PHOSPHORUS LEVELS IN SOILS OF SELECTED LAKE OKEECHOBEE WATERSHED DAIRIES[1]

Donald A. Graetz

Soil Science Department
Institute of Food and Agricultural Sciences
University of Florida
Gainesville, Florida

INTRODUCTION

Lake Okeechobee is the 4th largest lake in the United States with a surface area of 1890 km^2. Aquatic weed and algae problems are threatening the value of the lake for recreational uses such as fishing and hunting. Recent studies point to phosphorus as the limiting nutrient in the lake. Additional studies indicated that tributary watersheds with large numbers of cattle are primary contributors to the phosphorus loading of the lake. There are 41 dairies with an average of 700 cattle each in the Lake Okeechobee watershed. The State of Florida has passed a "DAIRY RULE" which has made it mandatory for dairy farmers in the watershed to reduce and eliminate, where possible, phosphate runoff from their farms. The South Florida Water Management District concurrently has initiated a series of research projects to aid the farmers in development of alternative management practices in order to respond to the Dairy Rule. Preliminary results of one such project entitled "Biogeochemical Behavior and Transport of Phosphorus in the Lake Okeechobee Basin" are presented herein.

The objective of this study was to determine existing levels of water-soluble, double-acid (0.05 M HCl in 0.025 M H_2SO_4) extractable and total phosphorus in soils of selected dairies in the watershed. The data will be used in an overall modelling effort being undertaken to quantify the fate of phosphorus in the Lake Okeechobee watershed and its potential transport to the lake.

SITE SELECTION

Six sites were selected for intensive soil sampling (Table 1). Four of the sites represented dairies ranging in age from 3 to 32 years. Four components of each dairy were sampled, i.e., intensive, holding, pasture and forage areas (Table 2). Areas next to the barn where cattle are held prior to milking and for some feeding were termed intensive areas. These areas were generally void of vegetation. Holding areas were generally larger areas near the barns and are used for feeding and holding cattle overnight. These areas were generally grass-covered except for around feeding bunks. Pastures were used for grazing and forage areas for forage production. Two areas not affected significantly by

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man's activities, termed native areas, were sampled to represent background conditions. In addition, two beef pastures and one citrus grove were included in the sampling program. Six soil profiles were sampled in each of the components.

SOIL DESCRIPTIONS

Three soil types were represented in the sites selected, i.e., Myakka, Immokalee, and Pomello fine sands (Table 1). All were sandy siliceous, hyperthermic Arenic Haplaquods. The soils are commonly known as flatwood soils. The soils were formed in thick beds of sandy marine deposits. Slopes ranged from 0 to 2%. The water table is at a depth of less than 25 cm for 1 to 4 months during most years and recedes to a depth of 100 cm during dry seasons.

Each soil consists of four primary horizons. The A (surface) horizon was sandy with small amounts of organic matter and generally had a depth of 15 to 20 cm. The E horizon was immediately below the A horizon with a thickness of several centimeters depending on soil type. The Bh horizon, below the E horizon, is a dark colored horizon commonly known as a "hard pan" layer. This horizon is generally thought to have a high retention capacity for phosphorus. The primary difference between the soils is the depth of the spodic horizon (Bh) with this horizon occurring at approximately 40, 75 and 140 cm for the Myakka, Immokalee and Pomello soils, respectively. The Bw horizon occurs below the spodic horizon. Generally only the upper portion of the Bw horizon was sampled. All soils were sampled to a depth of at least 150 cm (1 cm = 2.54 inches).

METHODOLOGY

Water-soluble phosphorus was extracted using a 1:4 soil:water ratio by shaking for 1 hour. Double-acid extractable (0.05 M HCl in 0.025 M H_2SO_4) phosphorus was extracted using a 1:4 soil:double-acid ratio by shaking for 15 minutes. Total phosphorus was determined by digestion with 3 ml concentrated H_2SO_4 containing 1 gm of 9:1 K_2SO_4:$CuSO_4$ catalyst. Soluble reactive phosphorus was determined in all extracts using the ascorbic acid method.

RESULTS

Selected information on the three forms of soil phosphorus extracted will be presented to show the trends observed in the overall data base. Water-soluble phosphorus represents the amount of phosphorus which is likely to be leached when water movement occurs with in the soil profile. Double-acid extractable phosphorus is used by the IFAS Extension Soil Testing Laboratory as an indicator of plant-available phosphorus. Total phosphorus represents all forms of organic and inorganic phosphorus.

A summary of the data for all sites is given in Table 3. Levels of water-soluble phosphorus in the A horizon of the native areas were less than 1 mg/kg (mg phosphorus/kg soil) compared to an average of 4, 13, 68 and 89 mg/kg in the forage, pasture, holding and intensive areas, respectively. Double-acid extractable phosphorus levels in the A horizon of the native areas were less than 2 mg/kg compared to 10, 31, 575 and 557 mg/kg in the forage, pasture, holding and intensive areas, respectively. A similar trend was observed with total phosphorus levels in the A horizon.

The E horizon is a white, sandy horizon with little phosphorus retention capacity. It contained considerably less of all 3 forms of phosphorus than the A horizon. However, the trend between components was similar to the A horizon. The Bh (spodic) horizon retained higher levels of the 3 forms of phosphorus than the E horizon, however, phosphorus levels in the Bh horizon were considerably lower than in the A horizons. The trend of phosphorus levels between components was again similar to the A and E horizons, i.e., native < forage < pasture < holding < intensive areas. Overall, there did not appear to be a significant amount of phosphorus accumulating below the Bh horizon, i.e., in the Bw horizon. This may be due to either a limited amount of vertical water movement through the Bh horizon or to the ability of the Bh horizon to retain phosphorus.

Beef pastures and a citrus grove contained phosphorus levels slightly above background levels and approximately equal to phosphorus levels in the dairy pasture and forage areas. From the limited amount of sampling of beef pastures and citrus groves, it appears that they should not significantly contribute to phosphorus loading to the streams in the watershed.

Water-soluble phosphorus was generally 5 to 10% of total phosphorus. Double-acid extractable phosphorus was generally 50% or greater of total phosphorus in the intensive areas and 15 to 25% in the forage and pasture areas. Both of these forms of phosphorus may be potential contributors to "leachable" phosphorus.

Phosphorus levels in the intensive areas of the four dairies are shown in Table 4 to illustrate the apparent effect of dairy age on phosphorus accumulation. The 3-year old dairy generally had lower levels of all 3 forms of phosphorus in the A horizon than the 8-, 20- and 32-year old dairies. The two older dairies had similar levels of phosphorus in all horizons. Phosphorus accumulation appeared to reach steady-state levels in the 8-, 20- and 32-year old dairies. However, factors in addition to dairy age, such as differences in cattle stocking rates over the years may be reflected in these numbers.

CONCLUSIONS

Intensive and holding areas of each dairy accumulated substantially greater amounts of phosphorus in all horizons compared to pasture and forage areas. The 3-year old dairy generally had lower levels of phosphorus than the older dairies. Significant amounts of this phosphorus was in the water-soluble and double acid-extractable forms which makes it potentially available for leaching. It appears that beef pastures and citrus groves should not significantly contribute to phosphorus loading to the streams in the watershed.

Florida's "Dairy Rule" states that runoff from intensive areas must be collected and retained on the farm. Some dairymen are constructing perimeter ditches around the intensive areas and pumping the runoff water into a lagoon. The water from the lagoon is then applied to forage areas through center pivot irrigation systems. Based on the levels of phosphorus in the A horizons of the intensive areas, this could have a significant impact on reducing the amount of phosphorus leaving the dairy through drainage. It should also be noted, that as defined herein, both intensive and holding areas contain high levels of phosphorus in the soil and should be considered for inclusion within the perimeter ditch.

TABLE 1. Soil series and dairy age of sampling sites selected for determination of soil phosphorus level.

Sampling Site	Soil Series	Dairy Age
W. F. Rucks Dairy	Myakka	3 yrs
C and M Dairy	Myakka	8 yrs
Larsen #6 Dairy	Pomello	20 yrs
Dry Lake #1 Dairy	Immokalee	32 yrs
Williamson Ranch	Immokalee	
Bass Ranch	Myakka	

TABLE 2. Components sampled for each sampling location.

W. F. Rucks	C and M Dairy	Dry Lake #1
Intensive	Intensive	Intensive
Holding	Holding	Holding
Pasture	Pasture	Pasture
Forage	Forage	Forage
Native		
Larsen #6	**Williamson Ranch**	**Bass Ranch**
Intensive	Beef Pasture	Beef Pasture
Holding	Citrus	
Pasture	Native	
Forage		

TABLE 3. Soil phosphorus levels averaged over all sampling locations.

Horizon	Component	WS-P†	DA-P†	TP†
		----------mg/kg----------		
A	Intensive	89	557	1360
	Holding	68	575	1070
	Pasture	14	31	235
	Forage	4	10	67
	Beef Pasture	2	10	79
	Citrus	2	69	236
	Nature	<1	2	41
E	Intensive	12	48	62
	Holding	13	51	120
	Pasture	2	7	31
	Forage	<1	3	27
	Beef Pasture	<1	2	28
	Citrus	<1	10	39
	Native	<1	1	18
Bh	Intensive	19	143	210
	Holding	13	74	171
	Pasture	4	65	122
	Forage	<1	18	75
	Beef Pastures	2	29	111
	Citrus	*	*	*
	Native	<1	5	73
Bw	Intensive	8	38	66
	Holding	4	19	99
	Pasture	<1	8	51
	Forage	<1	9	61
	Beef Pasture	<1	41	161
	Citrus	*	*	*
	Nature	<1	7	64

†WS-P, DA-P, and TP = water-soluble, double acid-extractable, and total phosphorus, respectively.

*Horizon not present.

TABLE 4. Soil phosphorus levels for the intensive areas of four Lake Okeechobee dairies compared with the phosphorus level of a native area.

Horizon	Component	WS-P†	DA-P†	TP†
		----------mg/kg----------		
A	Rucks (3)*	69	201	364
	C&M (8)	110	376	1842
	Larsen #6 (20)	87	840	1360
	Dry Lake #1 (32)	89	813	1860
	Native (Rucks)	0.7	1.6	40
E	Rucks	11	16	40
	C&M	20	105	108
	Larsen #6	9.0	12	25
	Dry Lake #1	7.4	59	85
	Native (Rucks)	0.1	0.8	11
Bh	Rucks	4.2	42	113
	C&M	28	117	278
	Larsen #6	32	246	263
	Dry Lake #1	12	169	185
	Native (Rucks)	<0.1	4.6	103
Bw	Rucks	6.2	34	71
	C&M	14	75	119
	Larsen #6	11	25	35
	Dry Lake #1	2.3	16	41
	Native (Rucks)	<0.1	8.4	87

†WS-P, DA-P, and TP = water-soluble, double acid-extractable, and total phosphorus, respectively.

*Dairy age (years).