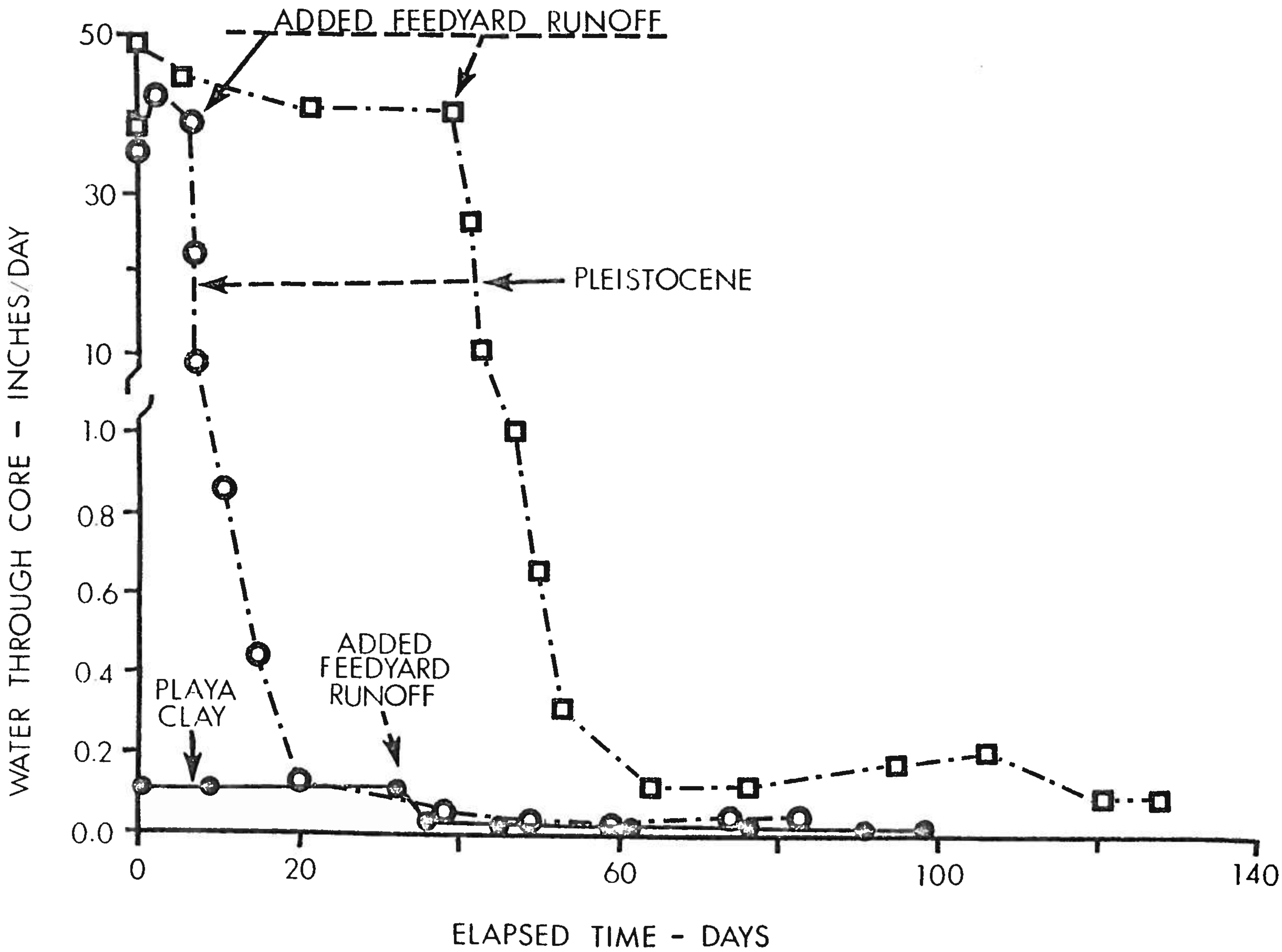

Figure 2.--Permeability (K_L) of playa clay and Pleistocene cores with time (water through core = K_L).