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PHOSPHORUS RELEASE AND RETENTION POTENTIAL OF CONSTRUCTED WETLANDS IN THE EMERALDA MARSH CONSERVATION AREA

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EXECUTIVE SUMMARY

The long-term effectiveness of wetland soils to retain nutrients, particularly phosphorus (P), depends on the physical, chemical, and biological processes that occur after flooding. Nutrient retention by wetlands created on lands previously used for agriculture also depends on the past management practices including crops grown and fertilizers applied. Phosphorus applied accumulates in soils, and as a result of several years of fertilization, agricultural lands generally have substantial amounts of bioavailable P. Upon flooding these soils, it is likely that the bioavailable P is readily released into the overlying water column. Several soil types including organic muck and sandy soils exist in the former farms of the Emeralda Marsh Conservation Area (EMCA), particularly in the Lake Griffin flow-way. The differences in soil type may influence the breakdown of organic matter and release or retention of P. The biogeochemical processes regulating water quality in constructed (Lake Griffin flow-way) and natural wetlands are the same, although the magnitude and rates of each of these processes may be different.

The objectives of the study were to: (i) quantify the potential P mobility and sink size of recently flooded soils, (ii) determine the time period before the existing soil horizons can function as net P sinks, and (iii) determine the long-term P storage, based on retention capacity of soils.

The first objective was to *quantify the potential P mobility and sink size of recently flooded soils.* There is a large variation throughout the flow-way in the bioavailability and mobility of P. For example, soil bioavailable P, as estimated by Fe oxide strip-extractable inorganic P, ranged between 4 and 70 mg kg^{-1}. Potentially mobile inorganic P ranged between

11 and 171 mg kg^{-1}. For all soils cumulative inorganic P correlated well ($r^2 = 0.67$) with the bioavailable P. From 2 to 20% of total P was in a potentially mobile, bioavailable form in the flow-way soils. Variability in P-sink size among soils (phosphorus sorption index, approximately 4-fold, from 94 to 380 L kg^{-1}) was less than that in P bioavailability and mobility (approximately 15-fold for bioavailable and potentially mobile P). Following removal of potentially mobile P, P-sink size increased in all soils. However, the increases were highly variable. Organic matter content among soils varied widely (10 to 64%). Neither P status nor P-sink size were related clearly with organic matter content. For example, both organic (>20% organic matter) and mineral (<20% organic matter) soils showed large variation in all P-related variables. However, the largest extremes were observed in the organic soils.

The second objective of the study was *to determine the time period before the existing soil horizons can function as net P sinks*. This was accomplished by conducting laboratory and field studies at selected locations to determine the steady P flux (total P, labile P, and non-labile P) from soil to the overlying water column. Labile P is distinquished from other P forms in that it is soluble and bioavailable. Total P, labile P, and non-labile P decreased with soil depth. Soils used in the study contain approximately 40% of inorganic P and 60% as organic P. About one-half of the inorganic P was labile, suggesting a potential for long-term release. Past fertilizer application practices resulted in large accumulation of labile inorganic P. About one-third of organic P was labile, suggesting high microbial activity in the soils.

Laboratory P flux studies have shown that the P release was rapid after flooding, and soluble reactive P concentration reached a steady value of approximately 0.2 mg L^{-1} in the water column. This suggests that steady flushing of floodwater with shorter residence time, less than the 35 days used in this study) may deplete labile soil P rapidly, and reduce long-term release. Although soils of the EMCA have high mineral matter compared to other wetland sites created on agricultural lands (such as ENR in south Florida), the P flux was in the same order of magnitude.

The third objective of the study was *to determine the long-term P storage, based on retention capacity of soils*. After approximately 25-30 weeks of flushing with low P water (SRP = < 0.01 mg L^{-1}), soils continued to release P steadily to the water column. However, when soil cores were loaded with high P floodwater (especially 1.0 and 5.5 mg L^{-1}), net P retention occurred. The EPC_w values (defined for floodwater P concentration when P release by underlying soil equals P retention by that soil) determined for soil cores at four stations were variable, and were in the range of 0.07 to 0.43 mg L^{-1}. This suggested that these soils will release P, as long as the floodwater P concentration is lower than these values. During 30 weeks of flushing with low P water, P release rates from soils were in the range of 0.25 to 1.62 mg P m^{-2} day^{-1} for soluble P, and 0.34 to 2.4 mg P m^{-2} day^{-1} for total P. These slow release rates are in the same range as those observed under field conditions as measured by using porewater equilibrators. At these release rates, the surface 15-cm soil has a supply of labile P that will last for 30-140 years. However, the labile P may be reduced by decreasing retention time of the overlying water column and by other biological processes, such as microbial activity. The addition of chemical amendments and stabilization of soil porewater P with emergent and submerged vegetation are other approaches used to immobilize labile P.

Based on laboratory and field sample analyses conducted in this research, the Lake Griffin flow-way soils are highly variable in physical and chemical characteristics, but generally reflect the altered nature of flooded agricultural soils that have large accumulation of P. Additional research should be conducted to determine the influence of rapid floodwater replenishment on P removal from the soil. Influence of vegetation (both emergent and submerged) on stabilization of soil porewater P needs further investigation. This information is critical in developing best management practices for these recreated wetlands to maintain acceptable water quality.

1.0. INTRODUCTION

Phosphorus (P) assimilation and storage in wetlands is influenced by physical, chemical and biological processes. The interactions among these processes and P cycling during decomposition of organic matter in wetlands to a large degree may determine the productivity and water quality of the ecosystem. The biogeochemical processes regulating water quality in constructed (Lake Griffin flow-way) and natural (Emeralda Marsh) wetlands are the same, although the magnitude and rates of each of these processes may be different.

Several soil types including organic muck and sandy clay soils, exist in the former farms of the Emeralda Marsh Conservation Area (EMCA), particularly in the Lake Griffin flow-way. The differences in the soil type may influence the breakdown of organic matter, release and retention of P. Flooding these soils will alter the redox conditions, thus solubilizing P. The overall objectives of this study was to determine the capacity of the EMCA soils to retain or release P. The specific objectives of this study were to: (i) quantify the potential P mobility and sink size of recently flooded soils, (ii) determine the time period before the existing soil horizons can function as a net P sink; and (iii) determine the long-term potential P storage based on retention capacity of these soils.

1.1 Site Description

The Emeralda Marsh Conservation Area (EMCA) is located in the Upper Ocklawaha River Basin, east of Lake Griffin in Lake County, Florida. Prior to drainage (before 1940's), this area supported sawgrass marshes, wet prairies, and other shallow marsh vegetation. This area was drained and used for agriculture until recently. The St. Johns River Water Management District purchased the farms in this area, in an effort to restore these lands to wetlands (Marburger and Godwin 1996).

2.0 SPATIAL DISTRIBUTION OF SOIL PHOSPHORUS [Task 2 as per contract]

The soils of EMCA vary in texture and physico-chemical properties. Soil types including organic muck, and sandy clay soils exists in the former farms in this area. To determine the P retention/release capacity of these soils, it is necessary to have a measure of spatial variability with regard to pertinent chemical and physical characteristics. The objective of this task was to evaluate the spatial variability associated with P species and soil characteristics which may affect retention or release.

2.1. Materials and Methods

2.1.1 Soil sampling

Soils were sampled in the Lake Griffin flow-way at 24 sites. For practical reasons and to improve sample reproducibility, sampling was restricted to areas with water depth of less than 130 cm. The sites were located close to five transects that ran in an approximate east-west direction. Deviation from linearity along each transect was necessary, to avoid sampling too close (< 5 m) to ditches, canals, or levees, and also to maximize soil variability among the sites. The geographic position of the field sites were determined with a Magellan 5000 D GPS receiver, equipped with a differential beacon receiver. The GPS equipment allowed positional accuracies of +/- 5 m for the sampling sites.

Surface (0-15 cm) soil samples were taken at the 24 sites, using an aluminum coring device (10-cm internal diameter). At each site, duplicate soil cores were taken, in order to account for any variability inherent in the sampling procedure. Cores were extruded in the field, mixed in a polyethylene pan, sealed in a zip-loc type bag, and transported in ice chests to the laboratory where they were stored at 4°C.

According to the Soil Survey of Lake County, Florida, the soils sampled should represent the following series: Oklawaha (clayey muck), Montverde (muck), Iberia (sandy clay), and Emeralda (fine sand) (Furman et al. 1975). However, it should be recognized that there may be slight differences between the published (Furman et al. 1975) and current descriptions of some of the soil characteristics may occur, largely due to effects of management practices with time on certain soil properties, especially organic matter content.

2.1.2. Soil characterization

All soils were mixed thoroughly in the laboratory, in preparation for the analyses, as described below:

Dry bulk density (B.D.) was determined on samples of the thoroughly mixed soil cores. Dry bulk density was computed from dry:moist weight ratio of the sample multiplied by the moist soil weight of a known core volume. Dry weight was determined by oven-drying soils at 70°C until a constant weight was obtained. Bulk density was expressed in gram(g) dry weight cm^{-3} soil. Soil organic matter was determined by the loss-by-combustion technique (Nelson and Sommers 1982). A known weight of oven-dry soil was combusted at 550°C for 4 hours. Organic matter content was calculated from the loss in sample weight following ignition.

Exchangeable cations (Ca, Mg, Fe, Al) were determined in extracts obtained by shaking 1 g air dried soil samples with 20 mL 0.1 M $BaCl_2$ for 2 h (Hendershot and Duquette 1986). All cations were analyzed using an inductively coupled argon plasma (Thermo Jarrell Ash ICAP 61E, Franklin, MA).

2.1.3 Soil phosphorus status and availability

Total soil P (TP) was determined by dry ashing a sample at 550°C and hydrolyzing the ash in 6 N HCl (Anderson 1976). Organic P (P_o) was estimated as the difference between 1 N H_2SO_4 extractable P in a soil sample ignited at 550°C and an unignited sample (Walker and Adams 1958). Plant-available soil P was estimated by extraction of moist soil samples with 0.5 M $NaHCO_3$; the concentration of P_i in the filtered extract provides an index for the level of plant-available P in soil. Sodium bicarbonate-P_i often forms the basis of P fertilizer recommendations in agricultural mineral soils (Olsen et al. 1954). Prior to P determination in the present study, all extracts were filtered through coarse pore, quantitative Whatman filter paper No. 41 (pore size 20-25 μm), to allow recovery of extractable P_o as well as P_i. Organic P in the extract was calculated as TP - P_i, where TP was measured as P_i following acid persulfate digestion of an aliquot of the extract (Bowman 1989, EPA 1993, Method 365.1). Sodium bicarbonate-P_o is an estimate of the potential contribution of P_o to the plant-available pool of soil P. Consequently, $NaHCO_3$-TP may provide a more realistic index of plant available P in soils that contain high organic matter compared to $NaHCO_3$-P_i.

Bioavailable P (BAP) is operationally defined, as the pool of P in soil that has the potential to become available for biological uptake in a receiving water body (for example, wetland floodwater, agricultural runoff, or stream) as well as in the source soil. Bioavailable P was estimated by extracting moist soil samples with a single iron oxide-impregnated strip of filter paper (Fe oxide-P extraction). The Fe oxide-P extraction method was originally developed to estimate bioavailable P in agricultural soils and runoff waters (Menon et al. 1989, and Sharpley et al. 1993). The Fe oxide removes BAP in soils by acting as a large sink for DP (dissolved P_i plus P_i that is derived from readily mineralized/hydrolyzed soluble organic/colloidal P), and P_i that is readily desorbed/dissolved from the solid phase (bioavailable particulate P, BPP). The extracted P is recovered from the Fe oxide strip of filter paper as P_i, and measured directly. For the extraction of BAP in the flow-way soils, we modified the method slightly (as stated in the Contract), to avoid overestimation of BAP in soils containing high organic P (Robinson and Sharpley 1994).

2.1.4 Soil phosphorus mobility

Soil P mobility is operationally defined as the maximum amount of dissolved P (DP) that is leached from the soil by lake water. Potential mobility of P in the flow-way soils was determined by leaching the soils continuously with filtered water (< 0.45 µm), collected from Lake Griffin. All soil samples (25 g) were leached in 3.5 x 15 cm, open-ended Plexiglas tubes. Prior to leaching, all columns of soil were maintained in a saturated state for 24 h, with a 5 cm head of aerated (N_2-purged) lake water. Throughout the leaching period (up to 30 d), the soils were maintained in a saturated state. Every 24 h, leachate fractions (approximately 100 mL) were collected, filtered (< 0.45 µm) and analyzed for dissolved P_i (DP_i) and total dissolved P (TDP). To assess the bioavailability of mobile soil P, leachates were extracted with a single iron oxide-impregnated strip of filter paper (Sharpley 1993, Robinson and Sharpley 1994). Leachate fractions were collected and analyzed until negligible further release of P occurred. Dissolved P_i was analyzed using colorimetric method (EPA 1993, Method 365.1), and TDP was determined after digestion with persulfate (Method 365.1, EPA 1993, Bowman 1989).

2.1.5 Phosphorus sink size

The P-sorption index (single point estimate of a soil's capacity to act as a P sink) was determined on moist samples of all soils, both before and after leaching of potentially mobile P. The amount of P sorbed, X (mg kg^{-1}), from one addition of 1500 mg P kg^{-1} (added as KH_2PO_4) was determined after shaking for 40 h at a soil:water ratio of 1:100. The P-sorption index (PSI) was calculated as the quotient $X \log C^{-1}$, where C is dissolved P (mg L^{-1}) (Bache and Williams 1971).

In all P extracts, digests, leachates, and PSI studies, P_i was measured by the colorimetric molybdenum-blue method (Murphy and Riley 1962, EPA 1993, Method No. 365.1). Total P in all extracts and TDP were measured as P_i following acid persulfate digestion (Bowman 1989, EPA 1993, Method No. 365.1).

2.2 Results and Discussion

2.2.1 General characteristics of sites and soils

The 24 sample sites throughout the flow-way are labeled on the map of the flow-way (for example, 1A, 3D, 5C) (Fig. 1); their geographic positions are shown in Table 1. Water depth at each site, and general soil properties (bulk density and organic matter) are also shown in Table 1. Bulk density of the soils ranged between 0.39 and 1.13 g cm^{-3}, and organic matter content between 10.4 and 64.4% (Table 1). Generally, soils with higher organic matter contents had lower bulk densities; an observation consistent with findings in the literature (Brady 1974). In fact, the negative relationship between soil bulk density and organic matter content in the flow-way soils was significantly linear ($P < 0.1\%$) (Fig. 2).

2.2.2 Soil phosphorus status and availability indices

Inorganic P extracted with $NaHCO_3$ ranged between 13 and 54 mg kg^{-1} (Table 2). In agricultural soils, these values would indicate adequate to very high levels of plant-available P (Olsen et al. 1954). The appreciable contents of $NaHCO_3$-P_o (estimated as $NaHCO_3$ -TP - $NaHCO_3$- P_i) in some of the more organic soils, for example, 1A (14 mg kg^{-1}), and 2Bϕ (5.6 mg kg^{-1}) emphasize the potential contribution of P_o towards the bioavailable pool of P in organic soils (Table 2). However, in the presence of such high levels of $NaHCO_3$-P_i, it is unlikely that these reserves of labile organic P would be utilized by plants.

Iron oxide-P_i (BAP) ranged between 4 and 70 mg kg^{-1}. The larger range in Fe oxide-P_i, compared to $NaHCO_3$-TP (14.6 to 60.4 mg kg^{-1}), indicates that the former extractant is more sensitive to variations in P bioavailability, the implications of which are discussed with the data on potential P mobility.

2.2.3 Soil phosphorus mobility

For all soils, the release of DP_i, TDP and Fe oxide-extractable P (BAP) in filtered leachate followed similar patterns, as shown for soils 1A and 1D (organic soils), and 5C and 5E (mineral soils) (Fig. 3). However, different soils released different amounts of the three P forms, again represented by the four soils in Fig. 3. The cumulative amount of P released from soil when negligible further release of P occurs is an estimate of the so-called potentially mobile P, in units of mg kg^{-1} soil (Table 3). Potentially mobile P varied significantly among all soils ($P < 0.1\%$). In organic soil 1A, sums of 170 mg DP_i kg^{-1} and 231 mg TDP kg^{-1} were leached; whereas soil 1D leached only 11 mg DP_i kg^{-1} and 15 mg TDP kg^{-1}. Mineral soils 5C (11% organic matter) and 5E (19% organic matter) also leached very different quantities of P (21 and 114 mg DP_i kg^{-1}, and 27 and 151 mg TDP kg^{-1}), respectively. The similar values between DP_i and BAP in all leachates indicates that the sum of leached P_i is an accurate measure of the

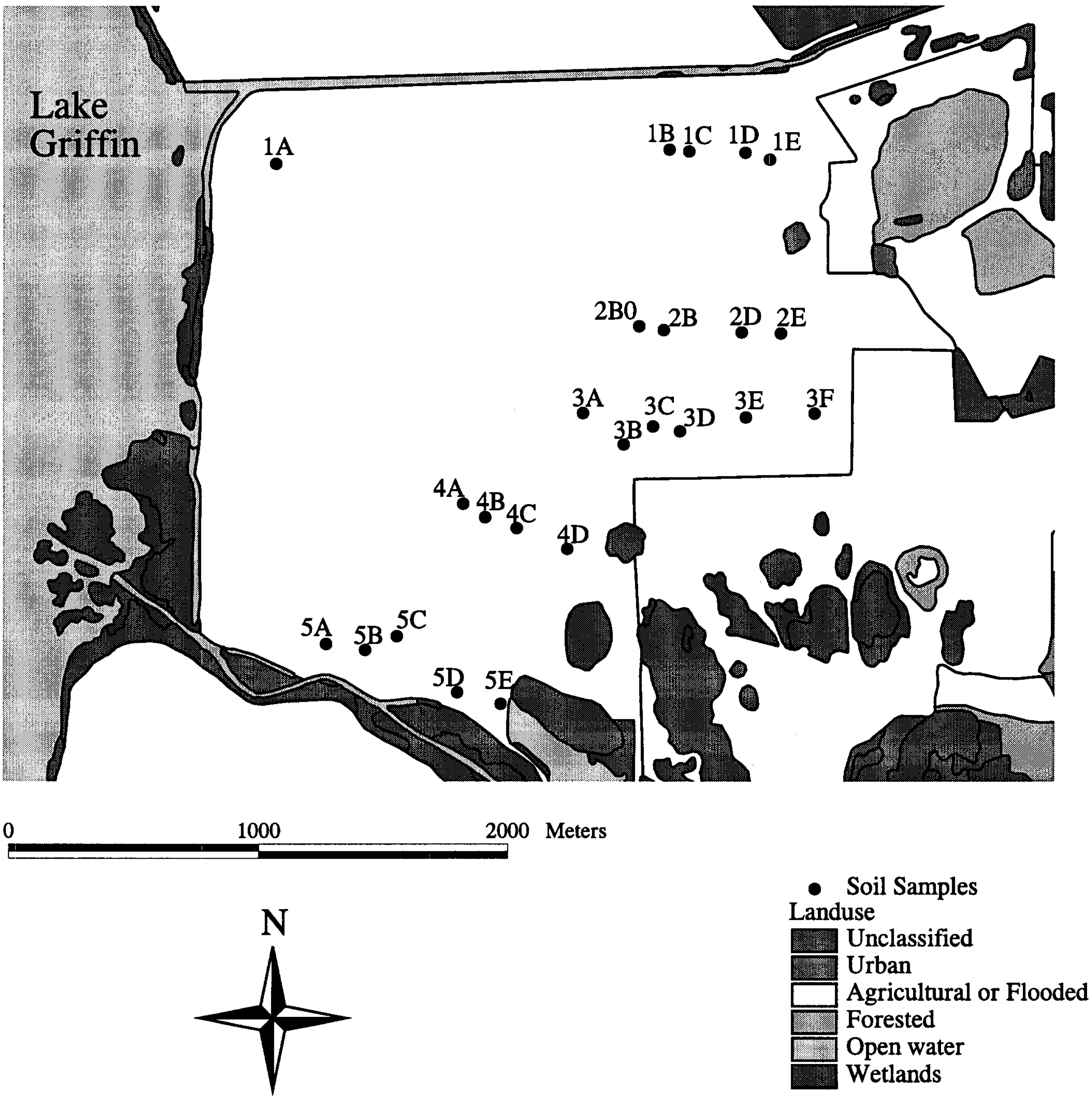

Figure 1. Map showing the soil sampling sites in Lake Griffin flow-way.

Table 1. General characteristics of sample sites and soils in the Lake Griffin flow-way.

Site label	Geographic* position		Water depth	Soil bulk density	Soil organic matter
	Latitude	Longitude			
			(cm)	(g cm^{-3})	(%)
1A	28.54.390	81.49.378	106	0.42	55.83
1B	28.54.427	81.48.409	62	0.60	29.32
1C	28.54.423	81.48.358	72	0.45	50.26
1D	28.54.421	81.48.222	22	0.63	48.14
1E	28.54.406	81.48.162	DRY	0.72	12.14
2B	28.54.038	81.48.479	125	0.58	50.61
2B	28.54.030	81.48.420	57	0.62	19.16
2D	28.54.026	81.48.230	11	0.64	15.87
2E	28.54.024	81.48.132	DRY	1.13	10.38
3A	28.53.847	81.48.617	122	0.39	54.33
3B	28.53.778	81.48.513	73	0.70	20.02
3C	28.53.818	81.48.442	15	0.78	21.07
3D	28.53.808	81.48.379	20	0.69	21.04
3E	28.53.839	81.48.218	21	0.86	18.86
3F	28.53.849	81.48.048	-	0.733	15.71
4A	28.53.645	81.48.912	122	0.39	64.40
4B	28.53.616	81.48.859	55	0.67	20.69
4C	28.53.592	81.48.780	61	0.73	18.88
4D	28.53.547	81.48.656	10	1.08	10.50
5A	28.53.336	81.49.247	79	0.73	23.52
5B	28.53.323	81.49.149	70	0.61	31.01
5C	28.53.354	81.49.074	31	0.87	10.72
5D	28.53.232	81.48.924	115	0.63	34.60
5E	28.53.207	81.48.813	65	0.78	19.29

*Geographic positions are expressed in: degrees. minutes.

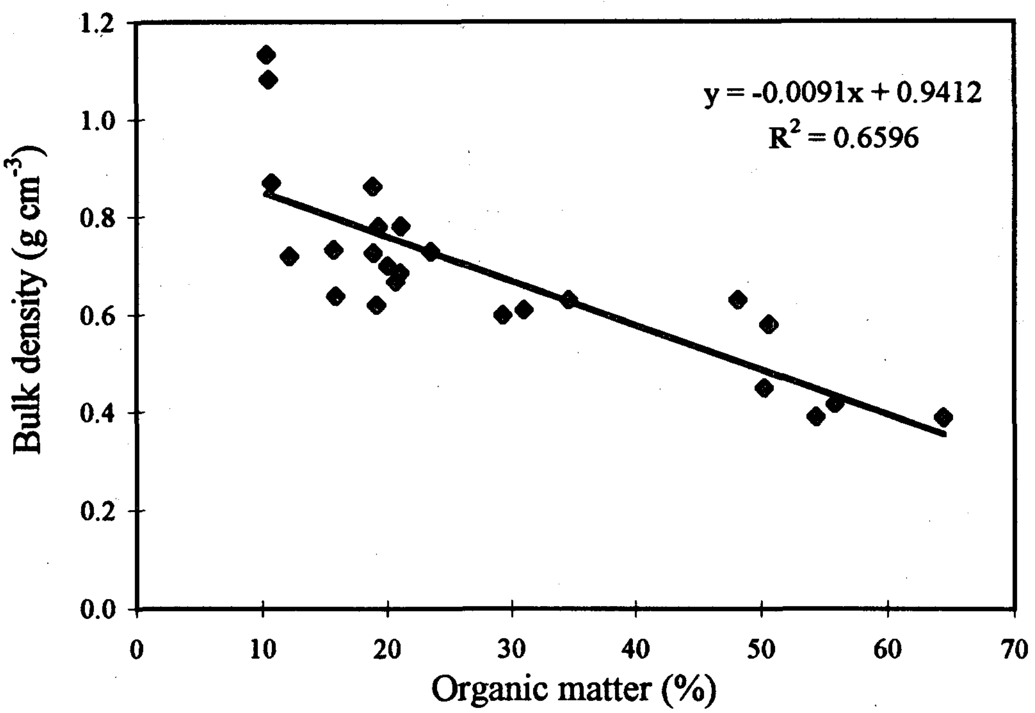

Figure 2. The relationship between bulk density and organic matter content in the 24 soils sampled throughout the flow-way.

Table 2. Phosphorus status and availability indices of the 24 soils sampled in the Lake Griffin flow way. Mean 541; SD± 151; Min 331; Max 782.

Site	Total P	Organic P	NaHCO$_3$-P$_i$	NaHCO$_3$-P$_o$	BAP
	-----mg kg^{-1}-----				
1A	891	596	46.4	14.0	70.1
1B	380	187	30.4	2.8	17.2
1C	531	371	19.6	0.2	22.3
1D	334	205	20.6	1.2	11.6
1E	367	173	35.0	0.2	14.6
2B	692	370	40.0	5.6	51.8
2B	433	221	37.0	4.8	13.6
2D	463	250	44.8	1.2	19.1
2E	331	172	13.4	1.2	7.4
3A	700	565	18.8	1.4	17.2
3B	595	470	16.0	0.2	6.3
3C	539	261	54.2	0.2	27.1
3D	520	291	39.8	0.6	22.2
3E	420	261	22.2	0.4	7.9
3F	441	218	53.2	0.2	25.8
4A	668	527	17.6	0.8	31.4
4B	598	284	29.2	0.6	10.7
4C	512	128	26.0	5.2	11.2
4D	502	257	19.8	0.0	9.8
5A	702	438	40.0	3.3	19.5
5B	782	451	40.7	2.1	26.2
5C	346	209	14.7	1.0	4.1
5D	686	492	33.8	5.2	21.8
5E	562	351	45.9	5.6	23.9
Mean	541	323	31.6	2.4	20.5
SD	± 151	± 137	± 12.6	± 3.2	± 14.7
Min	331	128.	13.4	0	4.1
Max	891	596	54.2	14.0	70.1

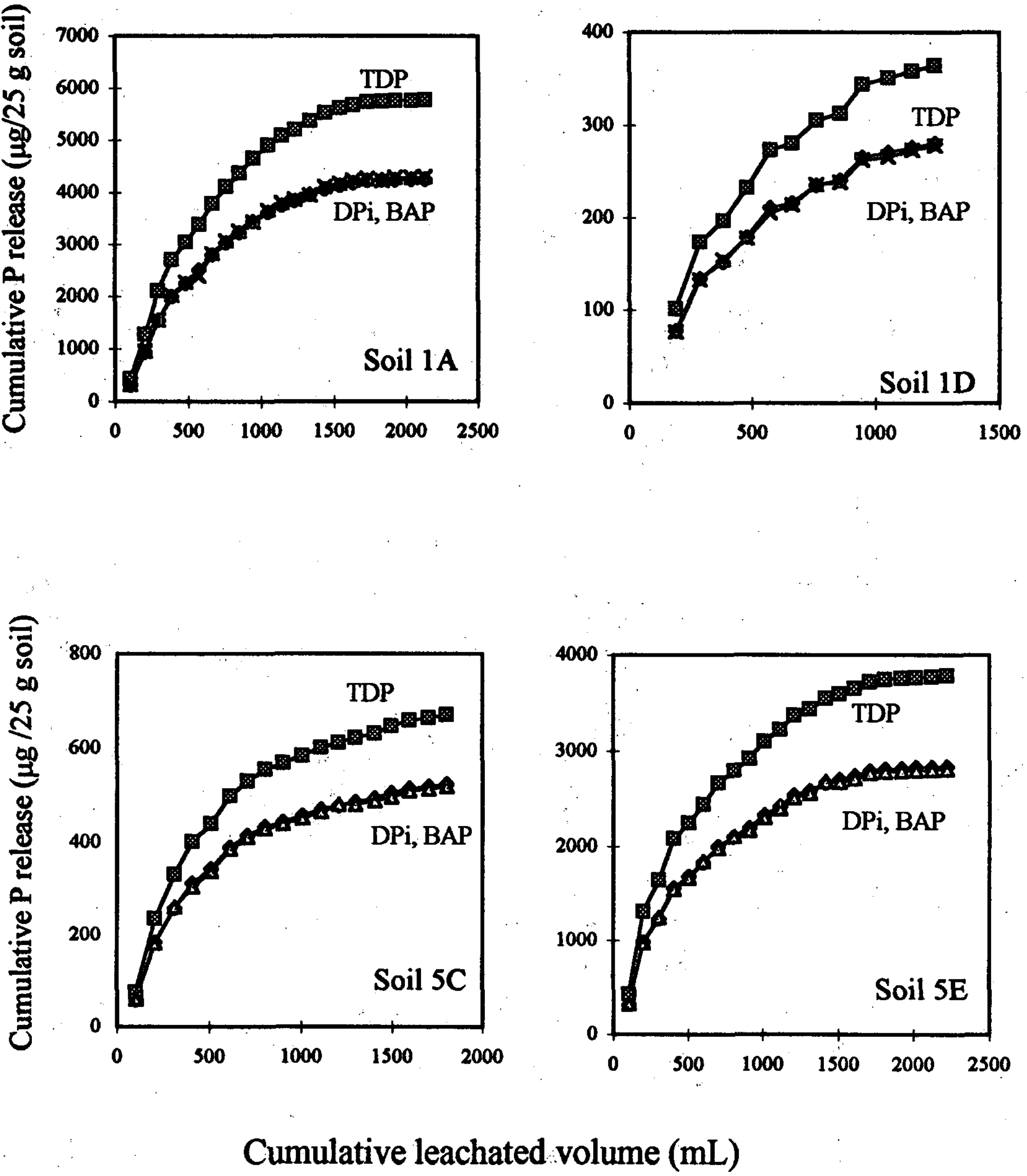

Figure 3. Cumulative release of dissolved forms of P from four flow-way soils during continuous leaching with filtered (<0.45 µm) water from Lake Griffin.

Table 3. Forms of potentially mobile phosphorus in relation to soil total P in the 24 soils sampled in the Lake Griffin flow-way.

Site	Potentially mobile P DP_i	 TDP	 BAP	DP_i % of total P
	-----mg kg^{-1}-----			
1A	171	232	172	19.1
1B	25	32	26	6.5
1C	54	71	57	10.2
1D	11	15	11	3.4
1E	51	72	53	13.8
2B	84	112	81	12.2
2B	31	45	29	7.1
2D	48	72	49	10.3
2E	23	28	24	7.0
3A	33	46	34	4.7
3B	12	19	13	2.1
3C	51	68	50	9.6
3D	52	70	51	10.0
3E	19	24	18	4.4
3F	58	83	57	13.2
4A	96	100	94	14.3
4B	41	58	42	6.8
4C	46	62	44	8.9
4D	42	58	39	8.3
5A	79	103	76	11.2
5B	114	153	115	14.6
5C	21	27	21	6.1
5D	102	131	107	14.9
5E	114	151	112	20.2
Mean	57	76	57	10.6
SD	± 39	± 51	± 39	± 4.7
Min	11	15	11	2.0
Max	114	153	115	20.3

bioavailability of potentially mobile P (Fig. 3; Table 3). However, averaged for all soils, only 74% of leached TDP is also bioavailable (Table 3). The overestimation of BAP by TDP measurements in filtered soil leachates may be due to the existence of P in colloidal organic forms that are biologically unavailable (Olila and Reddy 1995). Throughout the soils, potentially mobile DP_i ranges from 11 to 171 mg kg^{-1} (Table 3). The proportion of soil TP that was potentially mobile and bioavailable, ranges over a similar order of magnitude, from 2 to 20% (Table 3).

Leaching of soil columns, the method by which mobile soil P was determined, is similar in principle to the mode by which an iron oxide strip extracts soil P. In either case, soil P is mobilized in the presence of a sink of infinite size. Potentially mobile P_i correlated with soil BAP (r^2=0.67) much more closely than with either $NaHCO_3$-P_i ($r^2 = 0.28$) or $NaHCO_3$-TP ($r^2 = 0.40$) (Figs 4a, 4b and 4c); consequently, it is suggested that the Fe oxide-P test for soils is a reliable indicator of potential P bioavailability in both the soil and water components of wetlands.

2.2.4 Exchangeable cations

A wide range in selected cations (Ca, Mg, K, Al and Fe) were measured (Table 4). Calcium levels were in the range of 1.2 to 15.6 g kg^{-1}. Similarly, Mg levels were in the range of 130 to 1900 mg kg^{-1}. Exchangeable Fe and Al levels were very low, as compared to Ca, Mg and K.

2.2.5 Phosphorus sink size

Phosphorus-sorption index in the flow-way soils ranged between 94 and 378 L kg^{-1}. The positive relationship between PSI in unleached (native) and leached soils indicates there is an increase in P-sink size following the removal of potentially mobile P (Fig. 4d). However, as expected, the increase in P-sink size varies among the soils (Fig. 4d). Potential P mobility and PSI will be related to exchangeable cations, oxalate-extractable Fe, as well as organic C, soil factors that are known to influence P bioavailability and P-sink size.

2.3 Conclusions

There is large variation throughout the flow-way in P status (plant-available, bioavailable, and potentially mobile P). For example, soil BAP (Fe oxide strip-extractable P_i) ranges between 4 and 70 mg kg^{-1}, and potentially mobile P_i between 11 and 171 mg kg^{-1}. For all soils, cumulative P_i content of leachate provided a good

Table 4. Exchangeable Ca, Mg, K, Al and Fe in 24 soil samples in the Lake Griffin flow-way.

	Ca	Mg	K	Al	Fe
	mg kg^{-1}				
Mean	7,410	951	477	1.6	0.8
SD	± 4,608	± 625	± 318	± 1.7	± 1.5
Min	1,246	134	70	0	0
Max	15,630	1,943	1,205	8.0	6.7

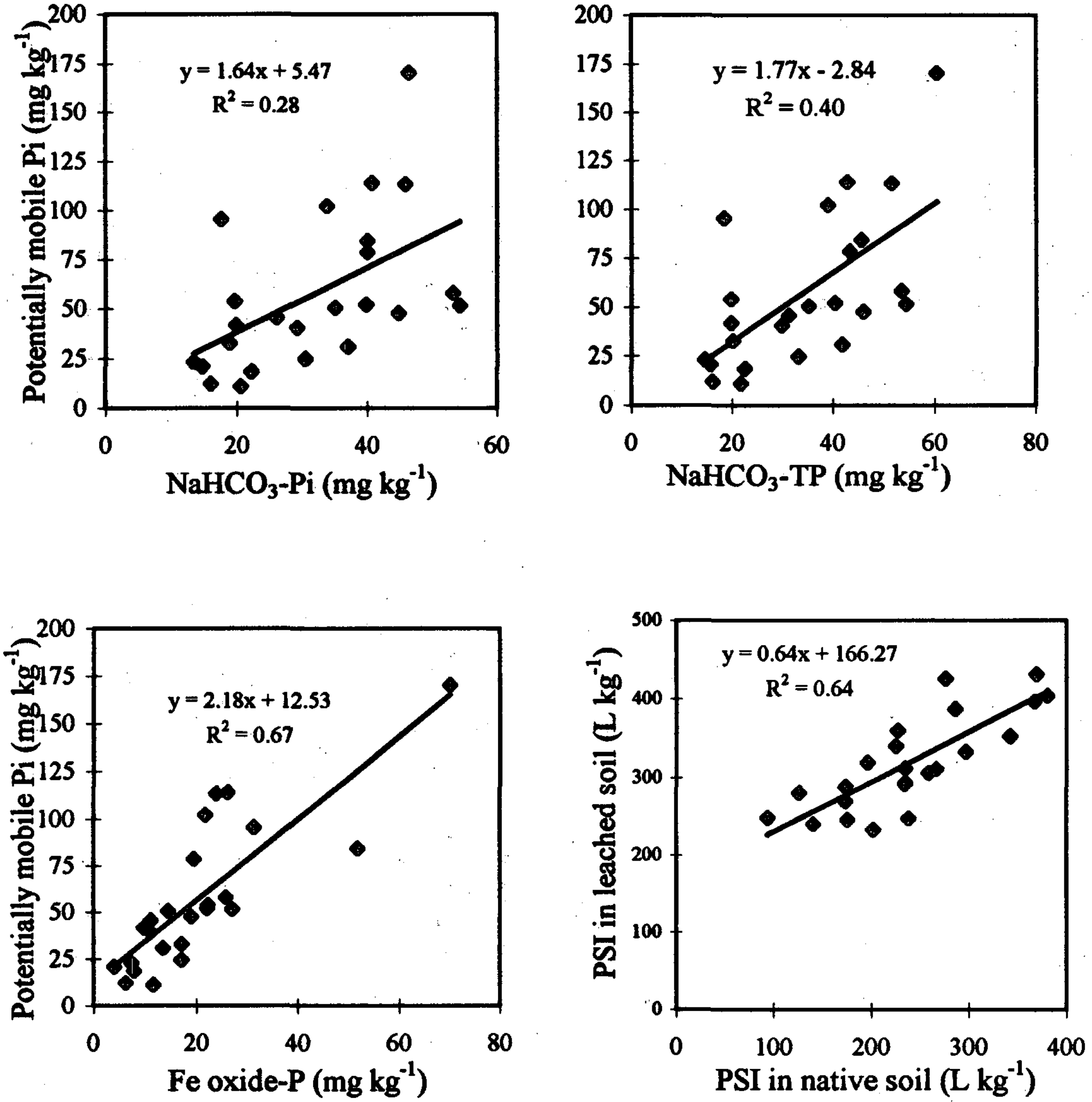

Figure 4. (a) The relationship between potentially mobile P and NaHCO$_3$-P$_i$ in 24 soils sampled throughout the flow-way; (b) the relationship between potentially mobile DP$_i$ and NaHCO$_3$-TP in 24 soils sampled throughout the flow-way; (c) the relationship between potentially mobile DP$_i$ and Fe-oxide P$_i$ in 24 soils sampled throughout the flow-way; and (d) the relationship between PSI in 24 soils before and after leaching with Lake Griffin water.

estimate of potentially mobile, bioavailable P, and correlated well ($r^2 = 0.67$) with the soil BAP content. From 2 to 20% of soil TP was in a potentially mobile, bioavailable form in a permanently flooded soil-water system. Variability in P-sink size among soils (approximately 4 fold, from 94 to 380 L kg^{-1}) was less than that in P status (approximately 15 fold for BAP and potential P mobility). Following removal of potentially mobile P, P-sink size increases in all soils. However, the increases were highly variable. Organic matter content among soils varied widely (10 to 64%). Neither P status nor P-sink size were related clearly with organic matter content. For example, both organic (> 20% organic matter) and mineral (< 20% organic matter) soils showed large variation in all P-related parameters. However, the largest extremes were observed in the organic soils. The data presented in this report are sufficient to obtain reasonable estimate of flow-way soils potential to release or retain P in a flooded environment. However, additional chemical analysis is needed to relate P release potential to physico-chemical properties of soils.

3.0 PHOSPHORUS EXCHANGE BETWEEN SOIL AND OVERLYING WATER COLUMN *[Task 3 and 4 as per contract]*

Phosphorus removal or release by wetland soils is dependent on the concentration of soluble P in floodwater, physico-chemical conditions in the floodwater, the interstitial P concentrations of soils, P sorption/precipitation reactions at the soil-water interface and biological activity (such as algal photosynthesis/respiration and plant uptake). In soils enriched with P (such as those in EMCA), flooding can result in solubilization of P, resulting in steady release into the overlying water column. The objectives of the tasks were to determine: (i) the forms of labile and non-labile pools of soil phosphorus, (ii) the steady flux of soluble P from soil to the overlying water column, and (iii) dissolved P concentration gradients in the soil-water column under *in-situ* conditions.

3.1 Materials and Methods

3.1.1 Laboratory experiments

3.1.1.1 Soil Sampling

At each site, we obtained 9 intact soil cores, on October 11, 1995 (stations 2E, 3D, and 5C) and on November 30, 1995 (Station ID) by driving Plexiglas columns into the soil. The total number of cores collected were 36. Upon return to the laboratory, excess floodwater was siphoned out of the columns, with minimum disturbance of soil material at the soil-water interface.

3.1.1.2 Soil phosphorus fractionation

Three of the nine soil cores from each site were sectioned horizontally at four or five depths using a stainless steel spatula. A sub-sample of wet soil was dried at 70°C for 48 hours and percent dry weight and water content was determined. The oven-dried sample was combusted at 550°C for 4 hours, and loss in weight after combustion was used to calculate the ash-free dry weight and ash content (mineral matter).

A portion of wet soil was used to determine labile and non-labile pools of P in the soil (Fig. 5). This procedure essentially consists of a sequential extraction of a wet soil sample starting with 1 *M* KCl, followed by 0.5 *M* $NaHCO_3$, 0.1 *M* NaOH and 0.5 *M* HCl. The residual soil remaining after these extractions was analyzed for total P. The solutions extracted with 0.5 *M* $NaHCO_3$ were analyzed for soluble inorganic P and total P. The difference in these two fractions represented labile organic P. Similarly, NaOH extractions were also analyzed for both inorganic P and organic P. The fraction of P extracted with 1 *M* KCl and 0.5 *M* $NAHCO_3$ represented labile inorganic P and organic P. The fraction of inorganic P extracted with NaOH and HCl, represented Fe- and Al- bound P, and Ca- and Mg-bound P, respectively. The organic P extracted with NaOH represented P associated with fulvic and humic acid fractions. The P not extracted with these chemicals was assumed to be resistant organic P.

Soluble reactive and total P in soil extracts were analyzing using standard methods (EPA 1993, Method No. 365.1). Total P in soils was analyzed by ashing (Anderson 1976).

3.1.1.3 Soil-water column incubations

This study was conducted to determine the steady release of P from the soil to the overlying water column under controlled laboratory conditions. This represents P flux regulated by diffusion in response to the concentration gradient between the soil and the water column. The previous study (see section 2.1.4) involved leaching of soils with filtered lake water to determine the maximum amount of mobile P in soils. Intact soil cores obtained were used in this study. Filtered (< 0.45 μm) Lake Griffin water (500 mL) was added carefully to 6 of the 9 cores from each site. The soil-water columns were then incubated at 25°C in the dark to prevent algal growth. Water column depth was maintained by adding deionized water to compensate for water loss due to evaporation. Every 1-2 weeks 100 mL (approximately 20%) of the floodwater were

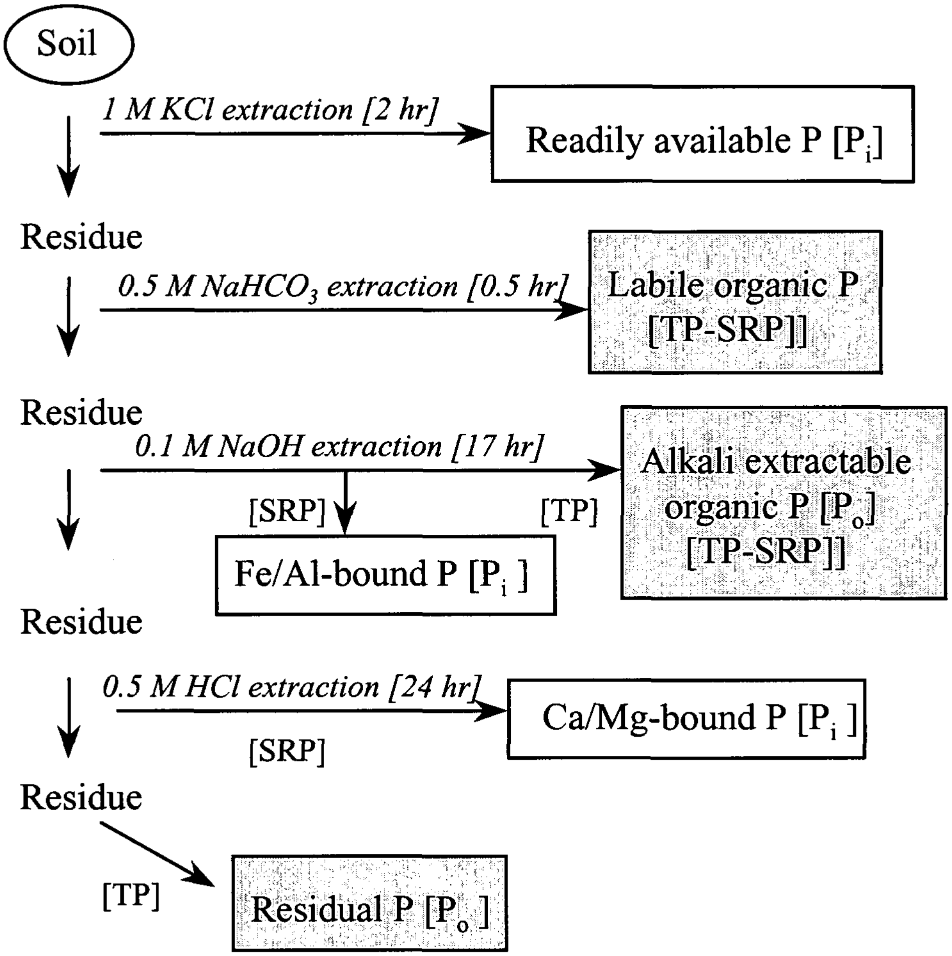

Figure 5. Schematic showing the scheme used to determine the labile and non-labile pools of soil phosphorus. SRP = soluble reactive phosphorus; TP = total phosphorus; P_i = inorganic phosphorus; P_o = organic phosphorus.

removed from all incubated cores. Floodwater removed from three of the six replicates was filtered (< 0.45 µm), and analyzed for SRP, TP, and for associated cations (Ca, Mg, Al, and Fe). At each sampling period, the floodwater removed was replaced with fresh, filtered lake water. This provided a complete turnover of the floodwater once every 5 weeks or about 35 days of hydraulic retention time. The experiment was conducted for a total period of 20 weeks for sites 2E, 3D, and 5C and 16 weeks for site 1D.

3.1.2 *In situ* determination of spatial distribution of porewater nutrients

At the time of obtaining soil cores, porewater equilibrators were installed at four sites, to obtain profiles of dissolved nutrient concentrations in the soil-water column at each sampling site. Porewater equilibrators consist of Plexiglas sheets (35 cm length) that have been machined to provide 8-mL cells at 1-cm intervals. Equilibrators were placed so that at least five cells were located above the soil surface. Two porewater equilibrators were installed on October 6, 1995 at stations 2E, 3D and 5C, and on October 20, 1995 at Station 1D. Prior to installing equilibrators, all cells were filled with deoxygenated and deionized water, and maintained under oxygen-free conditions until installed in the field. Upon placement in the field, pore water was allowed to equilibrate for a period of two weeks. After removal equilibrators were rinsed immediately with deionized water. Approximately 8 mL samples were withdrawn from each cell using a syringe. All samples were kept in the syringe (to prevent degassing), and transported on ice to the laboratory. Filtration of cell porewater for analysis of dissolved nutrients was not necessary, as porewater equilibrators are constructed with a 0.2 µm screen separating the cells from the surrounding porewater. Samples were analyzed for the following: SRP, TP, Ca, Mg, Al, and pH.

Phosphorus flux data, available from the *in situ* pore water equilibrators, were used to calculate the rate of P loading into the water column (D'Angelo and Reddy 1994). Vertical fluxes between soils and the overlying water was calculated as follows:

$$J_s = - \varnothing^3 D_o (dC/dX)$$

where J_s is the flux of soluble nutrient (µg cm^{-2} day^{-1}); D_o is the diffusion coefficient for substances diffusing in porewater (cm^2 day^{-1}); dC/dX is the concentration gradient in the soil (µg cm^{-4}); and X is the soil depth representing the concentration gradient.

3.2 Results and Discussion

3.2.1 Forms and storage of soil phosphorus

3.2.1.1 Inorganic P (P_i)

The bulk density of soils at Station 3D was lower than the other three stations sampled (Table 5). The bulk density increased with depth. High values at lower depths typically represent high mineral matter. Similar trends were observed for ash content, which also increased with depth (Table 5). Total P (as determined by ashing) was higher in surface soil layers and decreased with depth (Table 5).

Various pool sizes of soil inorganic P (P_i) as a function of depth are shown in Table 6. Labile P_i represents P_i extracted with 1 *M* KCl and 0.5 *M* $NaHCO_3$. The KCl-P_i and $NaHCO_3$-P_i generally decreased with depth. In the surface 0-3 cm depth, KCl-P_i accounted for approximately 0.2 to 2% of total P. At lower depth (12-15 cm), the KCl-P_i ranged from 0.2 to 1% of total P. The proportion of P_i recovered in this fraction is in the same range as these observed for other wetland soils (Reddy et al. 1995). The $NaHCO_3$ extracted a much larger pool of total P, as compared to KCl, suggesting for soils with Ca, a weak alkaline solution is a suitable chemical to extract labile P_i. The $NaHCO_3$-P_i decreased with depth up to 20% of total P was present in the labile pool. At lower depths (12-15 cm), however, the $NaHCO_3$-P_i decreased by four-fold, but the relative proportion in relation to total P, approximately remained the same.

The NaOH-P_i (Fe and Al- bound P) was higher in surface layers and decreased with depth (Table 6). Approximately 6-14% of total P was present in this pool at stations 1D, 2E and 3D, compared to 2-5% of total P at Station 5C. The HCl-P_i (Ca- and Mg-bound P_i) showed no definite trend with depth at Stations 1D and 3D but other stations, HCl-P_i decreased with depth (Table 6). Soils at stations 2E and 5C contained approximately 21-25% of total P in surface layers and decreased to 10-12% of total P at lower depths.

Approximately 35-40% of total P was present in the P_i pool in 0-3 cm soil depth of which about one-half was bioavailable or potentially can be released to the overlying water column. At lower depths (12-15 cm), about 31-36% of total P was present as inorganic P, of which about one-third to one-half was potentially mobile.

Table 5. Selected physico-chemical properties of the soil used in the study.

	Depth	1D		2E		3D		5C	
Parameter		Mean	SD	Mean	SD	Mean	SD	Mean	SD
Bulk density	cm	---------- g cm^{-3} ----------							
	0-3	0.573	0.390	0.458	0.211	0.368	0.143	0.419	0.130
	3-6	0.866	0.105	1.007	0.111	0.664	0.044	0.912	0.083
	6-9	0.962	0.164	1.142	0.147	0.803	0.108	1.200	0.257
	9-12	1.122	0.113	1.206	0.131	0.836	0.103	1.247	0.207
	12-15	1.239	0.099	1.301	0.192	1.012	0.040	1.335	0.022
Water content		---------- % ----------							
	0-3	58.2	25.5	58.1	12.2	66.6	11.1	64.0	9.6
	3-6	38.7	3.1	33.1	3.1	47.4	2.8	38.1	3.5
	6-9	34.1	0.5	27.9	1.7	43.1	3.3	28.9	7.9
	9-12	30.3	0.8	28.8	7.6	39.1	2.2	26.6	5.3
	12-15	29.6	0.4	23.4	0.2	35.8	1.1	24.1	1.2
Ash content		---------- % ----------							
	0-3	73.7	8.2	78.7	8.6	71.7	5.7	82.0	3.1
	3-6	78.6	0.8	86.5	1.5	77.6	1.3	85.4	2.7
	6-9	79.4	1.1	87.9	1.2	75.2	6.2	87.3	3.1
	9-12	79.9	0.2	88.5	1.0	79.7	0.9	88.2	1.7
	12-15	80.1	1.6	89.3	0.3	79.5	1.3	91.3	2.1
TP (ashing)		---------- mg kg^{-1} ----------							
	0-3	519.7	176.1	555.8	187.5	611.4	118.4	438.0	69.0
	3-6	398.4	45.0	422.7	34.3	526.2	16.9	287.1	73.9
	6-9	339.5	29.2	324.3	72.7	512.1	18.0	227.4	123.3
	9-12	276.2	19.7	190.9	47.2	485.8	39.7	174.3	95.3
	12-15	222.6	15.7	159.3	9.9	457.6	179.8	138.8	48.3

Table 6. Forms of inorganic P as a function of soil depth (n=3). KCl-Pi and $NaHCO_3$-P_i=labile inorganic P; NaOH-P_i = Fe and Al-bound P; HCl-P_i =Ca and Mg-bound P; TP_i = total inorganic P.

	Depth	1D		2E		3D		5C	
Parameter		Mean	SD	Mean	SD	Mean	SD	Mean	SD
		mg kg^{-1}							
KCl-P_i	0-3	1.79	0.41	4.82	0.55	4.12	2.57	9.13	4.38
	3-6	0.94	1.21	3.66	0.23	1.81	0.34	3.61	0.25
	6-9	0.87	0.40	4.69	1.07	2.10	0.19	2.40	0.88
	9-12	0.78	0.12	1.75	0.78	1.93	0.17	1.44	0.75
	12-15	0.54	0.38	1.04	0.35	1.53	1.01	1.46	0.94
$NaHCO_3$-P_i	0-3	108.3	18.4	63.9	21.4	107.8	33.6	59.3	14.9
	3-6	104.0	46.3	52.4	5.7	111.1	11.1	38.2	12.2
	6-9	96.4	36.8	46.3	8.1	132.2	3.5	25.2	21.2
	9-12	48.8	17.0	24.7	7.5	126.3	19.1	18.8	15.7
	12-15	28.3	2.4	14.2	2.3	82.3	17.9	25.3	8.3
NaOH-P_i	0-3	69.5	6.0	35.5	14.7	63.3	39.6	21.4	5.4
	3-6	75.1	6.9	30.3	1.7	89.4	11.4	13.3	4.4
	6-9	63.7	13.2	27.0	6.3	96.4	1.2	10.3	8.4
	9-12	45.3	6.4	20.6	6.6	93.7	8.3	9.8	4.2
	12-15	34.9	4.4	14.9	4.5	58.2	6.1	3.5	4.8
HCl-P_i	0-3	19.2	3.6	141.0	57.3	34.7	23.9	82.5	25.1
	3-6	14.9	3.7	121.7	2.6	23.2	1.2	52.6	22.2
	6-9	12.6	1.3	78.3	31.1	32.6	21.7	38.7	31.6
	9-12	12.5	1.6	54.3	54.1	21.6	4.4	20.3	15.9
	12-15	28.4	13.4	14.8	9.0	18.0	2.2	17.4	11.6
TP_i	0-3	198.9	28.0	245.3	92.4	209.8	96.1	161.0	45.4
	3-6	194.9	51.6	208.1	7.7	225.5	19.3	107.7	37.9
	6-9	173.6	49.4	156.3	25.5	263.4	22.8	76.6	61.8
	9-12	107.5	23.9	101.3	63.9	243.6	27.5	50.4	36.4
	12-15	92.1	15.3	44.9	16.2	160.0	24.2	47.7	9.0

3.2.1.2 Organic P (P_o)

The $NaHCO_3$-P_o represents labile organic P and this pool can be potentially mineralized into P_i. The rate of mineralization depends on physico-chemical characteristics of the soil and environmental conditions. The $NaHCO_3$-P_o was higher in surface layers and decreased with depth. Approximately 10-20% of total P was present in this pool, with the relative proportion remaining approximately the same with depth (Table 7).

The NaOH-P_o represents P_o associated with fulvic and humic acids. Organic P present in this pool is moderately labile. The NaOH-P_o followed a similar trend as those observed for $NaHCO_3$-P_o. Approximately 13-26% of total P was present in this pool at Stations 1D, 2E and 3D, as compared to 7-16% at Station 5C. The residual P essentially consists of highly resistant organic P and some mineral P not subjected to NaOH and HCl extractions. This pool of P is relatively stable and represents permanent storage in the soil. In the surface 0-3 cm depth, residual P accounted for approximately 19-27% of total P, as compared to 21-44% at the 12-15 cm depth.

3.2.1.3 Storage of phosphorus

Cumulative P storage on an areal basis was calculated for various depths, including 0-3, 0-6, 0-9, 0-12 and 0-15 cm soil depths (Tables 8-12). The soil labile P is most likely released into the water column. In 0-3 cm soil depth, approximately 40% of total P was in the P_i fraction, while the remaining P was P_o (Table 8). About half of P_i and one-third of P_o stored in this layer is labile and potentially can be released into the water column. Similar proportions of P storage were observed when all depths were included in the calculations (Tables 9-12). Fractional distribution of P in the labile and nonlabile pools of P in 0-15 cm soil depth is presented in Fig. 6. Labile pools which includes KCl-P_i + $NaHCO_3$-P_i (inorganic P pools), and $NaHCO_3$-P_o (organic P) are considered to be readily bioavailable. Total P stored in 15 cm of soil is in the range of 34-62 g m^{-2}. A large proportion is bioavailable; 13-20% of total P is the labile inorganic pool, and 12-20% in the labile organic pool. These data were used subsequently to estimate the long-term sustainable P flux from soil into the overlying floodwater.

3.2.2 Soil P release into floodwater

Lake water used to flood the soil cores contained a SRP concentration of 0.01 mg L^{-1}. Data shown in Fig. 7 indicates that floodwater P essentially consists of soluble

Table 7. Forms of organic P as a function of soil depth (n=3). $NaHCO_3$-P_o = labile organic P; NaOH-P_o = fulvic and humic bound P; Residue P = resistant organic P; TP_o = total organic P.

Parameter	Depth	1D Mean	1D SD	2E Mean	2E SD	3D Mean	3D SD	5C Mean	5C SD
	cm	mg kg^{-1}							
$NaHCO_3$-P_o	0-3	108.6	18.5	64.5	21.5	108.3	33.6	60.5	15.5
	3-6	104.1	46.3	52.8	5.7	111.3	11.0	38.6	12.2
	6-9	96.5	36.8	46.8	8.2	132.5	3.5	25.4	21.2
	9-12	48.9	17.0	24.9	7.6	126.6	19.1	19.0	15.8
	12-15	28.3	2.4	14.3	2.4	82.5	18.0	25.5	8.2
NaOH-P_o	0-3	90.7	8.1	106.4	62.9	152.7	60.5	62.5	16.7
	3-6	93.5	8.3	62.6	10.3	120.2	17.8	35.4	2.7
	6-9	72.0	17.3	52.1	14.6	135.4	12.0	24.6	16.3
	9-12	74.2	11.5	35.8	4.9	117.0	2.6	20.2	9.1
	12-15	66.2	8.5	24.6	5.9	105.1	21.2	10.3	6.3
Residue P	0-3	95.1	14.3	137.8	89.2	124.8	48.0	103.4	45.2
	3-6	107.1	2.6	100.6	0.5	114.6	7.0	99.4	33.3
	6-9	94.9	4.9	77.4	43.0	124.3	19.2	89.4	41.4
	9-12	101.3	25.9	73.6	14.4	124.9	12.9	75.3	32.0
	12-15	85.2	6.3	61.7	21.0	93.7	9.2	64.7	23.4
TP_o	0-3	294.3	20.4	308.6	172.4	385.8	138.1	226.3	46.8
	3-6	304.7	42.3	216.0	8.7	346.1	10.9	173.4	47.3
	6-9	263.4	58.2	176.3	43.2	392.2	22.4	139.4	78.8
	9-12	224.4	51.9	134.2	22.3	368.4	16.3	114.4	56.7
	12-15	179.7	14.6	100.6	29.3	281.4	43.5	100.5	21.5

Table 8. Phosphorus storage in a labile and non-labile pools (soil depth 0-3 cm). KCl-P_i and $NaHCO_3$-P_i = bioavailable inorganic P; NaOH-P_i = Fe and Al-bound P; HCl-P_i = Ca and Mg bound P; $NaHCO_3$-P_o = labile organic P; NaOH-P_o = humic and fulvic acid bound P; Residue P_o = residual organic P.

	1D		2E		3D		5C	
P forms	Mean	SD	Mean	SD	Mean	SD	Mean	SD
	-----------------µg cm^{-2} --------------				---------------µg cm^{-2}---------------			
KCl-P_i	2.8	1.7	6.4	2.3	3.9	1.1	12.6	7.6
$NaHCO_3$-P_i	177.1	116.5	78.7	12.1	113.2	33.8	89.4	47.9
NaOH-P_i	115.4	75.4	42.9	4.0	61.9	35.7	28.1	10.6
HCl-P_i	30.8	19.9	169.9	33.8	35.9	23.5	109.3	23.8
TP_i	326.1	212.4	297.9	44.9	214.8	86.0	239.4	88.6
$NaHCO_3$-P_o	177.4	116.7	79.4	12.3	113.7	33.7	42.2	37.7
NaOH-P_o	150.6	98.4	121.4	13.2	152.1	31.1	83.0	27.7
Residue P_o	174.7	126.5	153.5	26.5	126.4	34.1	188.2	66.7
TP_o	502.7	338.6	354.3	27.0	392.2	93.7	313.4	65.9
TP	828.8	550.4	652.2	33.6	607.1	179.7	552.7	151.5

Table 9. Phosphorus storage in a labile and non-labile pools (soil depth 0-6 cm). KCl-P_i and $NaHCO_3$-P_i = bioavailable inorganic P; NaOH-P_i = Fe and Al-bound P; HCl-P_i = Ca and Mg bound P; $NaHCO_3$-P_o = labile organic P; NaOH-P_o = humic and fulvic acid bound P; Residue P = residual organic P.

	1D		2E		3D		5C	
P forms	Mean	SD	Mean	SD	Mean	SD	Mean	SD
	$\mu g\ cm^{-2}$							
KCl-P_i	5.1	1.2	17.5	3.8	7.5	1.3	22.5	7.9
$NaHCO_3$-P_i	438.4	157.8	238.0	43.0	335.2	60.6	192.1	45.7
NaOH-P_i	310.2	101.1	134.4	10.6	239.9	20.3	63.6	15.0
HCl-P_i	69.0	13.4	537.1	69.2	82.2	27.4	250.1	42.3
TP_i	822.7	244.1	927.0	124.9	664.8	99.7	528.3	85.9
$NaHCO_3$-P_o	438.9	157.6	239.9	43.2	336.1	60.4	146.0	56.4
NaOH-P_o	394.6	140.3	308.2	23.0	390.0	22.6	179.2	26.6
Residue P	453.4	158.8	457.2	23.0	355.2	54.2	454.6	113.9
TP_o	1286.9	394.4	1005.3	48.1	1081.3	108.9	779.9	131.5
TP	2109.6	628.1	1932.3	167.3	1746.2	208.1	1308.2	217.3

Table 10. Phosphorus storage in a labile and non-labile pools (soil depth 0-9 cm). KCl-P_i and $NaHCO_3$-P_i = bioavailable inorganic P; NaOH-P_i = Fe and Al-bound P; HCl-P_i = Ca and Mg bound P; $NaHCO_3$-P_o = labile organic P; NaOH-P_o = humic and fulvic acid bound P; Residue P_o = residual organic P.

	1D		2E		3D		5C	
P forms	Mean	SD	Mean	SD	Mean	SD	Mean	SD
	μg cm^{-2}							
KCl-P_i	7.7	0.5	33.2	3.8	12.6	0.3	30.7	7.5
$NaHCO_3$-P_i	718.6	278.4	394.7	59.6	654.7	111.1	271.9	67.2
NaOH-P_i	495.2	133.7	224.9	16.4	472.4	52.3	96.7	31.6
HCl-P_i	105.0	15.9	807.4	59.7	162.9	86.6	373.6	113.1
TP_i	1326.5	398.8	1460.3	61.2	1302.6	224.7	772.9	199.2
$NaHCO_3$-P_o	719.4	278.4	398.5	59.9	656.1	111.0	226.7	103.8
NaOH-P_o	603.0	160.3	482.4	47.5	713.9	16.8	259.5	28.5
Residue P_o	726.5	184.5	727.5	160.9	652.1	87.1	755.7	159.7
TP_o	2048.9	535.6	1608.3	179.3	2022.2	196.0	1241.9	250.8
TP	3375.4	922.9	3068.6	234.8	3324.8	420.7	2014.8	449.6

Table 11. Phosphorus storage in a labile and non-labile pools (soil depth 0-12 cm). KCl-P_i and $NaHCO_3$-P_i = bioavailable inorganic P; NaOH-P_i = Fe and Al-bound P; HCl-P_i = Ca and Mg bound P; $NaHCO_3$-P_o = labile organic P; NaOH-P_o = humic and fulvic acid bound P; Residue P_o = residual organic P.

	1D		2E		3D		5C	
P forms	Mean	SD	Mean	SD	Mean	SD	Mean	SD
	---$\mu g\ cm^{-2}$---							
KCl-P_i	10.3	0.6	39.4	5.2	17.4	0.2	35.9	6.9
$NaHCO_3$-P_i	883.3	308.7	483.1	82.5	968.5	136.1	336.1	104.5
NaOH-P_i	647.7	123.5	297.7	26.4	706.0	44.8	131.6	38.8
HCl-P_i	146.9	16.7	1000.2	144.5	216.6	93.1	443.8	155.7
TP_i	1688.3	418.5	1820.5	247.0	1908.5	248.4	947.4	292.5
$NaHCO_3$-P_o	884.4	308.6	487.5	83.0	970.5	136.0	291.5	145.8
NaOH-P_o	851.6	155.6	610.7	48.9	1007.7	34.9	331.3	44.1
Residue P_o	1064.3	186.8	990.3	137.9	967.7	98.0	1024.0	199.5
TP_o	2800.3	579.5	2088.5	188.0	2945.9	255.6	1646.9	364.5
TP	4488.6	989.9	3908.9	426.6	4854.4	494.7	2594.3	657.0

Table 12. Phosphorus storage in a labile and non-labile pools (soil depth 0-15 cm). KCl-P_i and $NaHCO_3$-P_i = bioavailable inorganic P; NaOH-P_i = Fe and Al-bound P; HCl-P_i = Ca and Mg bound P; $NaHCO_3$-P_o = labile organic P; NaOH-P_o = humic and fulvic acid bound P; Residue P_o = residual organic P.

	1D		2E		3D		5C	
P forms	Mean	SD	Mean	SD	Mean	SD	Mean	SD
	---μg cm^{-2}---							
KCl-P_i	12.3	1.4	42.1	5.8	22.0	2.8	43.6	4.7
$NaHCO_3$-P_i	988.1	308.0	519.5	95.9	1217.6	141.5	482.7	65.8
NaOH-P_i	776.8	131.2	335.6	58.8	882.5	41.1	165.1	48.1
HCl-P_i	250.9	35.9	1037.1	146.4	271.1	98.6	562.7	232.3
TP_i	2028.1	425.1	1934.2	287.2	2393.2	232.4	1254.2	341.5
$NaHCO_3$-P_o	989.3	307.8	556.4	111.2	1220.2	141.6	414.6	168.4
NaOH-P_o	1098.7	166.1	731.0	37.3	1327.3	79.8	392.4	65.7
Residue P_o	1380.7	204.9	1195.4	134.3	1251.6	100.2	1382.1	246.4
TP_o	3468.7	574.5	2482.7	208.1	3799.1	242.4	2189.1	480.4
TP	5496.8	969.5	4540.4	479.5	6192.3	450.6	3443.3	821.9

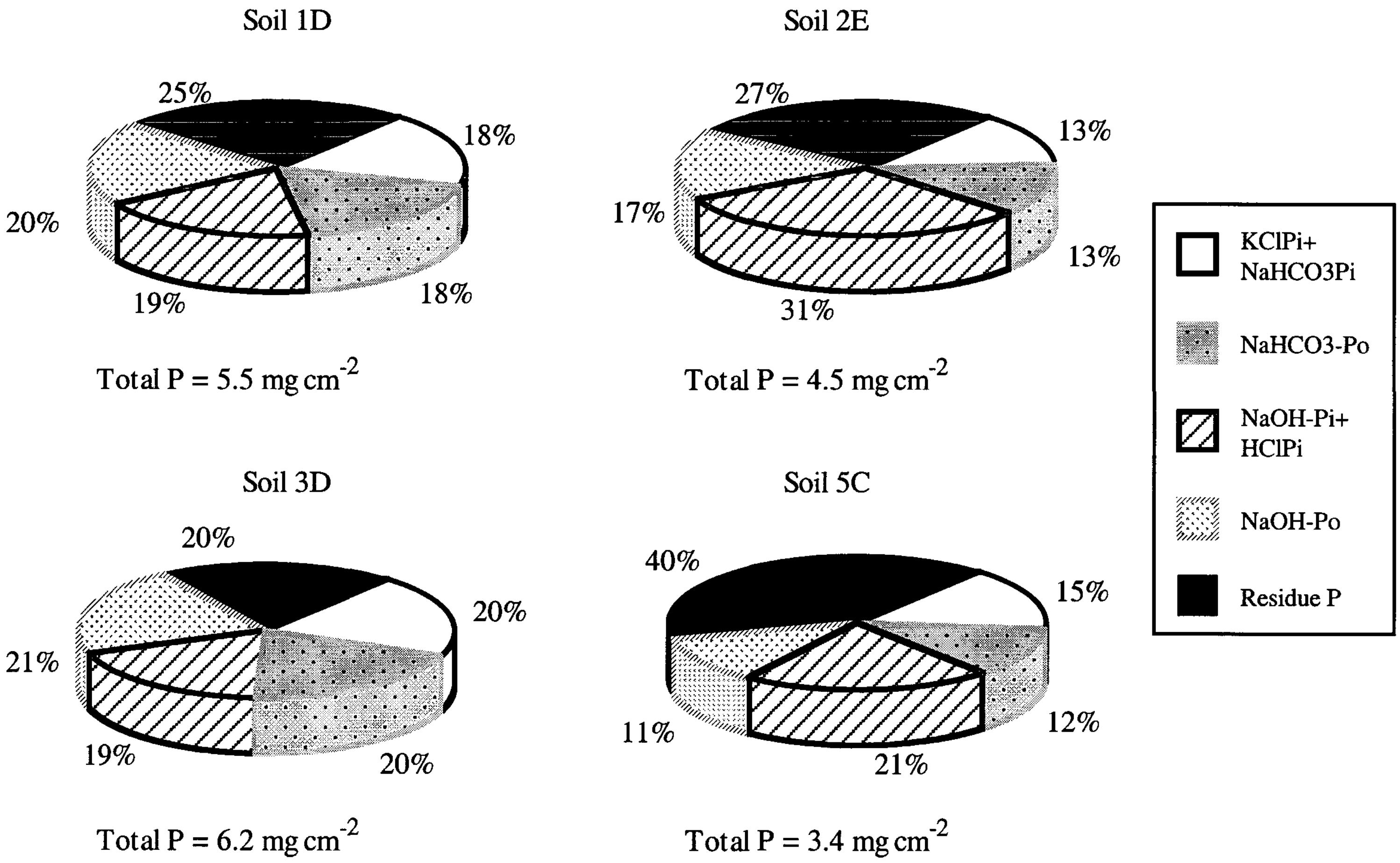

Figure 6. Distribution of labile and non-labile pools of phosphorus in 0-15 soil depth. Labile pools are readily bioavailable, and non-labile pools are slowly available. Residue P is highly resistance and unavailable.

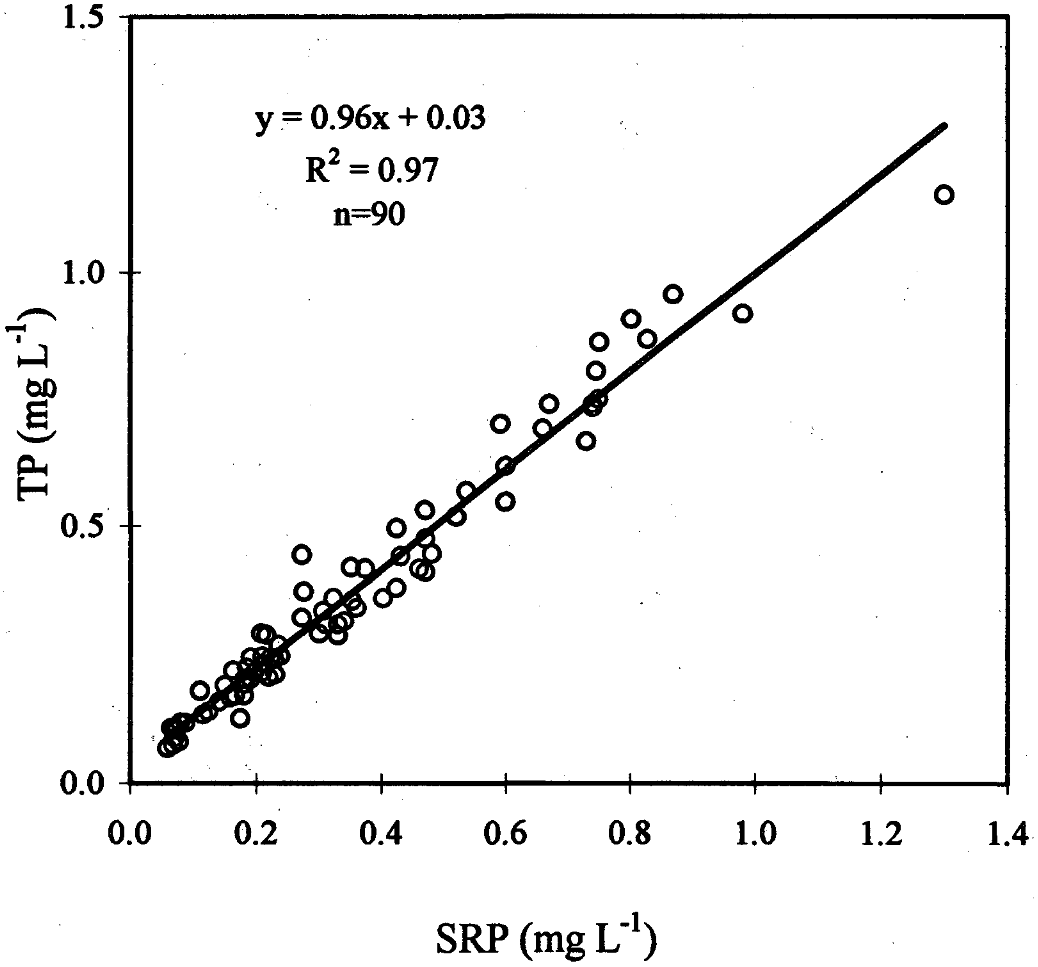

Figure 7. Relationship between soluble reactive P and total P of the floodwater samples obtained in laboratory flux experiments.

reactive P, suggesting very minimal biological activity in the water column. Rapid increase in floodwater SRP was observed in soil cores obtained from stations 2E, 3D and 5C, compared to Station 1C (Fig. 8). Replicate cores showed a high degree of variability. In soil cores from Station 1C, floodwater P increased to 0.4 mg L^{-1} during the 1st week, followed by a steady decrease to <0.2 mg L^{-1} within 5 weeks. In these soil cores, floodwater P remained at <0.2 mg L^{-1} during the remaining 10 weeks of the experimental period.

At stations 2E, 3D and 5C, floodwater P increased during the first 3 weeks, with peak concentration of up to 1.3 mg L^{-1} (Fig. 8). This was followed by a steady decrease to P concentrations of <0.2 mg L^{-1}, especially in soil cores obtained from Stations 2E and 3D. After a 10 week incubation, floodwater P in one soil core (Station 3D) increased from 0.2 mg P L^{-1} to 0.8 mg L^{-1}. Similar increases of lesser magnitude were also observed in soil cores obtained from Station 2E and 5C. These increases were observed only in one replicate core of each station. The considerable variability among replicate soil cores obtained from particular site may be due to soil management practices prior to flooding of these fields.

Mass P release rates were calculated on an areal basis (μg P cm^{-2}) and the results are presented in Fig. 9. Phosphorus release increased in the order of stations 1D< 2E< 3D< 5C. Mass P per unit area was linear during the first five weeks, followed by slow release during the remainder 15 weeks of incubation. Since P release at Station 1D were measured only for 15 weeks. P release for all stations were compared for this time period (Fig. 10). The amount of P released in 15 weeks was approximately the same at stations 3D and 5C, while P release was considerably lower at stations 2E (about one-half of P release at 3D and 5C) and 1D (about one-third of P release at 3D and 5C).

Two approaches were used to estimate P flux from intact soil cores. In the first approach, maximum P release was calculated from the initial linear phase of P release curves (Fig. 9) observed during the first few weeks (maximum five weeks). The second approach is the cumulative P flux over a 15 week period. Results of both approaches are presented in Table 13. A wide-range in maximum P flux was measured with 1.6 mg P m^{-2} day^{-1} at Station 1D to 9.4 mg P m^{-2} day^{-1} at Station 3D, respectively. Average P flux over a 15 week period ranged from 0.6 to 2 mg P m^{-2} day^{-1}. The P released over 15 weeks accounts for 0.3 to 2.3% of total labile P storage in 15 cm of soil, and 0.1 to 0.5% of total P storage. If we assume only the top 3 cm of the soil is actively involved in P flux, the P released over 15 weeks accounts for 2 to 17% of total labile P storage and 0.8 to 4.5% of total P. These results suggest that soils in this area have enough

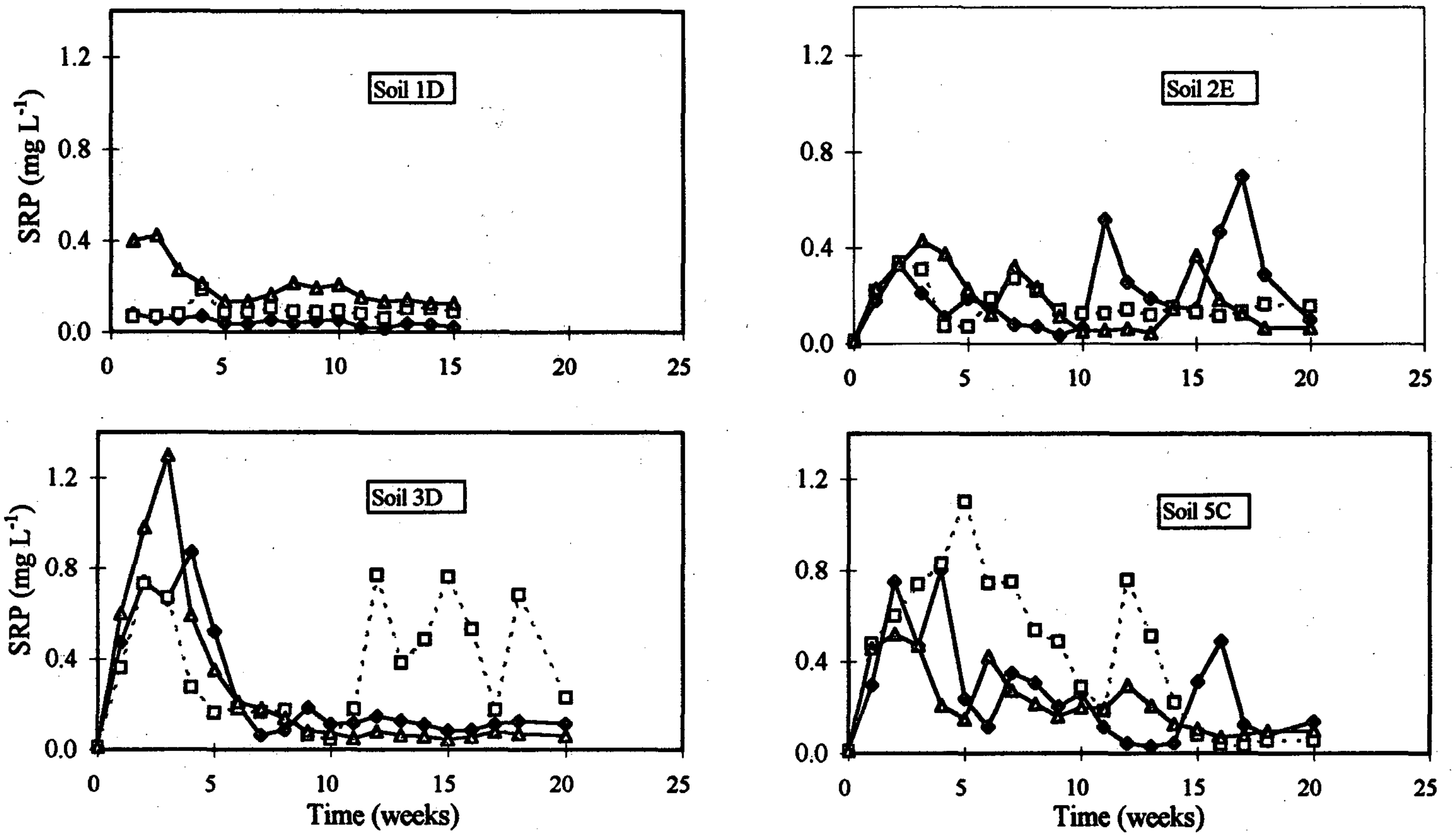

Figure 8. Soluble reactive phosphorus (SRP) concentration of the floodwater (during a 20-week period) of the soil cores obtained from selected stations. Soil cores were incubated in the dark at 25°C. Data represents three replicate cores obtained from the same site.

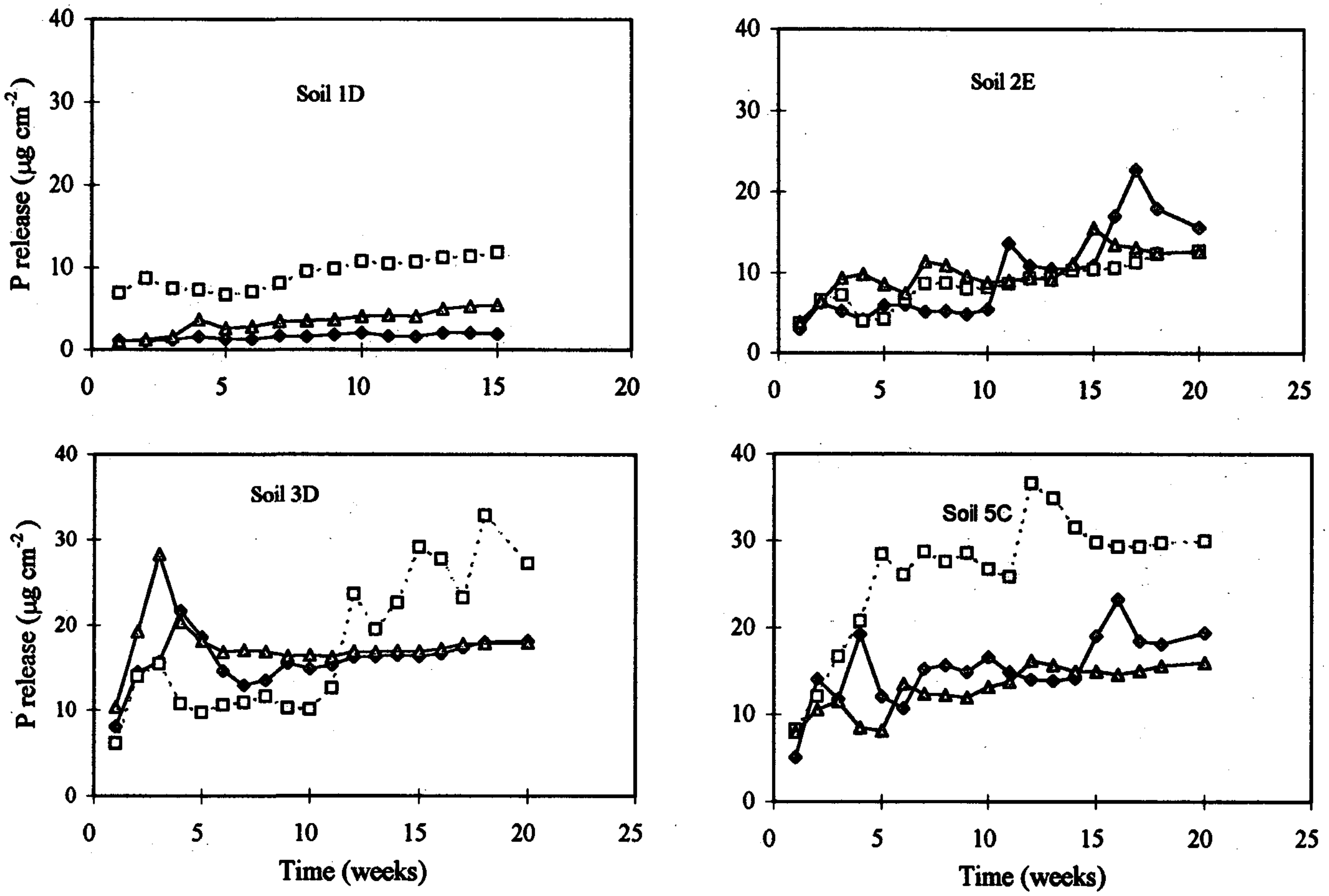

Figure 9. Soluble reactive phosphorus (SRP) release from soil to the overlying water column during a 20-week period. Soil cores were incubated in the dark at 25°C. Data represents three replicate cores obtained from same site.

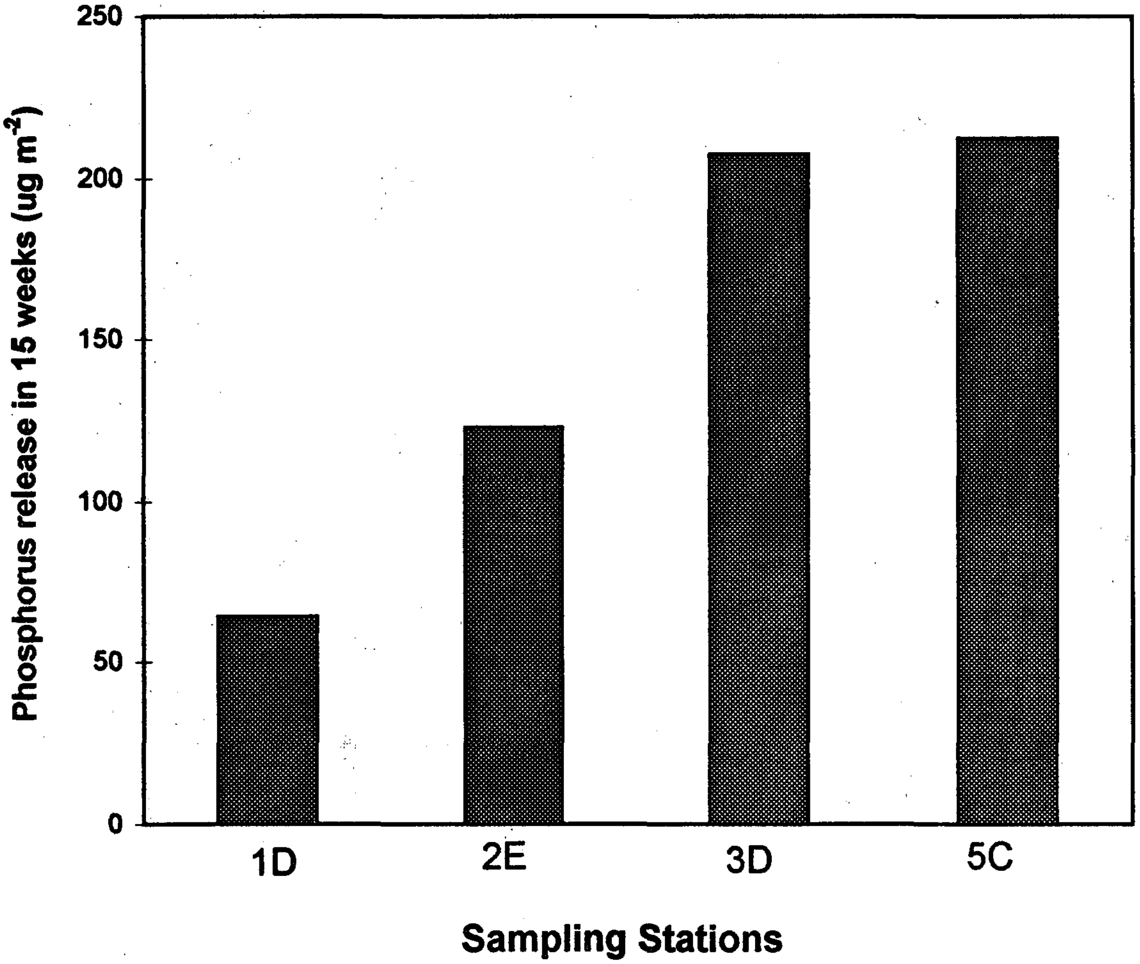

Figure 10. Soluble reactive phosphorus (SRP) release from soil to the overlying water-column during 15 week period (n=3).

Table 13. Potential phosphorus release from selected soil in the EMCA (n=3).

Station	Maximum P release		P release in 15 weeks			Soil P storage 15 cm depth	
	Mean	SD	P release	Labile P	Total P	Labile P	TP
	---mg m^{-2} day^{-1}-----		mg m^{-2}	----% of P stored ----		--------- g m^{-2}---------	
1D	1.64	1.66	64	0.3	0.1	19.9	55.0
2E	3.45	0.97	123	1.1	0.3	11.2	45.4
3D	9.43	3.51	208	0.8	0.3	24.6	61.9
5C	6.33	1.38	213	2.3	0.6	9.4	34.4

labile P in the soil for release at these rates for period of 3 to 16 years for 0-3 cm soil and 13-90 years for 0-15 cm soil, respectively.

3.2.3 *In situ* Nutrient Flux

Soil porewater concentration profiles were used to determine nutrient gradients, and calculate vertical P flux from soil to the overlying water column. Soluble reactive P concentration of the soil porewater were several-fold higher than floodwater P (Fig. 11). Duplicate profiles at Station 1D showed considerable variability, compared to porewater concentration measured at other stations. Soluble reactive P concentrations of up to 14 mg P L^{-1} were measured at lower soil depths. Distinct steep gradients, at the soil-floodwater interface indicated upward flux of P (i.e., from soil to the overlying water column) which was observed at all stations.

The ammonium N concentration profile in the soil porewater also showed distinct gradients within the top 4 cm of soil (Fig. 12). At Station 1D, gradients were noted in the floodwater. It is unlikely such a high NH_4 concentration occurred in the water column. The concentration profiles clearly suggest that the soil-floodwater interface was not clearly defined, and there was an apparent shift in the profile concentration by about 8 cm. A similar shift in profile was also noted for porewater P concentrations.

Dissolved Ca and Mg also showed distinct gradients at the soil-floodwater interface (Figs. 13 and 14). Dissolved Ca concentrations of up to 50-200 mg Ca L^{-1} were observed in soils at Station 5C. A much narrower range in Ca concentrations was observed at other stations. Dissolved Mg levels were in the range of 20-30 mg ${L^{-1}}_2$ in the soil and <10 mg L^{-1} in the floodwater. Dissolved Fe levels were highly variable with values <1 mg L^{-1} (Fig. 15).

Diffusive flux values estimated from concentration gradients are presented in Table 14. Average soluble P flux was estimated to be 1.2 ± 0.3 mg P m^{-2} day^{-1}, which is in the same order of magnitude of average P flux of 1.4 mg P m^{-2} day^{-1} measured over 15 weeks under laboratory conditions (Table 13). The ammonium N flux averaged 4.2 ± 1.8 mg m^{-2} day^{-1}; Ca and Mg flux was 17.3 and 2.7 mg m^{-2} day^{-1}, respectively.

3.3 Conclusions

Total P and labile and non-labile pools of P decreased with soil depth. Approximately 40% of total P was present as inorganic P, while the remaining 60% as

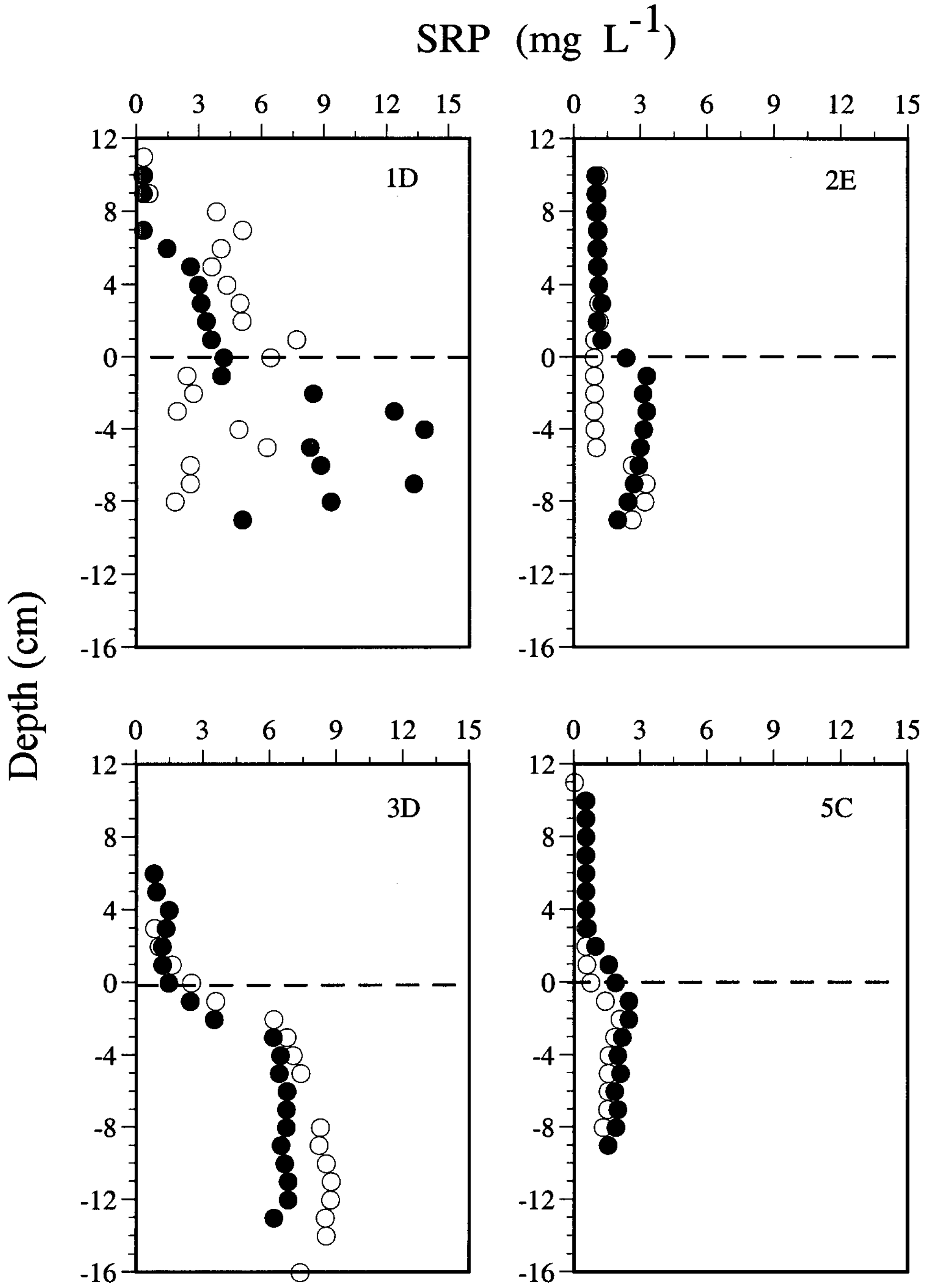

Figure 11. Soluble reactive phosphorus (SRP) concentration of the soil porewater at selected sites sampling period.

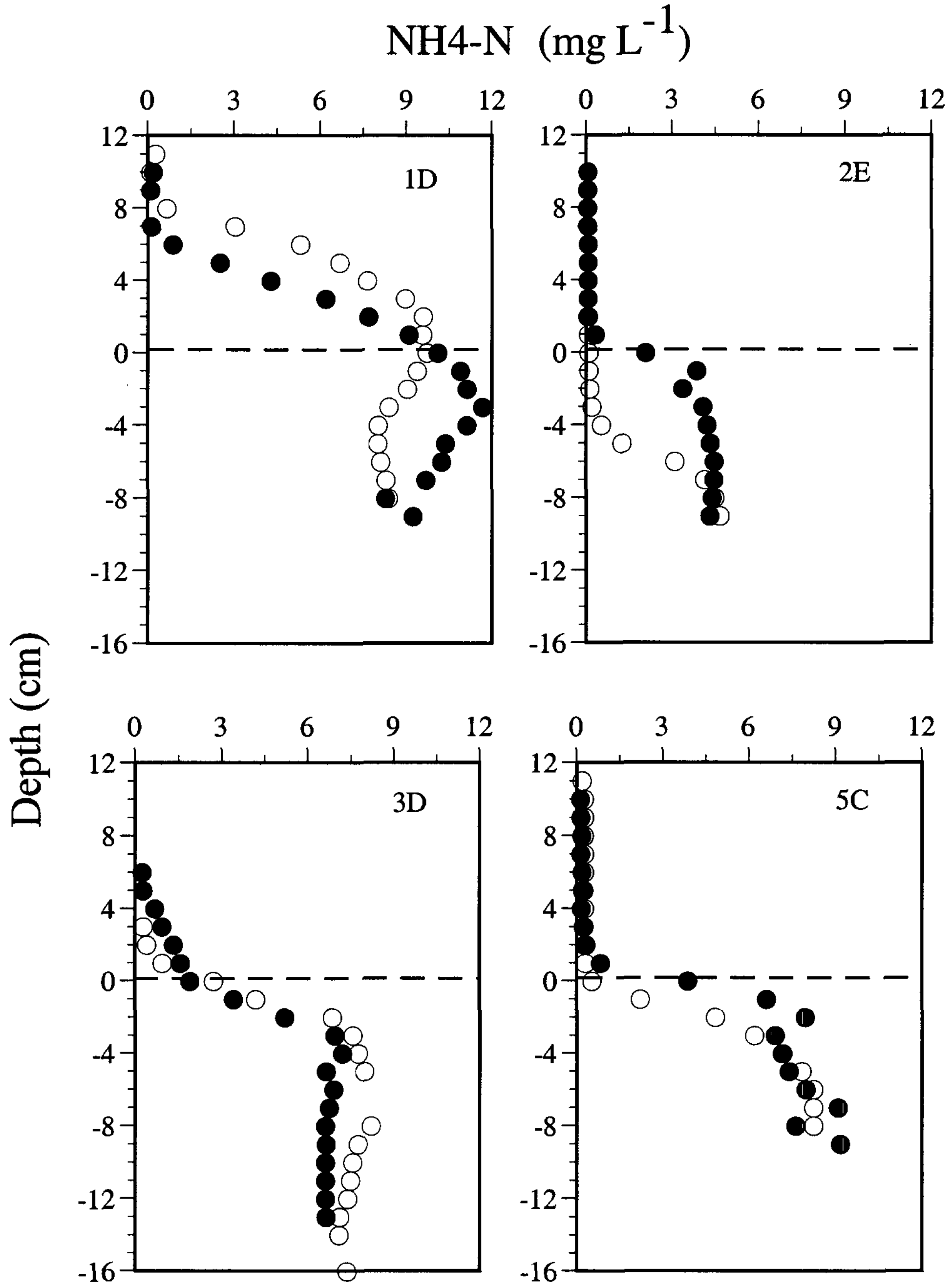

Figure 12. Dissolved ammonium N concentration (NH_4-N) of the soil porewater at selected sites during sampling period.

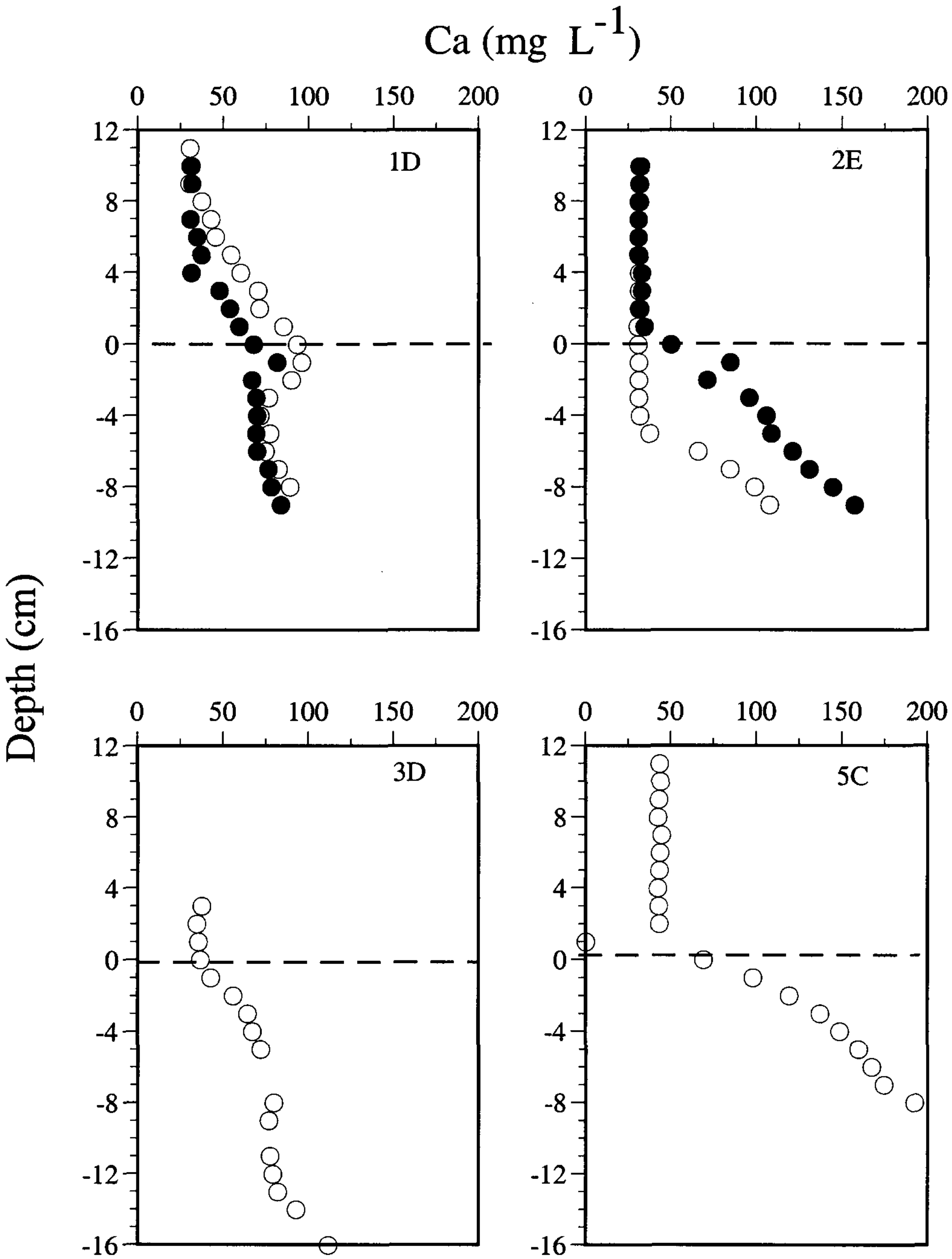

Figure 13. Dissolved calcium (Ca) concentration of the soil porewater at selected sites during the sampling period.

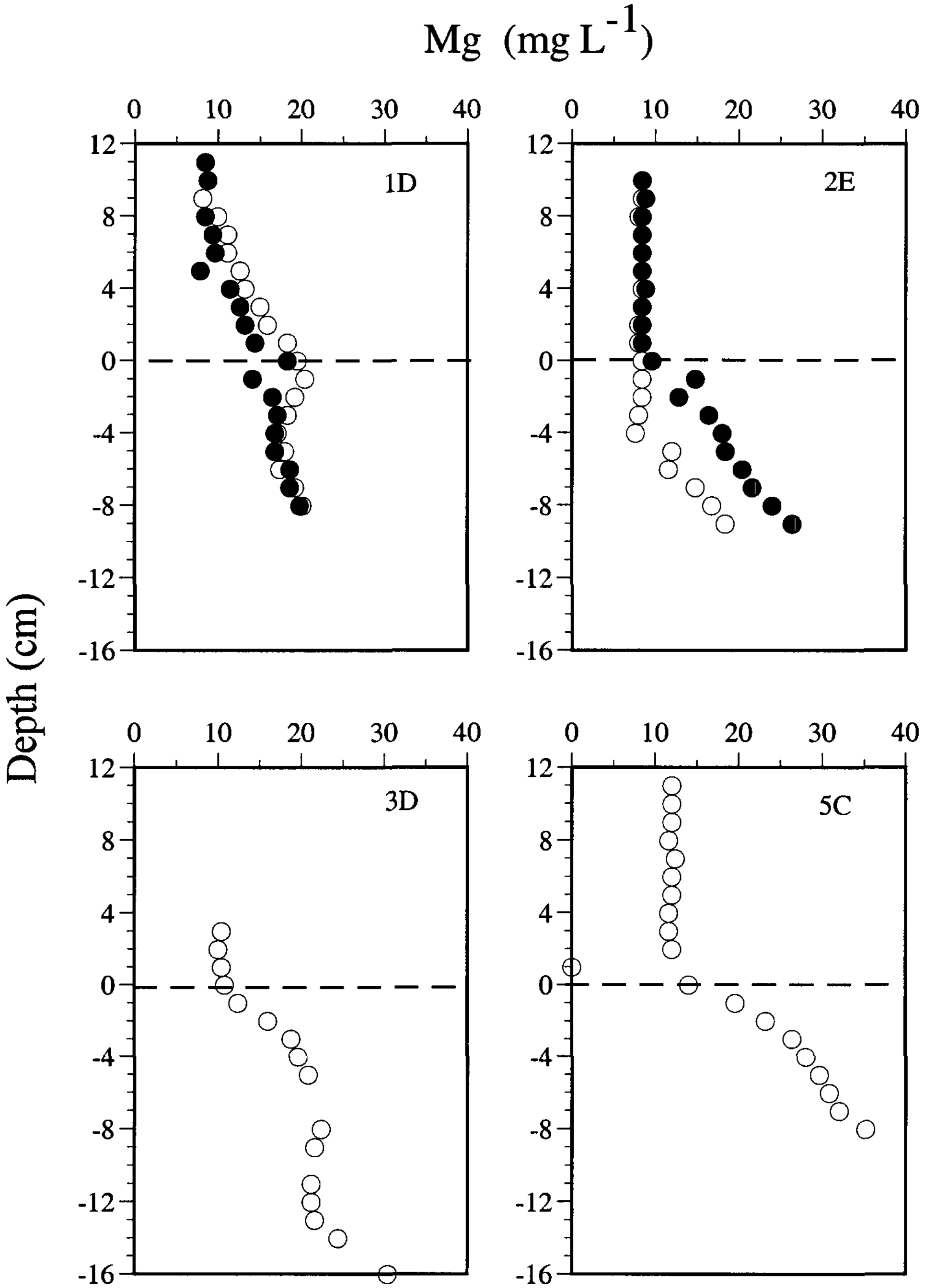

Figure 14. Dissolved magnesium (Mg) concentration of the soil porewater at selected sites during the sampling period.

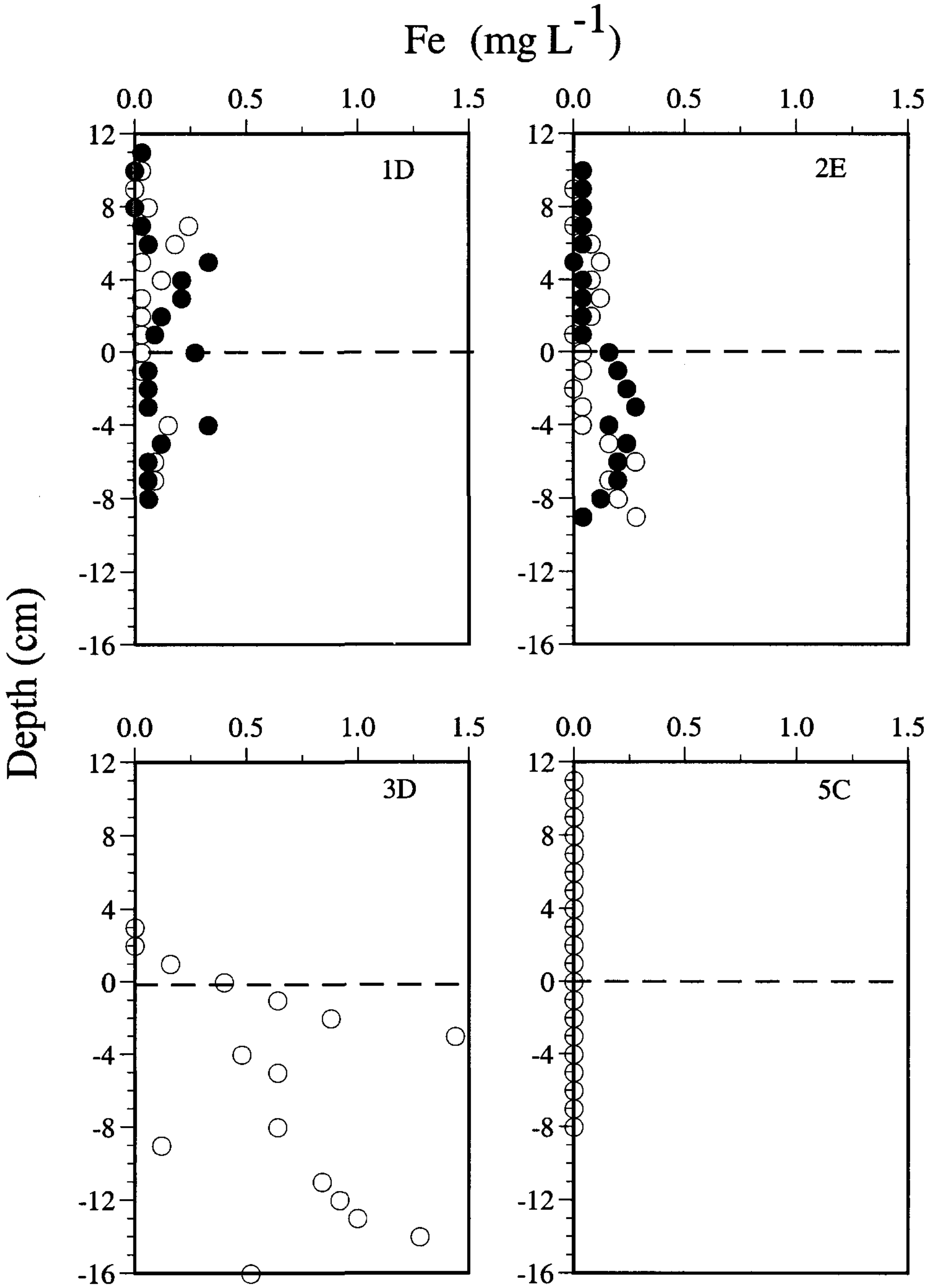

Figure 15. Dissolved iron (Fe) concentration of the soil porewater at selected sites during the sampling period.

Table 14. Diffusive flux of selected nutrients from the soil to the overlying water column. Soil porosities for sites 1D, 2E, 3D and 5C were 0.62, 0.55, 0.66 and 0.65 cm^3, cm^{-3} respectively. The D_o values for NH_4^+, P (as $H_2PO_4^-$), Ca^{2+}, Mg^{2+} and Fe^{2+} were 1.7, 0.68, 0.69, 0.61 and 0.52 $cm^2\ day^{-1}$, respectively.

Parameter	Replications	Sites				Mean
		1D	2E	3D	5C	
		----------mg m^{-2} day^{-1}----------				
NH_4-N	1	4.9	2.3	4.1	6.1	4.3
	2	5.2	1.4	4.0	6.7	± 1.8
SRP	1	0.9	1.3	1.6	1.0	1.2
	2	1.7	1.1	1.3	0.9	± 0.3
Ca	1	11.2	18.6	11.0	40.2	17.3
	2	10.2	12.6	ND	ND	± 11.6
Mg	1	1.8	2.0	2.7	6.4	2.7
	2	1.8	1.7	ND	ND	± 1.8
Fe	1	ND	0.1	0.5	ND	0.2
	2	0.05	ND	ND	± 0.2	

organic P. About one-half of the inorganic P is in the labile pool suggesting a potential for long-term release. About one-third of P_o is in the labile pool, suggesting high microbial activity in the soil. Large amounts of labile P suggests potential for long-term release from soil to the overlying floodwater.

Laboratory P flux studies showed that the P release was rapid after flooding resulting in a steady floodwater SRP concentration of approximately 0.2 mg L^{-1}. This suggests that steady flushing of floodwater with shorter residence time (than those used in this study - 35 days) may deplete labile soil P rapidly, and decrease long-term release.

Once the vegetation is established, the current P flux may be reduced significantly as plant roots can stabilize porewater concentrations. Settling of particulate matter may also decrease P flux as material forms a barrier at the soil-floodwater interface. However, this process depends on the nature of the particulate matter. Although, the soils of EMCA have high mineral matter compared to other wetland sites in Florida (such as ENR in south Florida), the P flux rates are in the same order of magnitude. Current observed P flux rates are slow and comparable to other wetland sites. At these rates and with a floodwater depth of 0.5 m, the dissolved P concentrations can only increase by approximately 2.5 µg P L^{-1} day^{-1}. Additional research should be conducted to determine the influence of rapid floodwater replenishment on P removal from the soil. Influence of vegetation (both emergent and submerged) on stabilization of soil porewater P needs further investigation.

4.0 EQUILIBRIUM FLOODWATER PHOSPHORUS CONCENTRATION IN EMCA [Task 5 as per contract]

Phosphorus assimilation by wetlands is influenced by the dissolved P concentration in soil porewater, and physical, chemical and biological characteristics of the soils. The purpose of this study was to determine the equilibrium P concentration (EPC_w) for the soil cores obtained from the EMCA. The EPC_w is the concentration at which point P retention by soil equals release. If the floodwater P concentration is $<EPCw_2$, net release P will occur from soil to floodwater. Under these conditions, soil will function as a source of P to the water column.

4.1 Materials and Methods

4.1.1 Laboratory Incubations

At each site, triplicate intact soil cores were obtained on October 11, 1995 from stations 2E, 3D, and 5C, and on November 30, 1995 from Station 1D. All soil cores were flooded with filtered Lake Griffin water and incubated under laboratory conditions at an hydraulic retention period of five weeks for a total period of 20 weeks. At the end of this study, (see Section 3.0), soil cores were subsequently used in the following experiments to determine the P release/retention capacity, as influenced by water column P concentration (Table 15). In the first treatment, all soil cores were flooded with distilled water, and allowed to equilibrate for a retention period of 32 days at 22°C. The water column was slowly aerated to maintain complete mixing and DO levels of approximately 5 mg L^{-1}. Aliquots of water samples (5 ml) were obtained at 0, 1, 2, 5, 8, 12, 16, 20, and 32 days from the center of the water column, filtered through a 0.45 μm membrane filter, and analyzed for SRP. Water samples collected at 0 days and at the incubation periods were also analyzed for total P, Ca, and Mg. During the incubation period floodwater pH and EC were determined. Following the equilibration Treatment 1, floodwater was replaced with filtered Lake Griffin water (Initial SRP = 0.013 mg L^{-1}), and equilibrated for a period of an additional 30 days (Treatment 2, Table Table 15). As described above, water samples were obtained periodically and analyzed for SRP. For treatments 3, 4, and 5, the floodwater was replaced subsequently with spiked lake water in the order of 0.1, 1, and 5 mg P L^{-1}, respectively. At each initial SRP concentration, the incubation period was approximately 30 days.

At the end of the high P loading treatment, (5 mg L^{-1}) floodwater was replaced with unspiked lake water (Treatment 6, SRP=0.01 mg L^{-1}), and sampled as described above, to determine net release of P from soil. To determine long-term sustained release of P, floodwater from the soil core was replaced with distilled water (Treatment 7), and water column SRP was monitored for an additional period of four months.

4.1.2 Analytical Methods

Water samples were analyzed for SRP and TP using standard methods (Method 365.1, EPA 1983). Soluble Ca and Mg were analyzed on Inductively Coupled Argon Plasma Spectrometry (ICAP). The experiment was concluded after a total of 310 days of incubation under laboratory conditions. At the end of the incubation, redox potential as a function of depth was determined using the technique by Patrick and Delaune (1972).

Table 15. Experimental conditions for soil cores used in P flux experiments. Soil cores were flooded for a total period of 20 weeks prior to the initiation of Treatment1.

Treatment	Flooding period	Type of floodwater	Initial SRP conc.
	- days-		mg L^{-1}
Treatment 1	0-32	distilled water	0
Treatment 2	32-62	lake water	0.01
Treatment 3	62-92	lake water	0.1
Treatment 4	92-125	lake water	1.0
Treatment 5	125-155	lake water	5
Treatment 6	155-187	lake water	0.01
Treatment 7	187-310	distilled water	0

4.1.3. Calculations

Phosphorus release/retention by soils was calculated as follows:

$$P_r = A\, C_o - P^1$$

where P_r = net P retention or release (mg m^{-2}) by soils [($P_r = C_o - C_t$) V/area]: C_o = initial SRP concentration of the floodwater (mg L^{-1}) at sampling period, t; V = volume of floodwater (L); area (m^2); P^1 = intercept which represents maximum P release (mg m^{-2}) potential of soils under conditions when floodwater P approaches values close to zero; and A = phosphorus assimilation coefficient (L m^{-2}). At equilibrium P concentration (EPC_w), P retention equals release ($P_r = 0$), and above equation can be written as:

$$EPC_w = P^1/A$$

4.2 Results and Discussion

Phosphorus retention capacity of soils was measured by loading the water column incrementally once every 30 days for a period of four months. Dissolved O_2 of the water column was 5-6 mg L^{-1}, and pH was 7.7 to 8.4 over the experimental period (Table 16). The pH and DO was in the same range as those typically observed in the floodwater of wetlands. The conductivity of the water was low where distilled water was used as floodwater, rather than Lake Griffin water (Table 17). Soil redox potential was high in the surface layers and decreased with depth (Figs. 17 and 18). The thickness of the aerobic layer was <0.5 cm, suggesting the oxidation of ferrous iron to ferric oxyhydroxide. This oxidized soil-floodwater interface can function as an effective sink for water column P and for the P released from the underlying anaerobic soil layer.

Changes in SRP concentration of the water column at several initial P concentrations are shown in Figs. 18-24. At all P loading rates, net P release or retention occurred during the first 2 weeks, followed by minimal changes during the remaining equilibration period.

At the end of Treatments 1 and 2 (62 days), average SRP concentration of the floodwater ranged from of 0.035 - 0.27 mg L^{-1}, with low values observed at Station 5C and high values at Station 3D (Table 18). At high initial P concentration (SRP=5.5 mg L^{-1}), the floodwater P decreased rapidly during the 30 day equilibration period, with 79, 91, 95 and 97% reduction at Stations 3D, 2E, 1D and 5C, respectively. Soluble reactive P concentration of the floodwater represented 54 ± 25, 61 ± 22, 68 ± 16, and 73 ± 17%

Table 16. Influence of floodwater type and initial soluble P concentration on water column pH at the end of each incubation period.

Floodwater	Initial SRP	Incubation period	1D		2E		3D		5C	
			Mean	SD ±	Mean	SD ±	Mean	SD ±	Mean	SD ±
	mg L^{-1}	days								
Distilled water	0	0-32	7.7	0.2	7.8	0.2	7.4	0.3	8.1	0.1
Lake water	0.01	32-62	8.3	0.2	8.0	0.2	8.0	0.3	8.4	0.0
Lake water	0.1	62-92	8.1	0.1	8.1	0.1	8.0	0.1	8.1	0.0
Lake water	1	92-125	7.9	0.2	8.3	0.2	7.8	0.0	7.9	0.1
Lake water	5	125-155	8.1	0.1	8.2	0.1	8.0	0.1	8.3	0.0
Lake water	0.01	155-187	8.1	0.2	8.3	0.1	8.1	0.0	8.4	0.0
Distilled water	0	187-310	7.8	0.3	8.0	0.0	7.8	0.1	8.2	0.1

Table 17. Influence of floodwater type and initial soluble P concentration on water column conductivity at the end of each incubation period.

Floodwater	Initial SRP	Incubation period	1D		2E		3D		5C	
			Mean	SD ±	Mean	SD ±	Mean	SD ±	Mean	SD ±
	mg L^{-1}	days	---------------- mmho cm^{-1} --------------							
Distilled water	0	0-32	165	±43	147	±14	100	26	240	78
Lake water	0.01	32-62	323	±28	287	±42	260	22	325	22
Lake water	0.1	62-92	275	±38	293	±6	267	15	307	12
Lake water	1	92-125	290	±35	300	±10	257	42	307	12
Lake water	5	125-155	268	±30	303	±12	261	27	320	10
Lake water	0.01	155-187	270	±26	293	±6	263	6	330	10
Distilled water	0	187-310	172	±10	180	±10	147	25	250	30

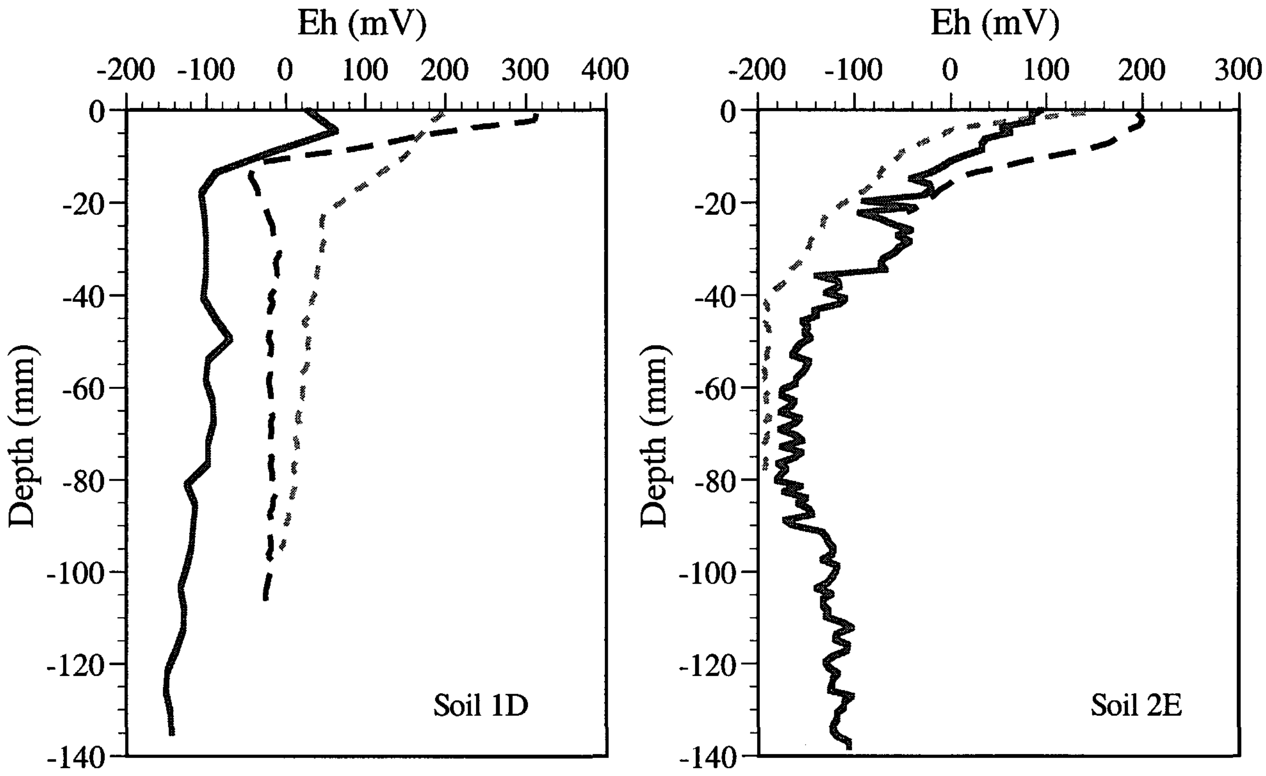

Figure 16. Redox potential of soils 1D and 2E at the end of a 310-day laboratory incubation study. Different data lines represent replicate soil cores collected from same sampling stations.

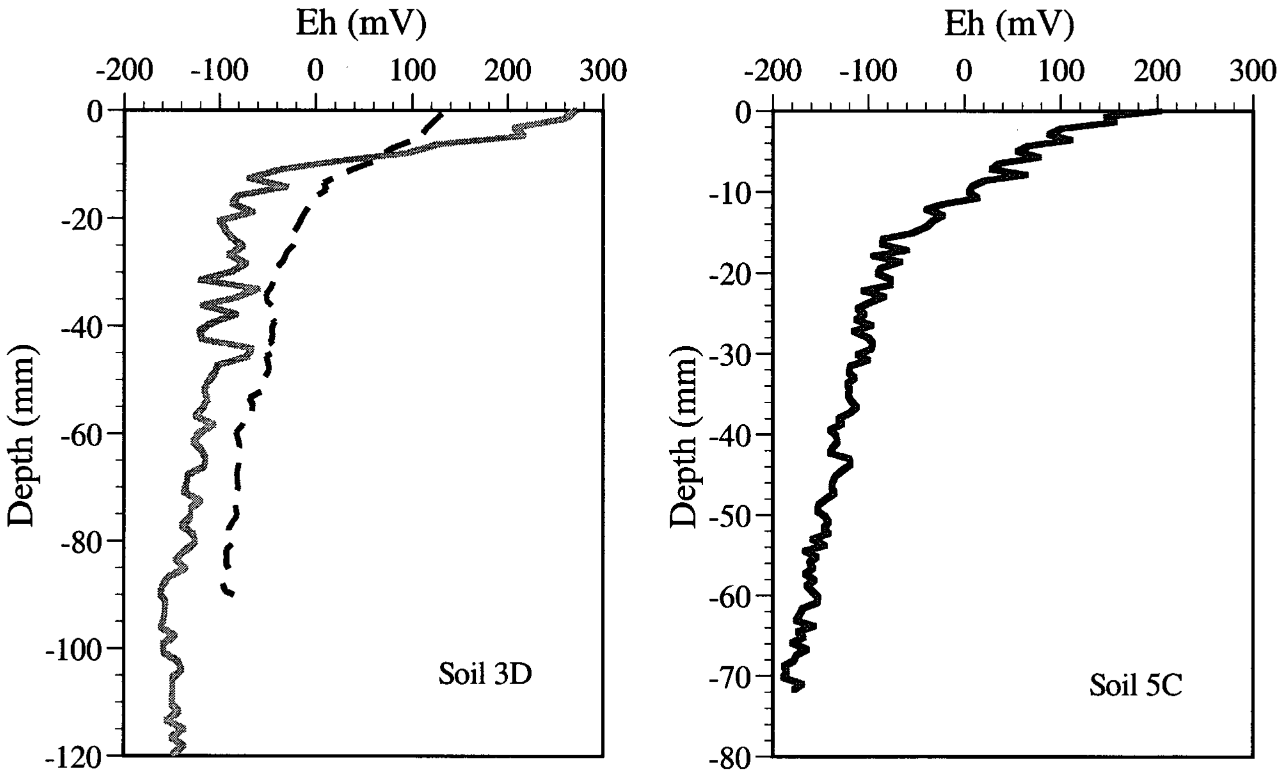

Figure 17. Redox potential of soils 3D and 5C at the end of a 310-day laboratory incubation study. Different data lines represent replicate cores.

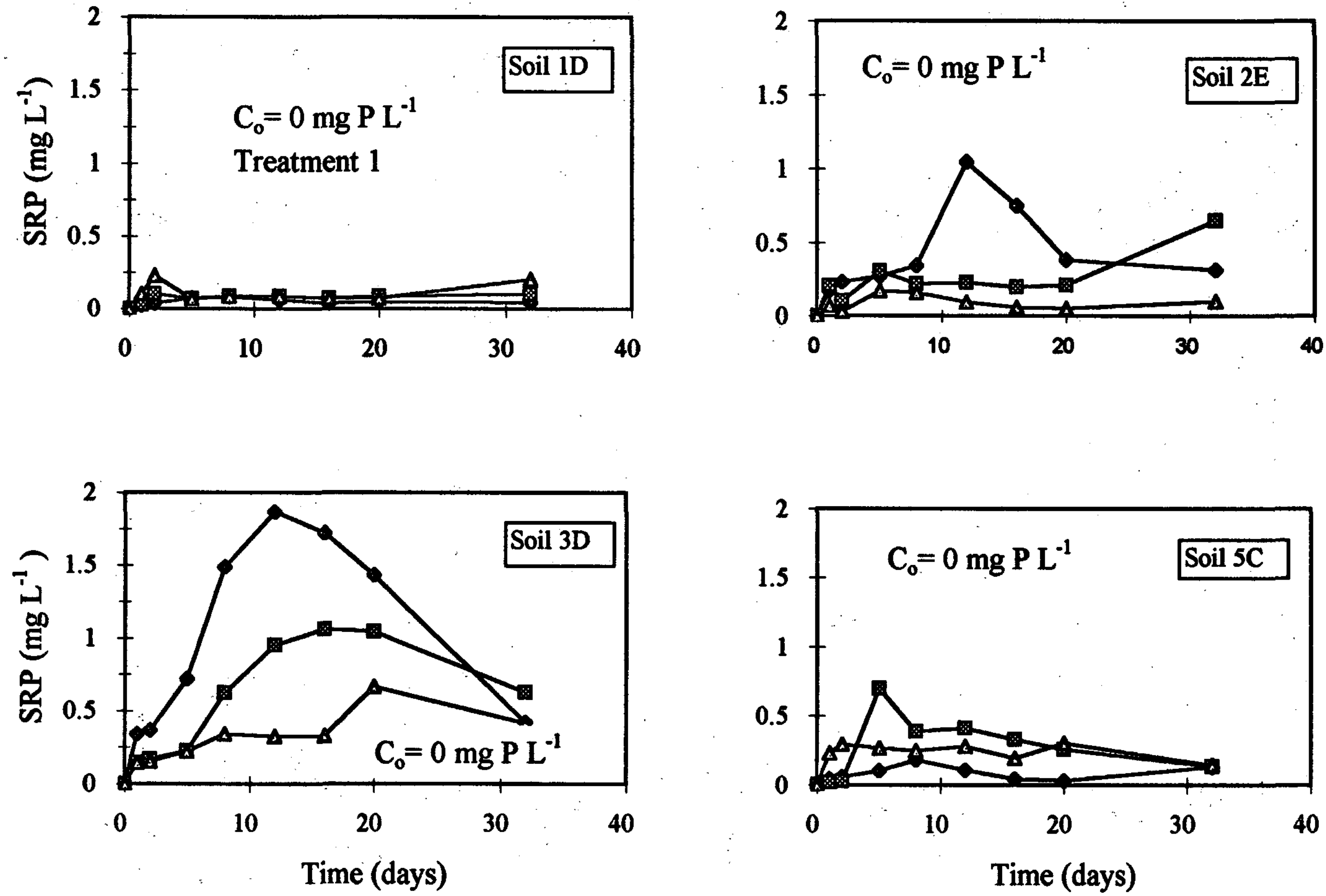

Figure 18. Changes in soluble reactive P concentration of the water column (Treatment 1) in soil cores flooded with distilled water (C_o=0 mg P L^{-1}). Different data lines represents replicate soil cores.

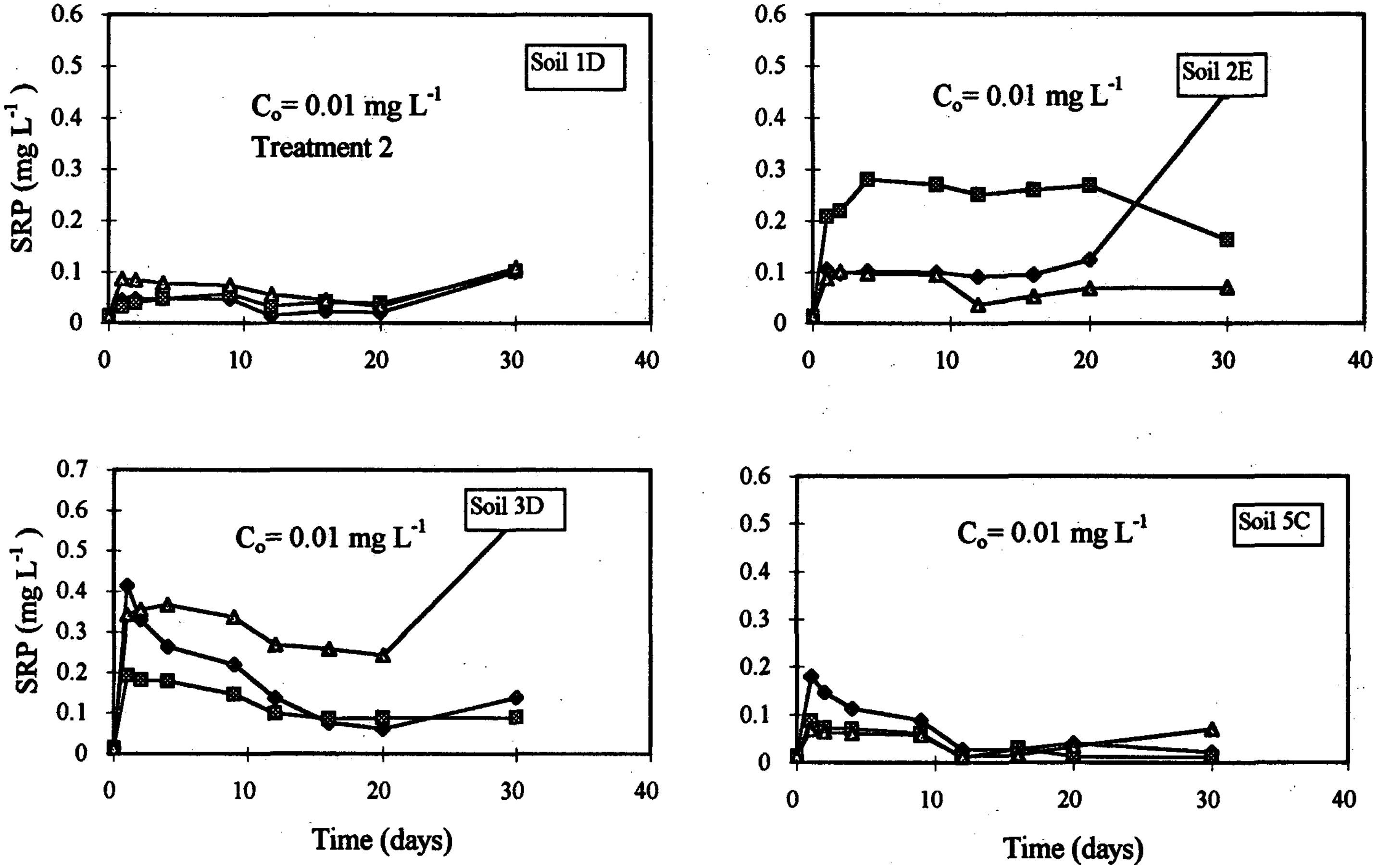

Figure 19. Changes in soluble reactive P concentration of the water column (Treatment 2) in soil cores flooded with filtered Lake Griffin water (C_o = 0.01 mg P L^{-1}). Different data lines represent replicate soil cores.

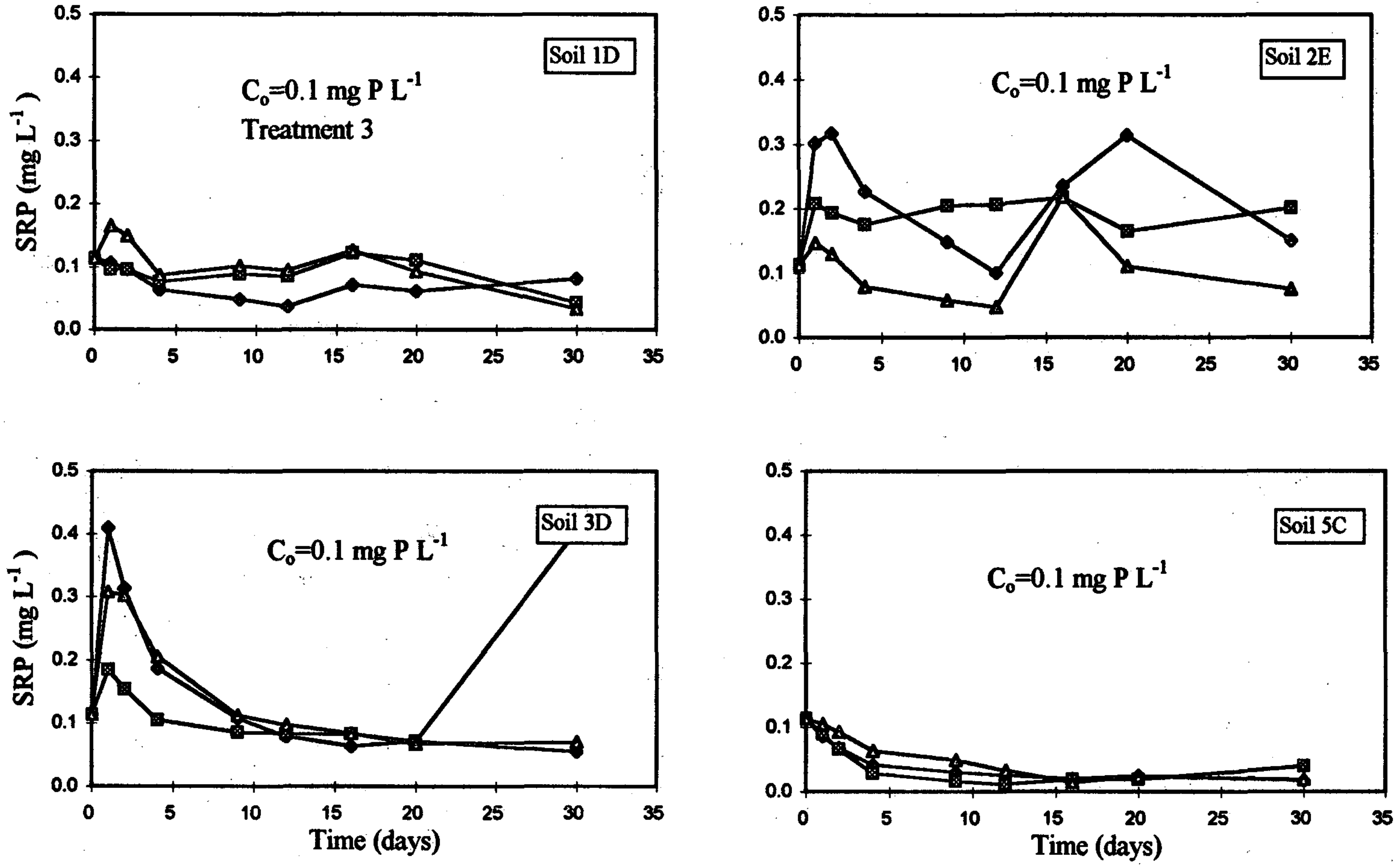

Figure 20. Changes in soluble reactive P concentration of the water column (Treatment 3) in soil cores flooded with filtered and spiked Lake Griffin water (C_o = 0.1 mg P L^{-1}). Different data lines represent replicate soil cores.

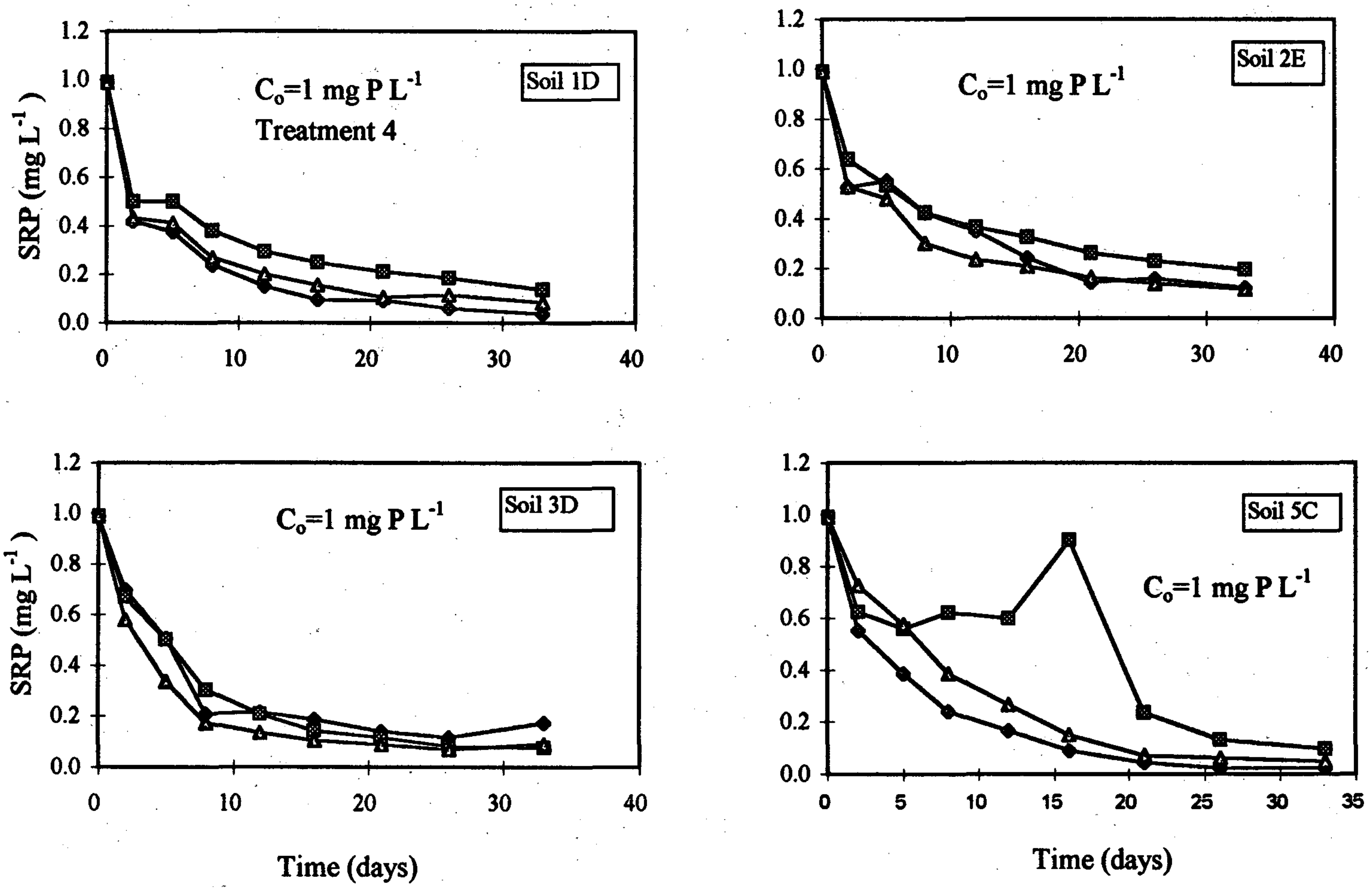

Figure 21. Changes in SRP concentration of the water column (Treatment 4) in soil cores flooded with filtered and spiked Lake Griffin water (C_o = 1 mg P L^{-1}). Different data lines represent replicate soil cores.

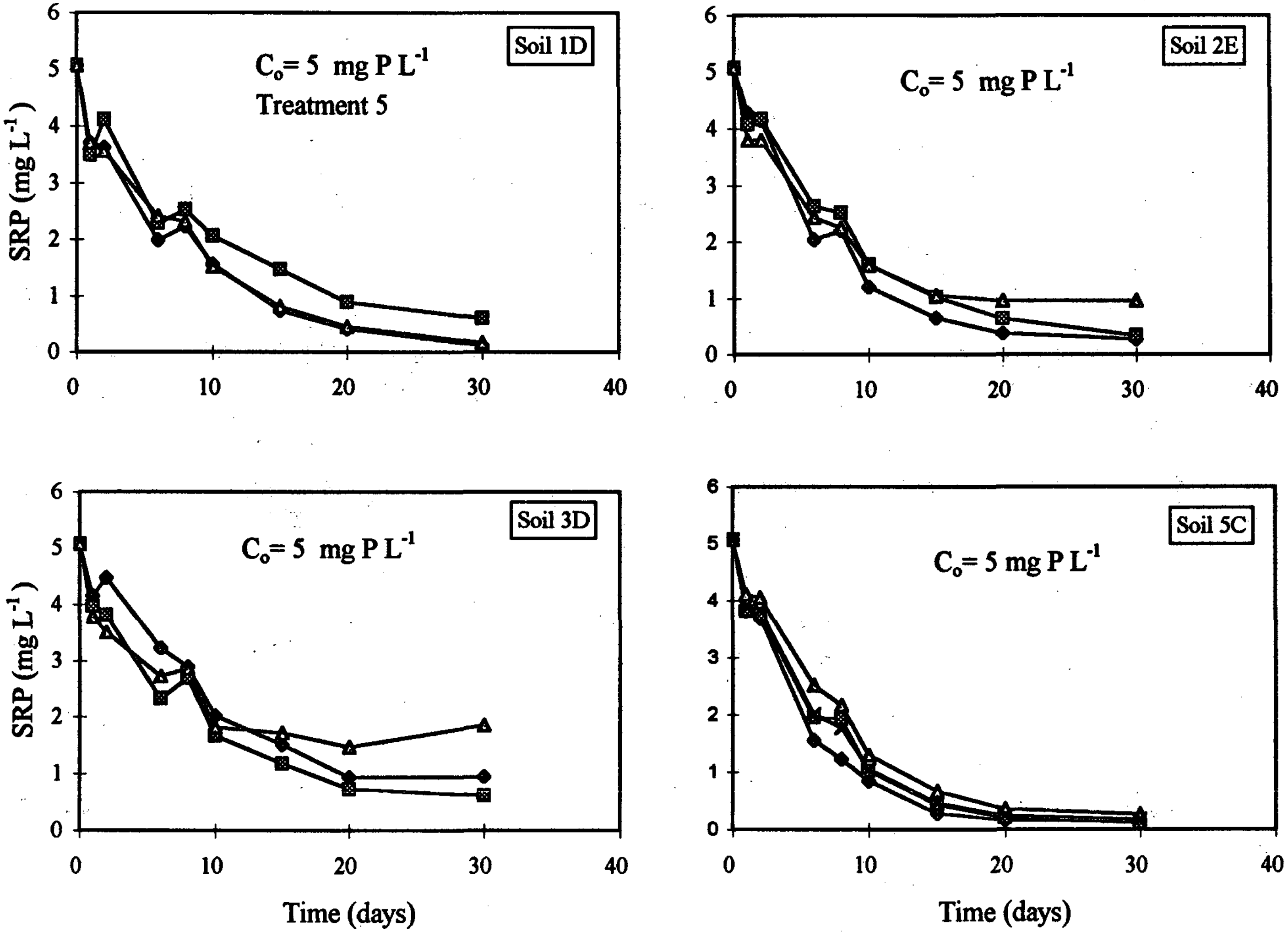

Figure 22. Changes in SRP concentration of the water column (Treatment 5) in soils cores flooded with filtered and spiked Lake Griffin water (C_o = 5.5 mg P L^{-1}). Different data lines represent replicate soil cores.

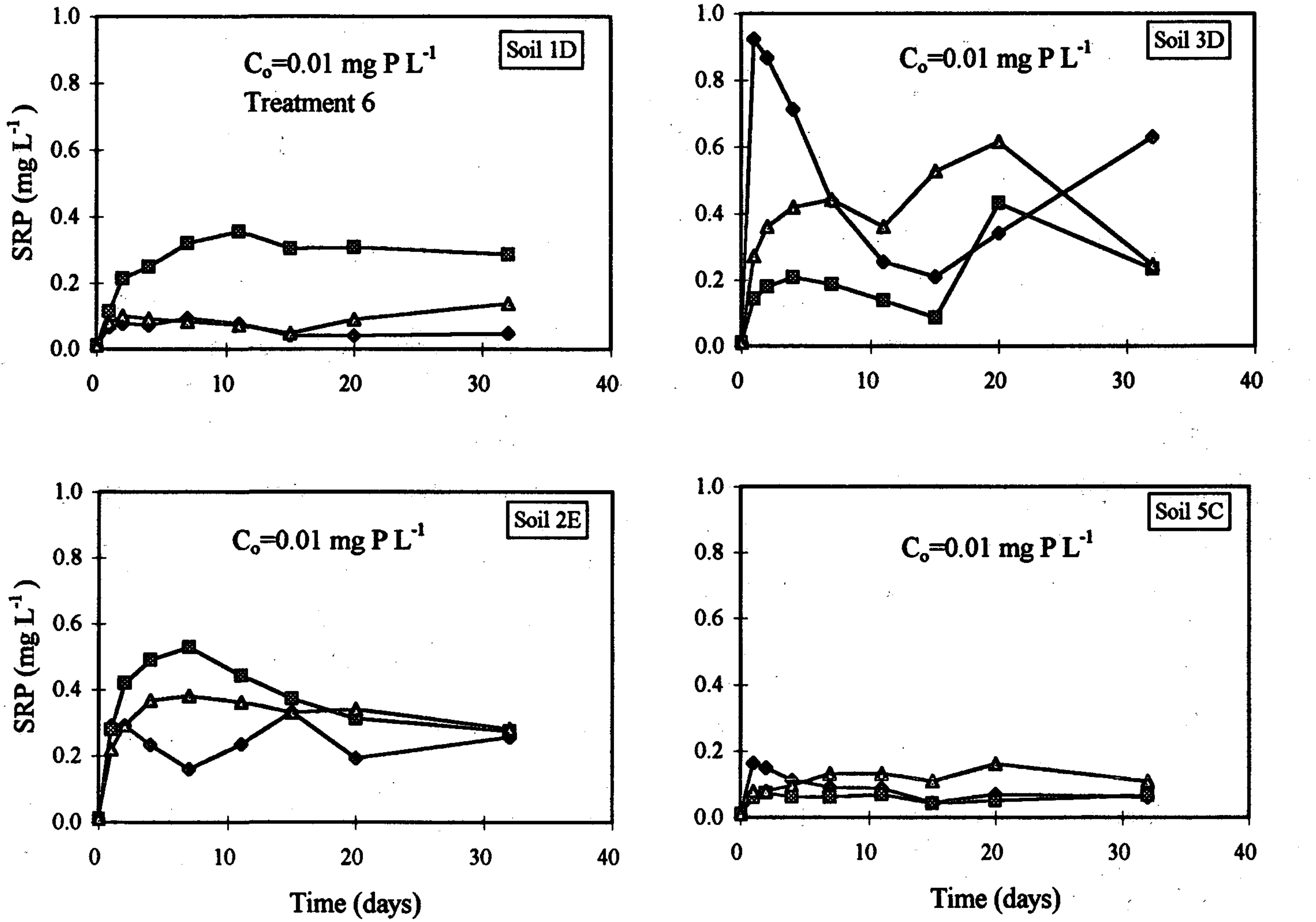

Figure 23. Changes in SRP concentration of the water column (Treatment 6) in soil cores flooded with filtered Lake Griffin water (C_o = 0.01 mg P L^{-1}). Different data lines represent replicate soil cores.

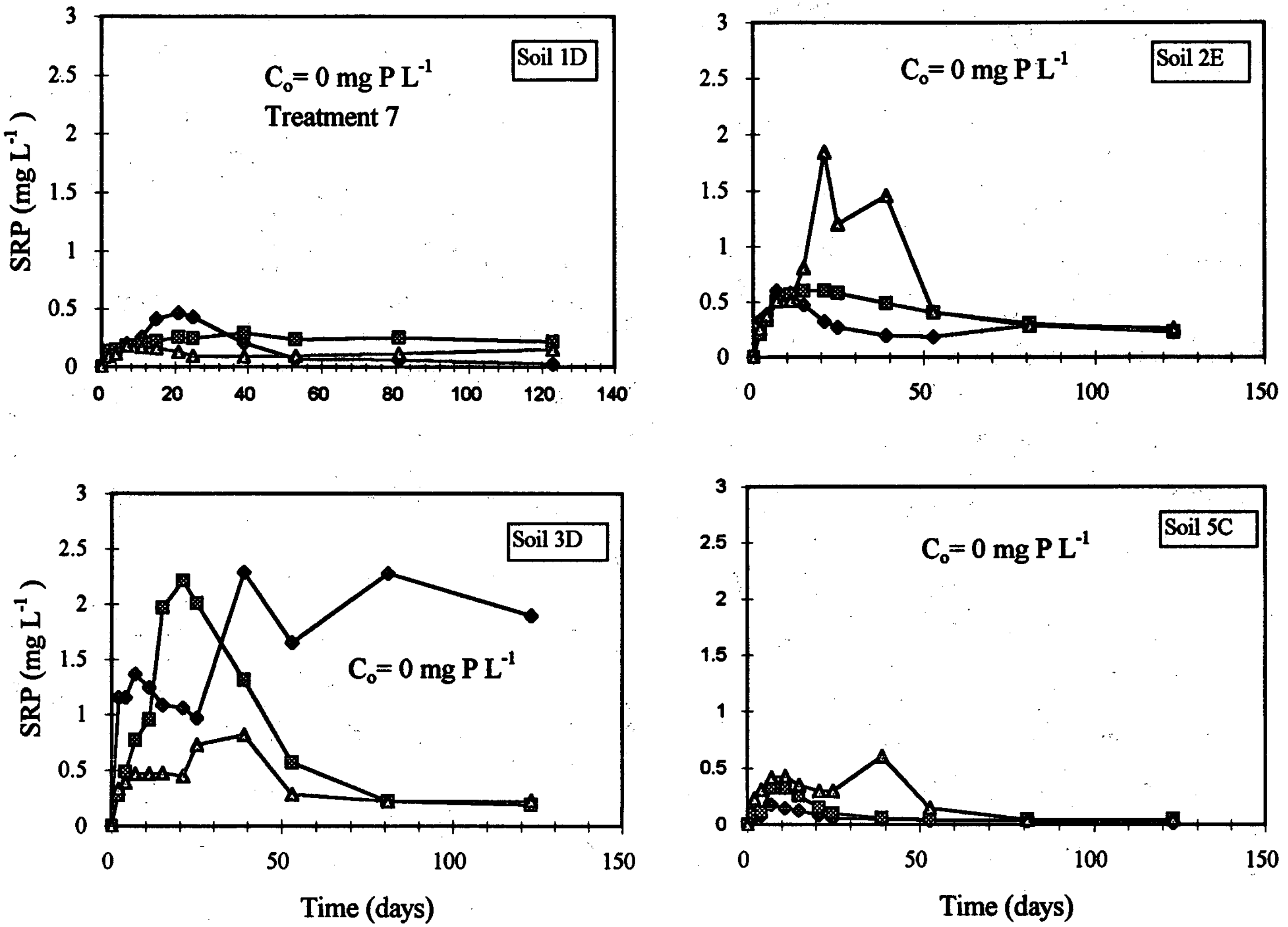

Figure 24. Changes in SRP concentration of the water column (Treatment 7) in soil cores flooded with distilled water (C_o = 0 mg P L^{-1}). Different data lines represent replicate soil cores.

Table 18. Influence of floodwater type and SRP loading on water column SRP at the the end of each incubation period.

Floodwater	Initial SRP	Incubation period.	1D		2E		3D		5C	
			Mean	SD ±	Mean	SD ±	Mean	SD ±	Mean	SD ±
	mg L^{-1}	days	mg L^{-1}							
Distilled water	0	0-32	0.117	0.081	0.354	0.278	0.487	0.121	0.137	0.007
Lake water	0.01	32-62	0.104	0.004	0.229	0.199	0.269	0.270	0.035	0.031
Lake water	0.1	62-92	0.052	0.025	0.143	0.063	0.177	0.198	0.025	0.013
Lake water	1	92-125	0.087	0.051	0.146	0.044	0.113	0.053	0.056	0.037
Lake water	5	125-155	0.296	0.269	0.523	0.378	1.141	0.643	0.173	0.080
Lake water	0.01	155-187	0.157	0.121	0.270	0.012	0.370	0.226	0.078	0.026
Distilled water	0	187-310	0.132	0.099	0.238	0.018	0.771	0.974	0.036	0.018

of total P for soils at stations 1D, 2E, 3D and 5C, respectively (Table 19).

During the 310-day incubation, (Treatment 1 to 7), a total of 1096 mg P m^{-2} (sum of P added through floodwater replacement) was added to the water column. Retention of added P varied among sampling stations, with 71, 83, 88, and 91% of added P retained by stations 3D, 2E, 1D, and 5C, respectively (Table 19). However, a large proportion of retained P was released back into water column, with 5, 8, 19, and 32% of added P released by soil cores from Station 5C, 1D, 2E, and 3D, respectively (Table 19). Net P release occurred primarily during the periods when soil cores were flooded with low P water (<0.1 mg L^{-1}) (Treatments 1, 2, 6 and 7). The total incubation period during the time that P release occurred was 217 days. Average P release rates were in the range of 0.25 to 1.62 mg P m^{-2} day^{-1} for SRP, and 0.34 to 2.38 mg P m^{-2} day^{-1} for TP (Table 19). These values are in the same range as those measured during *in situ* diffusive flux (0.9 to 1.6 mg P m^{-2} day^{-1}) for the same stations (Table 14).

Phosphorus retention or release for respective initial floodwater SRP concentrations is shown in Fig. 25. Phosphorus retention by soil showed a linear relationship with initial floodwater P concentration. Phosphorus assimilation coefficient (A) values were approximately the same for soils from stations 1D, 2E, and 5C (Table 20). Soils with high initial labile pools of P showed lower P assimilation coefficients (Station 3D). The EPC_w values for soils studied were in the range of 0.07 to 0.43 mg L^{-1}, with the highest values for Station 3D.

High soil EPC_w suggests that the flow-way soils, when flooded with Lake Griffin water, will function as a source of P to the water column, since lake water P concentrations are typically lower than the soil EPC_w values. Low EPC_w values of soils from Station 5C suggests that these soils are highly reactive, and adsorb P strongly. Laboratory experiments suggest that the water column P concentrations of this marsh cannot be reduced below EPC_w values unless these soils are treated with chemical amendments, and vegetation is established to stabilize the dissolved P concentration.

4.3 Conclusions

Results presented in this study indicate that the soils collected from selected stations have substantial amounts of labile P in both organic P and inorganic P. After approximately 25-30 weeks of flushing with low P water (SRP = <0.01 mg L^{-1}), soils continued to release P steadily to the water column. However, when soil cores were loaded with high P floodwater (especially 1 and 5.5 mg L^{-1}), net P retention occurred. The EPC_w values determined for soil cores at four stations were variable, and were in

Table 19. Influence of floodwater type and initial SRP loading on water column TP at the end of each incubation period.

Floodwater	Initial SRP	Incubation period	1D		2E		3D		5C	
			Mean	SD ±	Mean	SD ±	Mean	SD ±	Mean	SD ±
	mg/L^{-1}	days	mg L^{-1}							
Distilled water	0	0-32	0.103	0.020	0.357	0.300	0.592	0.173	0.324	0.071
Lake water	0.01	32-62	0.263	0.144	0.330	0.222	0.359	0.295	0.078	0.026
Lake water	0.1	62-92	0.091	0.031	0.282	0.140	0.271	0.256	0.134	0.142
Lake water	1	92-125	0.110	0.073	0.220	0.082	0.198	0.157	0.082	0.081
Lake water	5	125-155	0.642	0.622	0.891	0.435	1.466	0.891	0.226	0.152
Lake water	0.01	155-187	0.194	0.142	0.373	0.047	0.482	0.211	0.127	0.044
Distilled water	0	187-310	0.134	0.080	0.301	0.055	0.754	0.936	0.076	0.033

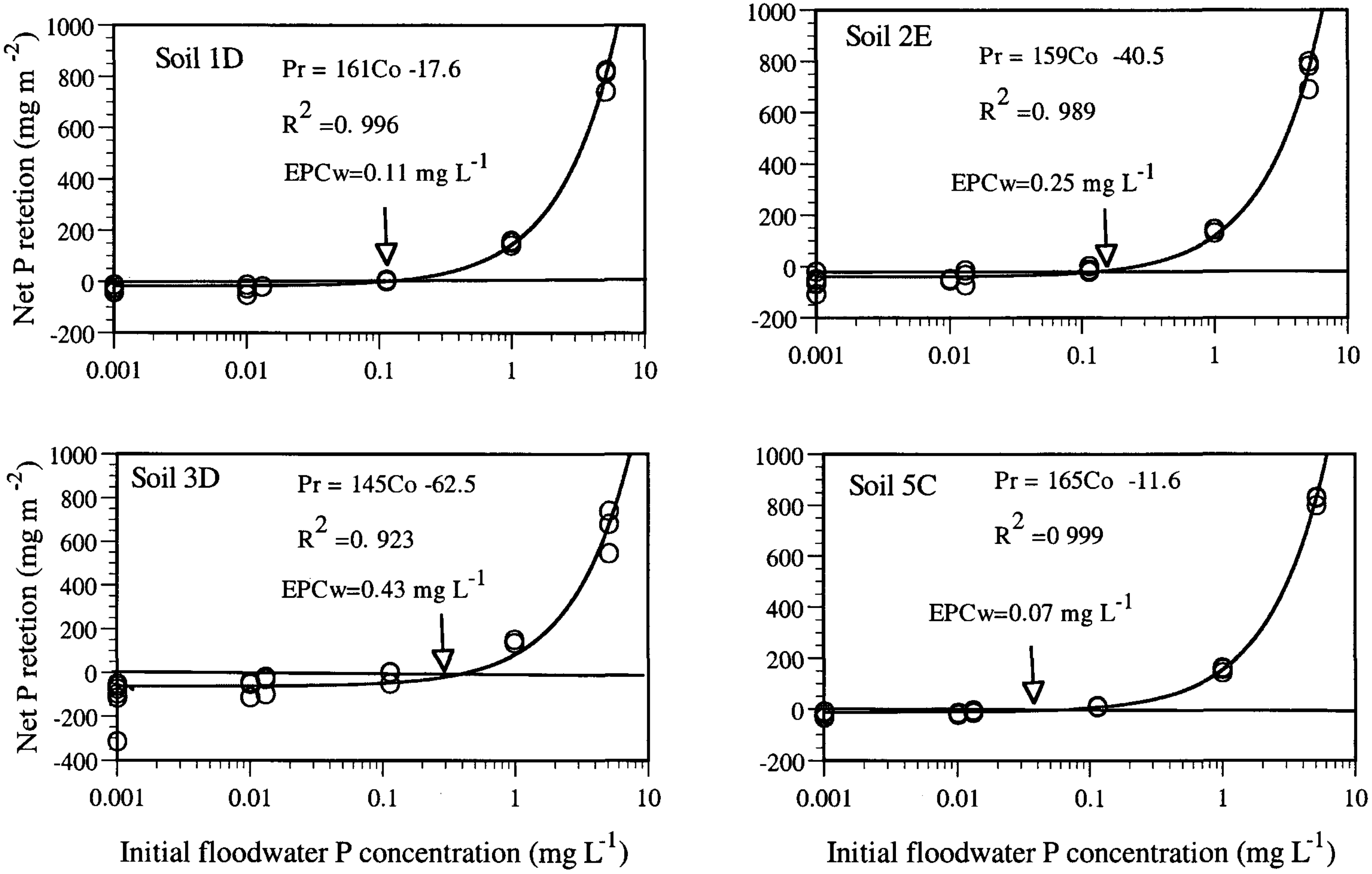

Figure 25. Relationship between P retention and initial P concentration. EPC_w refers to equilibrium floodwater P concentration when P retention equals release.

Table 20. Phosphorus retention by soils at the end of 310 days of incubation under variable P loading. Values in parenthesis are percent of added p.

							Phosphate release	
Soils	Added P	Total P retention		Total P release		Added P retained	SRP	TP
	---------------------------------mg m^{-2}					-----%-----	—mg P m^{-2} day^{-1} —	
1D	1096	963	(88)	86	(8)	80	0.40	0.74
		± 53	(±5)	± 40	(±4)	± 8		
2E	1096	908	(83)	204	(19)	64	0.94	1.54
		± 51	(±5)	± 56	(±5)	± 2		
3D	1096	781	(71)	352	(32)	39	1.62	2.38
		±100	(±9)	±158	(±14)	± 13		
5C	1096	997	(91)	55	(5)	86	0.25	0.34
		± 20	(±2)	± 17	(±2)	± 3		

Table 21. Phosphorus assimilation parameters, where A = phosphorus assimilation coefficient; P^1 = phosphorus release potential of soils under ambient conditions; EPC_w = equilibrium P concentration. Values calculated using the equations shown in the text.

Stations	A(Slope)	(P^1)	EPC_w	R^2
	L m^{-2}	mg m^{-2}	mg L^{-1}	
1D	161 ± 2	18 5	0.11	0.996
2E	159 ± 4	41 ±8	0.25	0.989
3D	145 ±10	63 ±19	0.43	0.923
5C	165 ± 1	12 ± 3	0.07	0.999

the range of 0.07 to 0.43 mg L^{-1}, suggesting that these soils will release P, as long as the floodwater P concentration is lower than these values. During 30 weeks of flushing with low P water, P release rates were in the range of 0.25 to 1.62 mg P m^{-2} day^{-1} for SRP, and 0.34 to 2.4 mg P m^{-2} day^{-1} for TP. These slow release rates were in the same range as those observed under field conditions. At these rates, the surface 15 cm soil has a supply of labile P which will last 30-140 years. However, the labile P may be immobilized by the addition of chemical amendments and stabilization of soil porewater P with emergent vegetation.

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APPENDIX
TABLES

Appendix 1. Cumulative phosphorus release from leaching study.

Site	Cumul.leach (mgPi/25g/@2L)	Cumul.leach (mgPi/ kg/ @2L)	PSI (Native) (L/kg)	PSI (leached) (L/kg)	Incr. PSI (L/kg)
1A	4.26	170.5	94.0	248.5	154.5
1B	0.62	24.7	286.3	387.2	101.0
1C	1.35	53.9	379.9	403.9	23.9
1D	0.28	11.2	341.7	352.2	10.5
1E	1.26	50.5	234.9	294.3	59.5
2B	2.11	84.2	196.5	319.6	123.1
2B	0.77	30.8	369.2	431.8	62.6
2D	1.19	47.7	266.3	311.0	44.8
2E	0.58	23.1	202.2	233.4	31.2
3A	0.82	32.9	174.0	270.3	96.3
3B	0.31	12.3	286.3	387.0	100.8
3C	1.29	51.4	234.9	291.6	56.8
3D	1.30	52.1	234.9	312.1	77.2
3E	0.47	18.6	367.1	396.6	29.5
3F	1.45	58.1	140.8	240.0	99.2
4A	2.39	95.7	174.0	288.7	114.7
4B	1.01	40.6	296.4	332.8	36.4
4C	1.14	45.6	238.8	247.3	8.5
4D	1.04	41.6	175.9	245.8	69.9
5A	1.96	78.5	225.2	340.4	115.2
5B	2.85	114.1	276.2	426.1	149.9
5C	0.52	20.9	258.4	306.2	47.9
5D	2.56	102.3	227.1	359.4	132.2
5E	2.84	113.5	126.2	280.9	154.6

Appendix 2. Exchangeable cations of soil used in the leaching study.

			Exchangeable cations		
Site	Ca	Mg	K	Al	Fe
			(mg/kg)		
1A	13710	1347	1018	2.0	0.60
1B	12180	1714	711	0.0	0.00
1C	15630	1887	695	2.0	0.00
1D	7480	1153	473	1.0	0.00
1E	7320	1012	465	1.0	0.00
2B0	15250	1502	1205	1.0	0.00
2B	9490	1943	745	2.0	0.00
2D	9030	1270	541	0.0	0.00
2E	7080	730	271	0.0	0.00
3A	14640	1488	909	2.0	0.00
3B	8220	1129	492	2.0	1.60
3C	9330	1350	619	1.0	0.00
3D	9580	1667	729	1.0	0.00
3E	8370	1392	562	1.0	1.00
3F	7050	1100	616	1.0	0.00
4A	5330	484	318	4.0	6.70
4B	4310	331	233	2.0	2.80
4C	4210	351	212	1.0	0.00
4D	2320	247	110	0.0	0.00
5A	2000	194	88	0.0	0.00
5B	1363	135	126	4.0	1.50
5C	1401	139	148	8.0	2.90
5D	1246	134	89	2.0	1.00
5E	1296	135	70	1.0	0.50

Appendix 3. Selected physico-chemical properties of soil used in the study.

Station	Repeat	Depth cm	Bulk density ug/cm^3	Water content %	Ash content %	TP(ashing) mg/kg
1D	I	0-3	0.126	87.5	64.4	717.4
		3-6	0.787	42.0	77.7	391.4
		6-9	0.794	34.6	78.1	350.3
		9-12	1.247	29.4	79.6	288.2
		12-15	1.235	29.3	79.8	205.8
1D	II	0-3	0.753	46.2	77.3	462.1
		3-6	0.825	38.1	79.3	446.5
		6-9	1.122	33.9	79.7	361.9
		9-12	1.027	30.5	80.0	287.0
		12-15.5	1.142	29.4	78.7	236.9
1D	III	0-3	0.841	40.8	79.5	379.6
		3-6	0.985	35.9	78.9	357.4
		6-9	0.968	33.7	80.4	306.5
		9-12	1.093	30.9	80.1	253.5
		12-14	1.339	30.1	81.9	225.1
2E	I	0-3	0.257	70.6	69.2	768.6
		3-6	0.891	36.5	85.2	441.5
		6-9	1.045	28.8	87.2	335.6
		9-12	1.082	37.6	88.9	162.1
		12-14.5	1.166	23.3	89.1	152.3
2E	II	0-3	0.439	57.4	81.2	483.7
		3-6	1.111	30.5	88.1	383.2
		6-9	1.069	29.0	87.3	390.7
		9-12	1.195	24.9	87.3	245.3
		12-15.5	1.437	23.6	89.5	166.2
2E	III	0-3	0.677	46.3	85.8	415.1
		3-6	1.019	32.4	86.1	443.5
		6-9	1.312	26.0	89.3	246.6
		9-13	1.342	24.0	89.1	165.2
3D	I	0-3	0.337	66.0	73.6	568.0
		3-6	0.678	45.4	78.0	513.9
		6-9	0.868	42.8	79.4	529.3
		9-12	0.755	39.2	79.6	511.1

Appendix 3. Selected physico-chemical properties of soil used in the study.

Station	Repeat	Depth cm	Bulk density ug/cm^3	Water content %	Ash content %	TP(ashing) mg/kg
		12-16	1.007	35.10	80.9	385.0
3D	II	0-3	0.524	55.8	76.1	520.9
		3-6	0.699	46.2	76.1	545.5
		6-9	0.864	39.9	68.0	493.4
		9-12	0.952	36.9	80.7	440.0
		12-15	0.974	35.2	78.5	662.4
3D	III	0-3	0.243	78.0	65.3	745.4
		3-6	0.614	50.6	78.5	519.4
		6-9	0.678	46.5	78.0	513.6
		9-12	0.801	41.2	78.9	506.2
		12-15	1.054	37.0	79.0	325.4
5C	I	0-3	0.549	55.7	84.4	412.5
		3-6	0.823	42.1	83.7	371.8
		6-9	0.914	37.4	84.1	369.8
		9-12	1.028	30.4	86.6	283.8
		12-14	1.351	25.0	89.9	172.9
5C	II	0-3	0.420	61.9	83.2	385.3
		3-6	0.926	36.9	83.9	235.0
		6-9	1.414	21.8	90.3	156.6
		9-12	1.440	20.6	90.0	128.4
		12-14	1.320	23.3	92.8	104.7
5C	III	0-3	0.289	74.5	78.6	516.0
		3-6	0.987	35.5	88.5	254.7
		6-9	1.272	27.6	87.6	155.9
		9-11	1.272	29.0	88.1	110.6

Appendix 4. Depth distribution of soil labile and nonlabile forms of phosphorus.

Station	Repeat	Depth	KClPi	NaHCO3Pi	NaOHPi	HClPi	TPi	NaHCO3Po	NaOHPo	ResidueP	TPo
		cm	----------mg/kg----------								
1D	I	0-3	2.25	120.2	75.3	22.1	220	120.5	98.0	78.6	297
		3-6	2.32	117.3	70.0	19.2	209	117.5	83.9	104.9	306
		6-9	0.40	109.2	66.5	13.9	190	109.2	79.3	99.3	288
		9-12	0.91	55.8	46.8	11.0	115	55.9	71.3	91.8	219
		12-15	0.81	26.2	32.9	41.5	101	26.3	59.0	78.0	163
1D	II	0-3	1.60	117.8	70.1	20.3	210	117.9	92.1	103.2	313
		3-6	0.10	142.2	83.0	13.0	238	142.2	97.6	106.3	346
		6-9	1.07	125.1	75.3	11.3	213	125.2	84.4	95.8	305
		9-12	0.72	61.2	50.9	14.2	127	61.2	86.9	130.6	279
		12-15.5	0.69	30.9	40.0	28.9	101	30.9	64.1	89.7	185
1D	III	0-3	1.51	87.1	63.2	15.2	167	87.3	81.9	103.5	273
		3-6	0.40	52.5	72.4	12.5	138	52.6	98.9	110.0	262
		6-9	1.13	54.9	49.3	12.7	118	55.1	52.3	89.6	197
		9-12	0.71	29.4	38.3	12.3	81	29.5	64.4	81.5	175
		12-14	0.10	27.7	32.0	14.7	74	27.7	75.5	87.9	191
2E	I	0-3	5.22	84.2	51.9	188.0	329	84.9	177.2	237.0	499
		3-6	3.45	49.9	31.5	124.4	209	50.2	74.1	101.1	226
		6-9	5.03	45.7	30.6	102.9	184	46.2	63.1	28.7	138
		9-12	1.91	23.7	27.1	33.2	86	23.9	38.3	89.3	152
		12-14.5	1.29	15.8	18.1	21.2	56	15.9	28.8	76.6	121
2E	II	0-3	5.04	66.0	31.4	158.0	260	66.5	84.8	112.3	264
		3-6	3.61	59.0	31.1	121.4	215	59.4	54.2	100.3	214
		6-9	5.55	54.7	30.6	43.3	134	55.3	57.6	110.3	223
		9-12	2.43	32.6	20.7	115.7	171	32.9	38.8	70.4	142
		12-15.5	0.80	12.5	11.7	8.4	33	12.6	20.5	46.9	80
2E	III	0-3	4.20	41.5	23.4	77.2	146	42.0	57.1	64.1	163
		3-6	3.91	48.4	28.3	119.3	200	48.9	59.4	100.3	209
		6-9	3.49	38.5	19.7	88.7	150	38.9	35.6	93.3	168
		9-13	0.90	17.7	13.9	13.9	46	17.8	30.2	61.1	109
3D	I	0-3	3.24	142.4	101.1	61.9	309	142.8	185.7	163.6	492
		3-6	2.01	107.2	76.9	24.5	211	107.4	108.1	118.2	334
		6-9	2.10	133.7	96.1	57.6	289	133.9	124.7	131.7	390
		9-12	2.12	148.1	95.9	26.7	273	148.3	114.0	121.5	384

Appendix 4. Depth distribution of soil labile and nonlabile forms of phosphorus.

Station	Repeat	Depth	KClPi	NaHCO3Pi	NaOHPi	HClPi	TPi	NaHCO3Po	NaOHPo	ResidueP	TPo
		cm	-----	-----	-----	-----mg/kg	-----	-----	-----	-----	-----
		12-16	0.79	65.6	51.8	20.0	138	65.7	81.1	87.1	234
3D	II	0-3	2.11	75.4	22.1	17.1	117	75.6	82.9	71.2	230
		3-6	1.43	123.6	99.1	23.1	247	123.8	111.8	118.9	354
		6-9	2.29	134.8	97.7	18.4	253	135.0	133.2	102.6	371
		9-12	1.79	112.5	84.5	19.5	218	112.7	118.3	139.1	370
		12-15	2.68	101.2	63.8	18.3	186	101.5	113.3	104.3	319
3D	III	0-3	7.01	105.5	66.6	25.0	204	106.4	189.5	139.8	436
		3-6	2.01	102.5	92.1	22.1	219	102.7	140.7	106.5	350
		6-9	1.91	128.2	95.4	21.9	247	128.4	148.4	138.7	415
		9-12	1.89	118.4	100.7	18.7	240	118.6	118.7	114.0	351
		12-15	1.10	80.2	59.1	15.6	156	80.3	121.0	89.8	291
5C	I	0-3	4.08	43.8	16.3	64.7	129	44.3	43.3	109.0	196
		3-6	3.44	52.2	18.1	77.6	151	52.6	38.4	133.3	224
		6-9	3.41	49.4	19.9	75.0	148	49.8	43.3	137.1	230
		9-12	2.30	36.9	14.5	38.7	92	37.1	30.5	110.9	179
		12-14	2.13	19.5	6.9	25.6	54	19.7	14.8	81.3	116
5C	II	0-3	11.88	73.5	27.0	949.8	1062	75.1	71.4	55.7	202
		3-6	3.49	32.0	12.2	35.4	83	32.4	34.3	98.2	165
		6-9	1.90	10.4	6.5	18.0	37	10.6	13.0	64.5	88
		9-12	1.12	8.4	6.9	12.4	29	8.5	13.4	49.1	71
		12-14	0.79	31.2	0.2	9.1	41	31.3	5.8	48.2	85
5C	III	0-3	11.43	60.6	20.9	100.2	193	62.0	72.7	145.6	280
		3-6	3.90	30.4	9.6	44.7	89	30.8	33.3	66.7	131
		6-9	1.88	15.7	4.4	23.2	45	15.9	17.5	66.4	100
		9-11	0.91	11.2	7.9	10.0	30	11.4	16.6	65.8	94

Task 3: P exchange between soil and overlying water column

Appendix 5. Floodwater soluble P, TP, Ca, Mg, Fe, and Al concentrations as influenced by release from the underlying soil

Times Sampling weeks	Column	Sampling date	SRP	TP*	Ca	Mg	Al	Fe
					mg/L			
0	Lake water		0.011		34.6	11.6	<0.1	<0.01
1	1D 1	Dec. 7	0.077	0.082	34.1	12.6	<0.1	0.08
1	1D 2		0.068	0.075	31.9	11.2	<0.1	0.02
1	1D 3		0.403	0.362	37	13	0.1	0.07
1	2E 1	Oct. 18	0.180	0.171	34.4	10	<0.1	0.06
1	2E 2		0.220	0.207	34.9	11.2	<0.1	0.05
1	2E 3		0.230	0.212	34.6	10.1	<0.1	0.04
1	3D 1	Oct. 18	0.470	0.414	36.4	13	0.2	0.02
1	3D 2		0.360	0.343	34.6	12.6	<0.1	0.04
1	3D 3		0.600	0.548	33.6	12.6	<0.1	0.09
1	5C 1	Oct. 18	0.300	0.292	44.8	13.6	0.2	0.02
1	5C 2		0.480	0.448	48.8	14.2	<0.1	0.07
1	5C 3		0.460	0.420	44.8	14	<0.1	0.03
2	1D 1	Dec. 13	0.058	0.069	38.4	11.9	0.1	0.05
2	1D 2		0.068	0.075	34.7	10	0.2	0.11
2	1D 3		0.424	0.382	43.3	13.3	0.1	0.04
2	2E 1	Oct. 26	0.330	0.288	38	10.4	<0.1	0.08
2	2E 2		0.340	0.318	39.2	11.6	0.4	0.04
2	2E 3		0.330	0.311	37.8	10.7	<0.1	0.04
2	3D 1	Oct. 26	0.740	0.733	38.2	13.3	0.2	0.09
2	3D 2		0.730	0.666	36.8	13.1	0.1	0.07
2	3D 3		0.980	0.918	35.7	13.1	<0.1	0.11
2	5C 1	Oct. 26	0.750	0.749	52.8	14.6	<0.1	0.1
2	5C 2		0.600	0.618	60.3	15.2	<0.1	0.09
2	5C 3		0.520	0.519	52.9	14.4	<0.1	0.08
3	1D 1	Dec. 20	0.058	0.084	38.7	11.1	<0.1	0.08
3	1D 2		0.080	0.216	35.9	9.9	<0.1	0.02
3	1D 3		0.273	0.305	43.8	12.9	<0.1	0.02
3	2E 1	Nov. 7	0.210	0.232	37.4	10	<0.1	0.03
3	2E 2		0.310	0.311	40.7	11.3	<0.1	0.06
3	2E 3		0.430	0.443	38.8	10.5	<0.1	0.03
3	3D 1	Nov. 7	0.660	0.691	37.2	12.5	<0.1	0.05

Appendix 5. Floodwater soluble P, TP, Ca, Mg, Fe, and Al concentrations as influenced by release from the underlying soil

Times Sampling weeks	Column	Sampling date	SRP	TP*	Ca	Mg	Al	Fe
					mg/L			
3	3D 2		0.670	0.739	34.2	11.8	0.4	0.24
3	3D 3		1.300	1.152	36.4	12.7	0.1	0.03
3	5C 1	Nov. 7	0.470	0.531	60.1	14.2	0.1	0.08
3	5C 2		0.740	0.739	70.4	14.8	0.3	0.03
3	5C 3		0.470	0.477	61.3	14.2	0.1	0.15
4	1D 1	Dec. 27	0.071	0.088	39.9	11.4	0.2	0.09
4	1D 2		0.184	0.226	37	10.2	<0.1	0.04
4	1D 3		0.210	0.248	44.3	13.1	<0.1	0.07
4	2E 1	Nov. 30	0.110	0.180	39.6	9.7	0.1	0.06
4	2E 2		0.071	0.107	43.3	10.5	<0.1	0.03
4	2E 3		0.374	0.420	39.4	10.2	<0.1	0.03
4	3D 1	Nov. 30	0.869	0.956	34.2	11.4	<0.1	0.06
4	3D 2		0.273	0.445	35.4	11.4	0.3	0.22
4	3D 3		0.592	0.701	33.6	11.2	0.1	0.02
4	5C 1	Nov. 30	0.802	0.906	68.3	15.2	<0.1	0.04
4	5C 2		0.827	0.867	80.8	15.8	0.1	0.18
4	5C 3		0.207	0.292	76.5	14.6	<0.1	0.01
5	1D 1	Jan.3,96	0.039		40.2	11.2	0.1	0.16
5	1D 2		0.086		38.5	10.5	<0.1	0.03
5	1D 3		0.135		43.2	12.5	<0.1	0.03
5	2E 1	Dec. 7,95	0.191	0.245	38.3	9.7	0.1	0.06
5	2E 2		0.071	0.104	42.6	10.4	<0.1	0.08
5	2E 3		0.229	0.241	39.8	10.5	0.1	0.01
5	3D 1	Dec. 7,95	0.521	0.519	34.7	11.7	0.4	0.27
5	3D 2		0.163	0.219	37.5	12.5	0.3	0.06
5	3D 3		0.352	0.357	35.6	12	0.1	0.11
5	5C 1	Dec. 7,95	0.239	0.248	68.1	15.9	<0.1	0.01
5	5C 2		1.100	1.037	79.8	16.6	<0.1	0.1
5	5C 3		0.149	0.190	80.8	16	0.1	0.01
6	1D 1	Jan.10,96	0.036		43.4	12.4	<0.1	0.05
6	1D 2		0.086		44.1	12.4	<0.1	0.02
6	1D 3		0.135		45.5	13.5	0.1	0.08
6	2E 1	Dec.13,95	0.159	0.167	40.8	10.9	0.1	0.08
6	2E 2		0.191	0.203	43.8	11.3	0.2	0.08
6	2E 3		0.124	0.139	40.7	11.4	<0.1	0.02
6	3D 1	Dec.13,95	0.197	0.216	33.5	12.5	0.4	0.18

Appendix 5. Floodwater soluble P, TP, Ca, Mg, Fe, and Al concentrations as influenced by release from the underlying soil

Times Sampling weeks	Column	Sampling date	SRP	TP*	Ca	Mg	Al	Fe
					mg/L			
6	3D 2		0.182	0.193	38.6	12.9	0.9	0.17
6	3D 3		0.210	0.216	36.2	12.2	0.2	0.39
6	5C1	Dec 13, 95	0.115	0.133	62.7	15.3	0.1	0.1
6	5C2		0.745	0.804	71.9	15.6	<0.1	0.12
6	5C3		0.424	0.497	77.3	15.7	<0.1	0.15
7	1D 1	Jan.17,96	0.054		38.9	10.9	0.1	0.34
7	1D 2		0.106		42.7	11.9	0.1	0.02
7	1D 3		0.166		42.5	12.4	<0.1	0.02
7	2E 1	Dec.20,95	0.080	0.117	42.6	11.3	<0.1	0.04
7	2E 2		0.273	0.324	42.9	11.2	0.1	0.09
7	2E 3		0.323	0.362	42.8	12.2	0.0	0.03
7	3D 1	Dec.20,95	0.065	0.107	30.8	12.6	0.2	0.32
7	3D 2		0.165	0.171	38.9	12.9	0.4	0.2
7	3D 3		0.181	0.203	37.5	12.5	0.1	0.12
7	5C 1	Dec.20,95	0.351	0.422	63.6	15.6	0.2	0.29
7	5C 2		0.751	0.860	71.3	15.8	<0.1	0.08
7	5C 3		0.275	0.375	75.9	15.4	0.4	0.1
8	1D 1	Jan.24,96	0.039		40.8	11.1	0.2	0.01
8	1D 2		0.090		43.2	11.7	0.0	0.01
8	1D 3		0.215		46.4	12.7	0.2	0
8	2E 1	Dec.27,95	0.073	0.103	42	11.6	<0.1	0.03
8	2E 2		0.222	0.245	42.9	11.7	0.2	0.06
8	2E 3		0.235	0.270	42.3	12.4	0.1	0.02
8	3D 1	Dec.27,95	0.087	0.117	30.9	12.7	<0.1	0.2
8	3D 2		0.174	0.126	39.2	13.2	0.3	0.14
8	3D 3		0.140	0.158	37.4	12.6	0.2	0.09
8	5C 1	Dec.27,95	0.307	0.337	58.5	15.4	0.2	0.08
8	5C 2		0.537	0.569	64.9	15.1	<0.1	0.12
8	5C 3		0.216	0.290	70.1	15.1	0.1	0.06
9	1D 1	Jan.31,96	0.048		40.7	11.1	0.1	0.03
9	1D 2		0.086		46.6	12.7	<0.1	0.01
9	1D 3		0.194		42	12	<0.1	0.04
9	2E 1	Jan.3,96	0.036		43.4	12.6	0.2	0.08
9	2E 2		0.140		40.7	11.8	0.1	0.04
9	2E 3		0.114		39.8	12.2	0.1	0.04
9	3D 1	Jan.3,96	0.184		34.9	13	0.1	0.73

Appendix 5. Floodwater soluble P, TP, Ca, Mg, Fe, and Al concentrations as influenced by release from the underlying soil

Times Sampling weeks	Column	Sampling date	SRP	TP*	Ca	Mg	Al	Fe
					mg/L			
9	3D 2		0.065		38.9	13	<0.1	0.18
9	3D 3		0.080		39.1	13	<0.1	0.13
9	5C 1	Jan.3,96	0.205		55.1	15.7	<0.1	0.1
9	5C 2		0.487		65.5	15.5	<0.1	0.23
9	5C3		0.159		70.3	15.3	0.1	0.13
10	1D1	Feb 7, 96	0.054		43.7	11.8	<0.1	0.02
10	1D2		0.092		50.6	13.7	0.1	0.02
10	1D3		0.207		46.9	13	0.1	0.18
10	2E1	Jan 10, 96	0.066		44	11.9	<0.1	0.06
10	2E 2		0.126		40.1	12.4	<0.1	0.03
10	2E 3		0.051		38.3	12.5	<0.1	0.02
10	3D 1	Jan.10,96	0.111		34.3	13	<0.1	0.06
10	3D 2		0.045		38.6	13	0.1	0.08
10	3D 3		0.073		38.9	13.1	<0.1	0.07
10	5C 1	Jan.10,96	0.260		49.3	15.7	0.1	0.06
10	5C 2		0.287		62.8	14.9	<0.1	0.1
10	5C 3		0.198		68.4	14.9	<0.1	0.07
11	1D 1	Feb.14,96	0.023		41.9	11.1	0.1	0.03
11	1D 2		0.081		47.5	12.7	<0.1	0.03
11	1D 3		0.154		43	12	<0.1	0.04
11	2E 1	Jan.17,96	0.518		43.1	11.7	<0.1	0.07
11	2E 2		0.126		36.4	11.2	<0.1	0.03
11	2E 3		0.057		30.8	10.7	<0.1	0.02
11	3D 1	Jan.17,96	0.117		34.4	12.3	0.1	0.13
11	3D 2		0.179		37.8	12.4	<0.1	0.05
11	3D 3		0.051		35.7	11.8	<0.1	0.03
11	5C 1	Jan.17,96	0.114		44.2	14.7	<0.1	0.02
11	5C 2		0.182		57.4	13.5	<0.1	0.09
11	5C 3		0.193		61.3	13.2	<0.1	0.04
12	1D 1	Feb.21,96	0.016		41.8	11	<0.1	0.06
12	1D 2		0.062		49.9	13.2	<0.1	0.04
12	1D 3		0.135		43.7	12	<0.1	0.04
12	2E 1	Jan.24,96	0.260		43.6	11.7	<0.1	0.3
12	2E 2		0.144		37.6	11.9	<0.1	0.02
12	2E 3		0.064		32	11.3	<0.1	0.02
12	3D 1	Jan.24,96	0.147		35.5	12.4	<0.1	0.02
12	3D 2		0.768		38.4	12.8	<0.1	0.09

Appendix 5. Floodwater soluble P, TP, Ca, Mg, Fe, and Al concentrations as influenced by release from the underlying soil

Times Sampling weeks	Column	Sampling date	SRP	TP*	Ca	Mg	Al	Fe
					mg/L			
12	3D 3		0.081		36.2	12.1	<0.1	0.02
12	5C 1	Jan.24,96	0.045		39.3	15.2	<0.1	0.03
12	5C 2		0.759		56.1	13.9	<0.1	0.2
12	5C 3		0.296		61.7	13.2	0.1	0.04
13	1D 1	Feb.28,96	0.039		43.4	11.4	<0.1	0.16
13	1D 2		0.103		54	14.2	<0.1	0.09
13	1D 3		0.143		46.2	12.5	<0.1	0.02
13	2E 1	Jan 31, 96	0.189		42.5	11.3	<0.1	0.05
13	2E 2		0.121		36.8	11.8	0.1	0.03
13	2E 3		0.047		31.6	11.6	<0.1	0.02
13	3D 1	Jan.31,96	0.128		60	12.9	<0.1	0.02
13	3D 2		0.383		39.9	12.7	<0.1	0.05
13	3D 3		0.063		37.7	12.6	<0.1	0.03
13	5C 1	Jan.31,96	0.031		34.4	15.4	<0.1	0.01
13	5C 2		0.511		52.7	13.9	<0.1	0.14
13	5C 3		0.209		36.1	12.5	<0.1	0.03
14	1D 1	Mar.7,96	0.033		43.2	11.6	<0.1	0.01
14	1D 2		0.103		55	14.5	<0.1	0.2
14	1D 3		0.126		46.2	12.4	0.1	0.02
14	2E 1	Feb.7,96	0.154		42.2	11.4	<0.1	0.06
14	2E 2		0.151		37.4	12.2	<0.1	0.03
14	2E 3		0.146		30.8	12	<0.1	0.42
14	3D 1	Feb.7,96	0.112		36.2	12.8	<0.1	0.1
14	3D 2		0.486		38.9	12.4	<0.1	0.13
14	3D 3		0.057		37.9	12.8	<0.1	0.03
14	5C 1	Feb.7,96	0.044		29.1	15.5	<0.1	0.16
14	5C 2		0.222		50.5	13.7	<0.1	0.04
14	5C 3		0.128		60.1	12.8	<0.1	0.02
15	1D 1	Mar.19,96	0.022		27.7	6.2	<0.1	<0.01
15	1D 2		0.091		41.6	9.7	<0.1	<0.01
15	1D 3		0.127		28.3	6.2	<0.1	0.01
15	2E 1	Feb.14,96	0.145		39	10.7	<0.1	0.02
15	2E 2		0.132		36.8	11.5	<0.1	0.04
15	2E 3		0.370		32.5	11.9	<0.1	0.07
15	3D 1	Feb.14,96	0.083		34.3	12.4	<0.1	0.02
15	3D 2		0.761		38.9	12.4	<0.1	0.1
15	3D 3		0.045		37.3	12.5	<0.1	0.02

Appendix 5. Floodwater soluble P, TP, Ca, Mg, Fe, and Al concentrations as influenced by release from the underlying soil

Times Sampling weeks	Column	Sampling date	SRP	TP*	Ca	Mg	Al	Fe
						mg/L		
15	5C 1	Feb.14,96	0.312		36.5	15.4	<0.1	0.12
15	5C 2		0.081		45.1	13.5	<0.1	0.02
15	5C 3		0.107		59.6	12.7	<0.1	0.01
16	2E 1	Feb.21,96	0.468		40.4	11.7	<0.1	0.23
16	2E 2		0.114		36.7	11.5	<0.1	0.02
16	2E 3		0.183		32	11.6	<0.1	0.02
16	3D 1	Feb.21,96	0.085		31.3	12.7	<0.1	0.02
16	3D 2		0.530		39.7	12.4	<0.1	0.08
16	3D 3		0.057		37.4	12.7	<0.1	0.03
16	5C 1	Feb 21, 96	0.489		38.4	15.2	<0.1	0.02
16	5C 2		0.039		40.2	14	<0.1	0.02
16	5C 3		0.068		58.1	12.4	<0.1	0.03
17	2E 1	Feb.28,96	0.697		40.2	12.5	<0.1	0.4
17	2E 2		0.133		36.4	11.6	<0.1	0.04
17	2E 3		0.126		29.7	11.9	<0.1	0.04
17	3D 1	Feb.28,96	0.112		23.4	13.4	<0.1	0.03
17	3D 2		0.172		39	12.1	0.1	0.08
17	3D 3		0.077		38.4	13.8	<0.1	0.02
17	5C 1	Feb.28,96	0.123		29.2	15.9	<0.1	0.03
17	5C 2		0.033		30.5	16.8	<0.1	0.06
17	5C 3		0.080		58.2	12.5	<0.1	0.02
18	2E 1	Mar.7,96	0.291		39.9	12.1	<0.1	0.1
18	2E 2		0.166		37.8	11.7	<0.1	0.02
18	2E 3		0.068		30.8	11.9	<0.1	0.02
18	3D 1	Mar.7,96	0.126		23.6	13.4	<0.1	0.02
18	3D 2		0.683		38.4	12.2	<0.1	0.12
18	3D 3		0.069		37	13.5	<0.1	0.01
18	5C 1	Mar.7,96	0.080		30.3	19.2	<0.1	0.04
18	5C 2		0.054		28.7	23.1	<0.1	0.03
18	5C 3		0.097		55.1	12.1	<0.1	0.02
19	2E 1	Mar.19,96	0.103		25.2	6.4	<0.1	<0.01
19	2E 2		0.158		26.1	7.1	<0.1	<0.01
19	2E 3		0.066		16.4	6	<0.1	<0.01
19	3D 1	Mar.19,96	0.114		16.5	7	<0.1	0.01
19	3D 2		0.230		23.7	6.6	<0.1	0.01
19	3D 3		0.062		22.7	8	<0.1	<0.01

Appendix 5. Floodwater soluble P, TP, Ca, Mg, Fe, and Al concentrations as influenced by release from the underlying soil

Times Sampling weeks	Column	Sampling date	SRP	TP*	Ca	Mg	Al	Fe
					mg/L			
19	5C 1	Mar.19,96	0.140		22.2	13.1	<0.1	0.03
19	5C 2		0.057		17.9	16.4	<0.1	0.02
19	5C 3		0.100		34.6	6.7	<0.1	<0.01

* Blank spaces in TP column indicated no analysis of the sample for TP.

Task 3: P exchange between soil and overlying water column

Columns Study P Release in Lake water

Appendix 6. Phosphorus release from soil to overlying water column, expressed as mass per unit area.

Station	Time	Phosphorus release					
	weeks	I	II	III	Mean	Stdev	C.V
		ug/cm^2					%
1D	1	1.17	6.92	1.01	3.04	3.37	110.9
	2	1.07	8.69	1.22	3.66	4.36	119.1
	3	1.24	7.47	1.62	3.44	3.49	101.5
	4	1.63	7.28	3.71	4.21	2.86	67.9
	5	1.28	6.67	2.59	3.51	2.81	80.0
	6	1.32	7.11	2.85	3.76	3.00	79.8
	7	1.73	8.10	3.48	4.43	3.29	74.3
	8	1.62	9.51	3.53	4.89	4.12	84.2
	9	1.87	9.86	3.73	5.15	4.18	81.1
	10	2.11	10.74	4.10	5.65	4.52	80.0
	11	1.71	10.49	4.19	5.47	4.53	82.8
	12	1.64	10.66	4.11	5.47	4.66	85.3
	13	2.06	11.25	5.01	6.11	4.69	76.8
	14	2.06	11.41	5.33	6.27	4.74	75.7
	15	1.94	11.83	5.45	6.41	5.02	78.3
2E	1	2.99	3.70	3.87	3.52	0.47	13.3
	2	6.24	6.56	6.42	6.40	0.16	2.5
	3	5.25	7.19	9.31	7.25	2.03	28.1
	4	4.18	4.02	9.80	6.00	3.29	54.8
	5	5.96	4.23	8.51	6.23	2.15	34.6
	6	6.04	6.56	7.43	6.68	0.71	10.6
	7	5.15	8.65	11.35	8.39	3.11	37.1
	8	5.29	8.68	10.90	8.29	2.83	34.1
	9	4.84	7.98	9.55	7.45	2.40	32.2
	10	5.46	8.18	8.80	7.48	1.78	23.7
	11	13.65	8.59	9.05	10.43	2.80	26.8
	12	10.88	9.32	9.34	9.85	0.90	9.1
	13	10.51	9.38	9.22	9.70	0.70	7.3
	14	10.51	10.31	11.10	10.64	0.41	3.9
	15	10.86	10.46	15.54	12.29	2.82	22.9
	16	17.06	10.57	13.51	13.71	3.25	23.7
	17	22.71	11.27	13.10	15.69	6.15	39.2
	18	17.96	12.29	12.48	14.24	3.22	22.6
	20	15.62	12.69	12.64	13.65	1.71	12.5

Appendix 6. Phosphorus release from soil to overlying water column, expressed as mass per unit area.

Station	Time			Phosphorus release			
	weeks	I	II	III	Mean	Stdev	C.V
				$\mu g/cm^2$			%
3D	1	8.12	6.17	10.42	8.23	2.12	25.8
	2	14.51	13.95	19.22	15.89	2.89	18.2
	3	15.68	15.43	28.30	19.80	7.36	37.2
	4	21.67	10.73	20.34	17.58	5.97	33.9
	5	18.55	9.72	18.15	15.48	4.99	32.2
	6	14.62	10.59	16.84	14.02	3.17	22.6
	7	12.94	10.91	17.03	13.63	3.12	22.9
	8	13.53	11.61	16.92	14.02	2.69	19.2
	9	15.52	10.25	16.30	14.02	3.29	23.5
	10	14.83	10.09	16.42	13.78	3.30	23.9
	11	15.30	12.58	16.25	14.71	1.91	13.0
	12	16.20	23.60	16.93	18.91	4.08	21.6
	13	16.34	19.46	16.85	17.55	1.67	9.5
	14	16.48	22.59	16.94	18.67	3.40	18.2
	15	16.33	29.13	16.88	20.78	7.24	34.8
	16	16.62	27.70	17.21	20.51	6.23	30.4
	17	17.35	23.21	17.74	19.43	3.27	16.8
	18	17.95	32.81	17.83	22.87	8.61	37.7
	20	18.16	27.17	17.91	21.08	5.28	25.0
5C	1	5.11	8.29	7.94	7.11	1.74	24.5
	2	14.09	12.07	10.59	12.25	1.76	14.3
	3	11.75	16.63	11.51	13.30	2.89	21.7
	4	19.25	20.76	8.48	16.16	6.70	41.4
	5	12.08	28.47	8.15	16.23	10.78	66.4
	6	10.70	26.05	13.50	16.75	8.17	48.8
	7	15.24	28.73	12.33	18.77	8.75	46.7
	8	15.66	27.58	12.21	18.48	8.06	43.6
	9	14.90	28.55	11.93	18.46	8.86	48.0
	10	16.56	26.70	13.15	18.80	7.05	37.5
	11	14.86	25.82	13.73	18.14	6.68	36.8
	12	14.00	36.63	16.18	22.27	12.48	56.1
	13	13.88	34.89	15.64	21.47	11.66	54.3
	14	14.17	31.55	14.92	20.22	9.83	48.6
	15	19.04	29.80	14.95	21.26	7.67	36.1
	16	23.23	29.31	14.61	22.39	7.39	33.0
	17	18.46	29.31	15.02	20.93	7.46	35.6
	18	18.08	29.76	15.57	21.13	7.57	35.8
	20	19.38	29.95	15.93	21.75	7.30	33.6

Task 4: In situ determination of pore water nutrients (peepers)

Peepers installed at 2E, 3D, 5C on Oct. 6, 1995; 1D installed on Oct. 20.

Two peepers at each site

Appendix 7. Dissoved NH_4-N, soluble P, pH, and selected cations in soil porewater. (Sampling: Nov. 1995)

Site	Sample #	Depth	pH	NH4-N	SRP	Ca	Mg	Al	Fe
		cm		mg/L					
1D1	1	11		0.28	0.34	30.6	8.4	<0.1	0.03
	2	10		0.11	0.30	31.5	8.7	<0.1	0.03
	3	9		0.11	0.59	30.3	8.1	<0.1	<0.01
	4	8		0.67	3.83	37.5	9.9	<0.1	0.06
	5	7		3.04	5.08	42.9	11.1	<0.1	0.24
	6	6		5.30	4.04	45.6	11.1	<0.1	0.18
	7	5		6.68	3.61	54.6	12.6	<0.1	0.03
	8	4		7.63	4.33	60	13.2	<0.1	0.12
	9	3		8.96	4.95	70.2	15	<0.1	0.03
	10	2		9.59	5.06	71.1	15.9	<0.1	0.03
	11	1		9.57	7.68	85.2	18.3	<0.1	0.03
	12	0		9.73	6.44	93.3	19.5	<0.1	0.03
	13	-1		9.39	2.42	96	20.4	<0.1	0.03
	14	-2		9.05	2.73	90	19.2	<0.1	0.06
	15	-3		8.40	1.96	76.8	18.3	<0.1	0.06
	16	-4		8.02	4.91	71.7	17.1	<0.1	0.15
	17	-5		8.01	6.26	77.4	18	<0.1	0.12
	18	-6		8.11	2.58	74.7	17.4	<0.1	0.09
	19	-7		8.30	2.58	82.5	19.2	<0.1	0.09
	20	-8		8.36	1.86	89.4	20.1	<0.1	0.06
1D2	1	10		0.19	0.34	30.9	8.4	<0.1	0.03
	2	9		0.11	0.33	31.8	8.7	<0.1	<0.01
	3	8		NS	NS	NS	NS	NS	NS
	4	7		0.13	0.33	30.9	8.4	<0.1	<0.01
	5	6		0.87	1.46	34.8	9.3	<0.1	0.03
	6	5		2.51	2.60	37.2	9.6	<0.1	0.06
	7	4		4.28	2.96	31.2	7.8	<0.1	0.33
	8	3		6.19	3.09	47.7	11.4	<0.1	0.21
	9	2		7.68	3.34	53.7	12.6	<0.1	0.21
	10	1		9.10	3.58	59.4	13.2	<0.1	0.12
	11	0		10.10	4.18	67.8	14.4	<0.1	0.09
	12	-1		10.90	4.08	81.6	18.3	<0.1	0.27
	13	-2		11.13	8.49	66.9	14.1	<0.1	0.06
	14	-3		11.67	12.38	69.3	16.5	<0.1	0.06
	15	-4		11.13	13.82	69.9	17.1	<0.1	0.06
	16	-5		10.38	8.34	69.3	16.8	<0.1	0.33

Appendix 7. Dissoved NH_4-N, soluble P, pH, and selected cations in soil porewater. (Sampling:Oct. 20,1995)

Site	Sample #	Depth	pH	NH4-N	SRP	Ca	Mg	Al	Fe
		cm		mg/L					
	17	-6		10.24	8.84	69.9	16.8	<0.1	0.12
	18	-7		9.70	13.32	76.5	18.6	<0.1	0.06
	19	-8		8.27	9.33	78.3	18.6	<0.1	0.06
	20	-9		9.23	5.09	84	19.8	<0.1	0.06
2E1	1	10	7.12	0.06	1.10	32.4	8.4	<0.1	0.04
	2	9	7.10	0.05	1.04	32	8.4	<0.1	<0.01
	3	8	7.10	0.05	1.04	31.2	8	<0.1	0.04
	4	7	7.11	0.05	1.03	31.2	8.4	<0.1	<0.01
	5	6	7.11	0.06	1.06	31.2	8.4	<0.1	0.08
	6	5	7.10	0.06	1.07	30.8	8.4	<0.1	0.12
	7	4	7.12	0.06	1.11	31.2	8.4	<0.1	0.08
	8	3	7.15	0.06	1.11	31.2	8.4	<0.1	0.12
	9	2	7.12	0.05	1.13	31.2	8	<0.1	0.08
	10	1	7.13	0.07	0.93	30.4	8	<0.1	<0.01
	11	0	7.11	0.09	0.90	30.8	8.4	<0.1	0.04
	12	-1	7.10	0.09	0.92	31.2	8.4	<0.1	0.04
	13	-2	7.10	0.13	0.93	31.2	8.4	<0.1	<0.01
	14	-3	7.10	0.21	0.89	31.2	8	<0.1	0.04
	15	-4	6.99	0.54	0.94	32	7.6	<0.1	0.04
	16	-5	6.88	1.25	1.01	37.6	12	<0.1	0.16
	17	-6	6.75	3.10	2.64	66	11.6	<0.1	0.28
	18	-7	6.70	4.14	3.25	84.8	14.8	<0.1	0.16
	19	-8	6.70	4.47	3.19	99.2	16.8	<0.1	0.2
	20	-9	6.67	4.66	2.64	108	18.4	<0.1	0.28
2E2	1	10	7.35	0.07	0.97	31.6	8.4	<0.1	0.04
	2	9	7.30	0.07	0.97	31.6	8.8	<0.1	0.04
	3	8	7.30	0.06	0.97	32	8.4	<0.1	0.04
	4	7	7.30	0.06	1.07	31.2	8.4	<0.1	0.04
	5	6	7.28	0.06	1.02	31.2	8.4	<0.1	0.04
	6	5	7.29	0.06	1.04	31.6	8.4	<0.1	<0.01
	7	4	7.27	0.07	1.10	32.8	8.8	<0.1	0.04
	8	3	7.23	0.06	1.24	32.8	8.4	<0.1	0.04
	9	2	7.22	0.07	1.03	32	8.4	<0.1	0.04
	10	1	7.14	0.32	1.24	34.4	8.4	<0.1	0.04
	11	0	6.87	2.07	2.35	50	9.6	<0.1	0.16
	12	-1	6.80	3.86	3.29	84.8	14.8	<0.1	0.2
	13	-2	6.88	3.37	3.12	71.2	12.8	<0.1	0.24
	14	-3	6.79	4.08	3.29	96	16.4	<0.1	0.28
	15	-4	6.75	4.22	3.14	106	18	<0.1	0.16

Appendix 7. Dissoved NH_4-N, soluble P, pH, and selected cations in soil porewater. (Sampling:Oct. 20,1995)

Site	Sample #	Depth cm	pH	NH4-N	SRP	Ca	Mg	Al	Fe
				mg/L					
	16	-5	6.76	4.33	2.99	108.8	18.4	<0.1	0.24
	17	-6	6.75	4.47	2.93	121.2	20.4	<0.1	0.2
	18	-7	6.71	4.46	2.71	131.2	21.6	<0.1	0.2
	19	-8	6.73	4.39	2.44	144.8	24	<0.1	0.12
	20	-9	6.78	4.30	1.97	157.6	26.4	<0.1	0.04
3D1	1	3	7.45	0.28	0.82	37.6	10.4	<0.1	<0.01
	2	2	7.32	0.41	1.04	34.8	10	<0.1	<0.01
	3	1	7.05	0.94	1.62	35.6	10.4	<0.1	0.16
	4	0	6.70	2.73	2.49	36.8	10.8	<0.1	0.4
	5	-1	6.50	4.19	3.58	42.8	12.4	<0.1	0.64
	6	-2	6.35	6.85	6.19	56	16	<0.1	0.88
	7	-3	6.30	7.57	6.77	64.4	18.8	<0.1	1.44
	8	-4	6.23	7.76	7.06	67.2	19.6	<0.1	0.48
	9	-5	6.15	7.97	7.41	72	20.8	<0.1	0.64
	12	-8	6.11	8.21	8.28	79.6	22.4	<0.1	0.64
	13	-9	6.10	7.76	8.22	76.8	21.6	<0.1	0.12
	14	-10	6.15	7.57	8.54	NS	NS	NS	NS
	15	-11	6.09	7.49	8.77	77.6	21.2	<0.1	0.84
	16	-12	6.01	7.38	8.74	79.2	21.2	<0.1	0.92
	17	-13	6.01	7.12	8.51	82	21.6	<0.1	1
	18	-14	6.00	7.09	8.54	92.8	24.4	<0.1	1.28
	20	-16	6.10	7.36	7.38	111.6	30.4	<0.1	0.52
3D2	1	6	7.35	0.23	0.80				
	2	5	7.40	0.27	0.91				
	3	4	7.01	0.67	1.48				
	4	3	6.90	0.93	1.34				
	5	2	6.75	1.33	1.18				
	6	1	6.73	1.57	1.18				
	7	0	6.68	1.91	1.47				
	8	-1	6.55	3.43	2.43				
	9	-2	6.42	5.19	3.51				
	10	-3	6.34	6.93	6.16				
	11	-4	6.30	7.20	6.48				
	12	-5	6.29	6.64	6.42				
	13	-6	6.28	6.91	6.77				
	14	-7	6.20	6.75	6.74				
	15	-8	6.20	6.61	6.74				
	16	-9	6.13	6.64	6.51				
	17	-10	6.11	6.61	6.68				

Appendix 7. Dissoved NH_4-N, soluble P, pH, and selected cations in soil porewater. (Sampling:Oct. 20,1995)

Site	Sample #	Depth	pH	NH4-N	SRP	Ca	Mg	Al	Fe
		cm		----------------------------mg/L					----------------------------
	18	-11	6.08	6.61	6.83				
	19	-12	6.05	6.61	6.83				
	20	-13	6.10	6.64	6.19				
5C1	1	11	7.30	0.19	0.02	43.6	12	<0.1	<0.01
	2	10	7.20	0.26	0.53	44	12	<0.1	<0.01
	3	9	7.23	0.27	0.53	42.8	12	<0.1	<0.01
	4	8	7.20	0.26	0.53	42.4	11.6	<0.1	<0.01
	5	7	7.25	0.27	0.53	44.4	12.4	<0.1	<0.01
	6	6	7.23	0.27	0.53	43.6	12	<0.1	<0.01
	7	5	7.23	0.25	0.54	43.2	12	<0.1	<0.01
	8	4	7.20	0.27	0.54	42.4	11.6	<0.1	<0.01
	9	3	7.23	0.26	0.53	42.8	11.6	<0.1	<0.01
	10	2	7.20	0.27	0.54	43.2	12	<0.1	<0.01
	11	1	7.10	0.31	0.58	0	0	<0.1	<0.01
	12	0	6.89	0.53	0.76	69.2	14	<0.1	<0.01
	13	-1	6.78	2.23	1.41	98	19.6	<0.1	<0.01
	14	-2	6.65	4.83	2.06	119.2	23.2	<0.1	<0.01
	15	-3	6.63	6.19	1.83	137.2	26.4	<0.1	<0.01
	16	-4	6.59	7.17	1.57	148.8	28	<0.1	<0.01
	17	-5	6.62	7.84	1.54	159.6	29.6	<0.1	<0.01
	18	-6	6.62	8.24	1.54	167.2	30.8	<0.1	<0.01
	19	-7	6.60	8.24	1.51	174.4	32	<0.1	<0.01
	20	-8	6.51	8.24	1.31	192.4	35.2	<0.1	<0.01
5C2	1	10	7.50	0.13	0.49				
	2	9	7.58	0.13	0.52				
	3	8	7.60	0.17	0.53				
	4	7	7.00	0.14	0.52				
	5	6	7.61	0.18	0.53				
	6	5	7.59	0.19	0.53				
	7	4	7.60	0.16	0.53				
	8	3	7.55	0.23	0.60				
	9	2	7.51	0.33	0.97				
	10	1	7.40	0.84	1.56				
	11	0	7.20	3.88	1.87				
	12	-1	7.10	6.61	2.47				
	13	-2	7.05	7.94	2.47				
	14	-3	7.01	6.91	2.18				
	15	-4	6.98	7.15	1.98				
	16	-5	6.95	7.38	2.09				

Appendix 7. Dissoved NH_4-N, soluble P, pH, and selected cations in soil porewater. (Sampling:Oct. 20,1995)

Site	Sample #	Depth	pH	NH4-N	SRP	Ca	Mg	Al	Fe
		cm		-----------------------	-------------	---mg/L---	---------------	---------------	----------------
	17	-6	6.90	7.97	1.83				
	18	-7	6.87	9.09	1.98				
	19	-8	6.90	7.62	1.89				
	20	-9	6.99	9.17	1.54				

Emeralda Marsh Columns Study II

Treatment 1: Phosphorus Release in DDI water. Date: 3/21/96-4/22/96

Appendix 8: Soluble P concentration of the water column of soil cores flooded with distilled water.

Stations	Time			SRP		
	days	I	II	III	Mean	Stdev
		------------------------------mg/L				-------------------------------
1D	0	0	0	0		
	1	0.025	0.027	0.104	0.052	0.045
	2	0.038	0.106	0.231	0.125	0.098
	5	0.072	0.070	0.072	0.071	0.001
	8	0.080	0.086	0.086	0.084	0.003
	12	0.060	0.089	0.085	0.078	0.016
	16	0.038	0.073	0.073	0.062	0.020
	20	0.053	0.085	0.073	0.071	0.016
	32	0.044	0.103	0.204	0.117	0.081
2E	0	0	0	0		
	1	0.171	0.205	0.070	0.148	0.070
	2	0.233	0.102	0.029	0.121	0.103
	5	0.271	0.305	0.173	0.250	0.069
	8	0.345	0.221	0.157	0.241	0.095
	12	1.047	0.227	0.094	0.456	0.516
	16	0.751	0.199	0.058	0.336	0.366
	20	0.382	0.212	0.050	0.215	0.166
	32	0.315	0.648	0.097	0.354	0.278
3D	0	0	0	0		
	1	0.341	0.145	0.143	0.210	0.114
	2	0.365	0.171	0.153	0.230	0.118
	5	0.719	0.227	0.223	0.390	0.285
	8	1.489	0.624	0.342	0.818	0.598
	12	1.867	0.950	0.324	1.047	0.776
	16	1.722	1.062	0.327	1.037	0.698
	20	1.434	1.043	0.665	1.047	0.384
	32	0.424	0.626	0.412	0.487	0.121
5C	0	0	0	0		
	1	0.045	0.019	0.230	0.098	0.115
	2	0.059	0.027	0.294	0.127	0.146
	5	0.105	0.698	0.265	0.356	0.307
	8	0.178	0.386	0.249	0.271	0.106
	12	0.109	0.409	0.278	0.265	0.150
	16	0.044	0.327	0.195	0.188	0.142
	20	0.032	0.256	0.300	0.196	0.144
	32	0.130	0.137	0.145	0.137	0.007

Emeralda Marsh Columns Study II

Treatment 2: Phosphorus Release in the Lake water.

Appendix 9: Soluble P concentration of the water column of soil cores flooded lake Griffin water.

Stations	Time		SRP			
	day	I	II	III	Mean	Stdev
		----------------------------	mg/L	------------------------------------		
1D	0	0.013	0.013	0.013		
	1	0.045	0.032	0.087	0.055	0.029
	2	0.048	0.039	0.085	0.057	0.024
	4	0.048	0.048	0.079	0.058	0.018
	9	0.048	0.058	0.075	0.060	0.014
	12	0.015	0.033	0.056	0.035	0.021
	16	0.023	0.042	0.045	0.037	0.012
	20	0.020	0.039	0.034	0.031	0.010
	30	0.101	0.101	0.109	0.104	0.004
2E	0	0.013	0.013	0.013		
	1	0.106	0.208	0.087	0.134	0.065
	2	0.097	0.220	0.101	0.139	0.070
	4	0.102	0.281	0.097	0.160	0.105
	9	0.100	0.271	0.095	0.155	0.101
	12	0.092	0.252	0.036	0.127	0.112
	16	0.095	0.260	0.053	0.136	0.109
	20	0.124	0.268	0.068	0.153	0.103
	30	0.452	0.164	0.071	0.229	0.199
3D	0	0.013	0.013	0.013		
	1	0.414	0.192	0.343	0.316	0.113
	2	0.330	0.181	0.355	0.288	0.094
	4	0.263	0.178	0.367	0.269	0.095
	9	0.220	0.146	0.336	0.234	0.096
	12	0.137	0.099	0.268	0.168	0.089
	16	0.076	0.086	0.257	0.140	0.102
	20	0.061	0.088	0.242	0.130	0.098
	30	0.139	0.090	0.579	0.269	0.270
5C	0	0.013	0.013	0.013		
	1	0.180	0.087	0.069	0.112	0.059
	2	0.146	0.073	0.064	0.094	0.045
	4	0.113	0.070	0.060	0.081	0.028
	9	0.089	0.060	0.057	0.069	0.017
	12	0.027	0.011	0.013	0.017	0.009
	16	0.027	0.029	0.015	0.024	0.008
	20	0.039	0.014	0.034	0.029	0.014
	30	0.022	0.011	0.070	0.035	0.031

Emeralda Marsh Columns Study II

Treatment 3: Phosphorus Release in P level 0.1 mg/L of the Lake water .

Appendix 10: Soluble P concentration of water columns of soil cores flooded with Lake Griffin water containing 0.1 mg P/L.

Stations	Time		SRP			
	day	I	II	III	Mean	Stdev
		--------------------------	--------mg/L	--------------------------	------------------------	------------
1D	0	0.113	0.113	0.113		
	1	0.106	0.095	0.165	0.122	0.038
	2	0.095	0.095	0.149	0.113	0.031
	4	0.063	0.076	0.087	0.075	0.012
	9	0.049	0.089	0.101	0.080	0.027
	12	0.037	0.085	0.095	0.072	0.031
	16	0.072	0.123	0.126	0.107	0.030
	20	0.062	0.111	0.093	0.089	0.025
	30	0.081	0.043	0.033	0.052	0.025
2E	0	0.113	0.113	0.113		
	1	0.302	0.208	0.147	0.219	0.078
	2	0.317	0.194	0.129	0.213	0.095
	4	0.227	0.176	0.079	0.161	0.075
	9	0.148	0.205	0.058	0.137	0.074
	12	0.101	0.207	0.048	0.119	0.081
	16	0.235	0.217	0.219	0.224	0.010
	20	0.314	0.165	0.110	0.196	0.105
	30	0.151	0.201	0.076	0.143	0.063
3D	0	0.113	0.113	0.113		
	1	0.410	0.184	0.308	0.300	0.113
	2	0.314	0.153	0.302	0.257	0.090
	4	0.186	0.104	0.206	0.165	0.054
	9	0.107	0.085	0.113	0.102	0.014
	12	0.079	0.083	0.096	0.086	0.009
	16	0.064	0.082	0.083	0.076	0.011
	20	0.071	0.071	0.067	0.070	0.002
	30	0.055	0.406	0.070	0.177	0.198
5C	0	0.113	0.113	0.113		
	1	0.086	0.089	0.104	0.093	0.010
	2	0.068	0.066	0.092	0.076	0.015
	4	0.041	0.029	0.063	0.044	0.018
	9	0.030	0.016	0.049	0.032	0.016
	12	0.025	0.011	0.033	0.023	0.011
	16	0.020	0.019	0.014	0.018	0.003
	20	0.025	0.019	0.023	0.022	0.003
	30	0.017	0.040	0.019	0.025	0.013

Emeralda Marsh Columns Study II

Treatment 4: Phosphorus Release in P levell mg/L of the Lake water .

Appendix 11: Soluble P concentration of water columns of soil cores flooded with Lake Griffin water containing 1 mg P/L.

Stations	Time		SRP			
	day	I	II	III	Mean	Stdev
		-------------------------mg/L		--------------------------------		
1D	0	0.989	0.989	0.989		
	2	0.421	0.501	0.433	0.452	0.043
	5	0.374	0.501	0.412	0.429	0.065
	8	0.238	0.381	0.270	0.296	0.075
	12	0.150	0.294	0.201	0.215	0.073
	16	0.095	0.249	0.155	0.166	0.078
	21	0.093	0.212	0.105	0.136	0.066
	26	0.061	0.186	0.115	0.121	0.063
	33	0.038	0.139	0.084	0.087	0.051
2E	0	0.989	0.989	0.989		
	2	0.528	0.638	0.530	0.566	0.063
	5	0.552	0.534	0.481	0.522	0.037
	8	0.424	0.424	0.302	0.383	0.070
	12	0.350	0.365	0.235	0.317	0.071
	16	0.243	0.326	0.207	0.259	0.061
	21	0.144	0.262	0.164	0.190	0.063
	26	0.161	0.230	0.140	0.177	0.047
	33	0.124	0.196	0.117	0.146	0.044
3D	0	0.989	0.989	0.989		
	2	0.698	0.670	0.579	0.649	0.062
	5	0.507	0.502	0.336	0.448	0.097
	8	0.207	0.302	0.172	0.227	0.068
	12	0.215	0.207	0.134	0.185	0.045
	16	0.186	0.142	0.104	0.144	0.041
	21	0.139	0.117	0.087	0.114	0.026
	26	0.115	0.080	0.069	0.088	0.024
	33	0.174	0.075	0.089	0.113	0.053
5C	0	0.989	0.989	0.989		
	2	0.552	0.625	0.725	0.634	0.087
	5	0.387	0.560	0.575	0.507	0.105
	8	0.239	0.623	0.387	0.416	0.193
	12	0.166	0.599	0.267	0.344	0.227
	16	0.091	0.902	0.149	0.381	0.452
	21	0.045	0.236	0.072	0.118	0.103
	26	0.024	0.132	0.063	0.073	0.055
	33	0.022	0.096	0.049	0.056	0.037

Emeralda Marsh Columns Study II

Treatment 5: Phosphorus Release in P level 5 mg/L of the Lake water .

Appendix 12: Soluble P concentration of water column of soil cores flooded with Lake Griffin Water containing 5 mg P/L.

Stations	Time		SRP			
	day	I	II	III	Mean	Stdev
		----------------	----------------	mg/L	----------------	
1D	0	5.07	5.07	5.07	5.07	
	1	3.713	3.495	3.713	3.641	0.126
	2	3.629	4.113	3.568	3.770	0.299
	6	1.992	2.282	2.413	2.229	0.215
	8	2.237	2.532	2.322	2.363	0.152
	10	1.566	2.066	1.527	1.720	0.301
	15	0.743	1.470	0.817	1.010	0.400
	20	0.412	0.894	0.453	0.586	0.267
	30	0.118	0.606	0.165	0.296	0.269
2E	0	5.07	5.07	5.07	5.07	
	1	4.270	4.077	3.798	4.048	0.237
	2	4.149	4.173	3.798	4.040	0.210
	6	2.038	2.634	2.435	2.369	0.304
	8	2.197	2.521	2.254	2.324	0.173
	10	1.209	1.595	1.583	1.462	0.220
	15	0.658	1.021	1.061	0.913	0.222
	20	0.382	0.647	0.958	0.663	0.288
	30	0.271	0.341	0.958	0.523	0.378
3D	0	5.07	5.07	5.07	5.07	
	1	4.149	3.968	3.774	3.964	0.188
	2	4.476	3.810	3.507	3.931	0.496
	6	3.225	2.322	2.719	2.755	0.453
	8	2.890	2.691	2.861	2.814	0.108
	10	2.026	1.669	1.811	1.835	0.180
	15	1.515	1.175	1.725	1.472	0.278
	20	0.935	0.735	1.470	1.047	0.380
	30	0.947	0.617	1.858	1.141	0.643
5C	0	5.07	5.07	5.07	5.07	
	1	3.810	3.810	4.113	3.911	0.175
	2	3.689	3.750	4.052	3.830	0.195
	6	1.561	1.953	2.521	2.011	0.483
	8	1.231	1.924	2.163	1.773	0.484
	10	0.845	1.016	1.299	1.053	0.230

Appendix 12: Soluble P concentration of water column of soil cores flooded with Lake Griffin Water containing 5 mg P/L.

Stations	Time	SRP				
	day	I	II	III	Mean	Stdev
		--mg/L ----------------------------				
	15	0.277	0.436	0.669	0.461	0.197
	20	0.165	0.206	0.359	0.243	0.102
	30	0.135	0.118	0.265	0.173	0.080

Emeralda Marsh Columns Study II

Treatment 6: Phosphorus Release in the Lake water .

Appendix 13: Soluble P concentration of water columns of soil cores flooded with Lake Griffin water.

Stations	Time		SRP			
	day	I	II	III	Mean	Stdev
		-----------------------------mg/L			--------------------------	
1D	0	0.010	0.010	0.010		
	1	0.067	0.114	0.079	0.087	0.024
	2	0.078	0.214	0.102	0.131	0.073
	4	0.073	0.249	0.092	0.138	0.097
	7	0.094	0.320	0.083	0.166	0.134
	11	0.078	0.355	0.073	0.169	0.161
	15	0.041	0.305	0.048	0.132	0.150
	20	0.040	0.308	0.091	0.147	0.142
	32	0.047	0.287	0.138	0.157	0.121
2E	0	0.010	0.010	0.010		
	1	0.290	0.279	0.220	0.263	0.038
	2	0.290	0.420	0.290	0.333	0.075
	4	0.234	0.490	0.367	0.364	0.128
	7	0.159	0.529	0.381	0.356	0.186
	11	0.235	0.443	0.361	0.346	0.105
	15	0.331	0.373	0.330	0.345	0.024
	20	0.194	0.311	0.340	0.282	0.077
	32	0.257	0.273	0.281	0.270	0.012
3D	0	0.010	0.010	0.010		
	1	0.924	0.144	0.273	0.447	0.418
	2	0.868	0.181	0.361	0.470	0.356
	4	0.713	0.208	0.420	0.447	0.253
	7	0.439	0.188	0.443	0.357	0.146
	11	0.255	0.138	0.361	0.249	0.158
	15	0.210	0.087	0.527	0.275	0.227
	20	0.341	0.431	0.617	0.463	0.140
	32	0.630	0.234	0.245	0.370	0.226
5C	0	0.010	0.010	0.010		
	1	0.164	0.059	0.078	0.100	0.056
	2	0.150	0.073	0.079	0.101	0.042
	4	0.112	0.062	0.097	0.090	0.026
	7	0.091	0.060	0.132	0.094	0.036

Appendix 13: Soluble P concentration of water columns of soil cores flooded with Lake Griffin water.

Stations	Time		SRP			
	day	I	II	III	Mean	Stdev
		---mg/L---				
	11	0.087	0.067	0.132	0.100	0.046
	15	0.045	0.042	0.108	0.065	0.037
	20	0.070	0.051	0.161	0.094	0.059
	32	0.060	0.067	0.108	0.078	0.026

Emeralda Marsh Columns Study II

Treatment 7: Phosphorus Release in DDI water for 123 days (9/23-1/15/97)

Appendix 14: Soluble P concentration of water columns of soil cores flooded with distilled water.

Stations	Time	SRP				
	days	I	II	III	Mean	Stdev
		------------------------------ mg/L				----------------------------
1D	0	0	0	0		
	2	0.086	0.135	0.089	0.103	0.027
	4	0.125	0.146	0.113	0.128	0.017
	7	0.201	0.183	0.183	0.189	0.011
	11	0.261	0.199	0.174	0.211	0.045
	15	0.416	0.225	0.162	0.268	0.132
	21	0.466	0.261	0.130	0.286	0.169
	25	0.430	0.250	0.098	0.259	0.166
	39	0.207	0.294	0.091	0.197	0.102
	53	0.070	0.238	0.096	0.135	0.091
	81	0.060	0.252	0.116	0.143	0.099
	123	0.024	0.217	0.153	0.132	0.099
2E	0	0	0	0		
	2	0.333	0.209	0.253	0.265	0.063
	4	0.386	0.336	0.378	0.367	0.027
	7	0.600	0.501	0.507	0.536	0.055
	11	0.577	0.570	0.510	0.552	0.037
	15	0.472	0.602	0.809	0.628	0.170
	21	0.322	0.600	1.844	0.922	0.810
	25	0.271	0.577	1.199	0.682	0.473
	39	0.194	0.487	1.457	0.713	0.661
	53	0.184	0.404	0.410	0.333	0.129
	81	0.289	0.309	0.289	0.295	0.011
	123	0.227	0.227	0.259	0.238	0.018
3D	0	0	0	0		
	2	1.153	0.274	0.333	0.587	0.491
	4	1.153	0.487	0.388	0.676	0.416
	7	1.367	0.768	0.47	0.868	0.457
	11	1.245	0.955	0.471	0.890	0.391
	15	1.084	1.968	0.472	1.175	0.752
	21	1.061	2.21	0.447	1.239	0.895
	25	0.968	2.003	0.726	1.233	0.678
	39	2.29	1.314	0.819	1.474	0.749

Appendix 14: Soluble P concentration of water columns of soil cores flooded with distilled water.

Stations	Time		SRP			
	days	I	II	III	Mean	Stdev
		----------------------------------	---------------------------------- mg/L	------------------------		
	53	1.648	0.570	0.284	0.834	0.719
	81	2.280	0.220	0.220	0.907	1.189
	123	1.895	0.190	0.227	0.771	0.974
5C	0	0	0	0		
	2	0.060	0.096	0.231	0.129	0.090
	4	0.077	0.107	0.308	0.164	0.125
	7	0.176	0.325	0.413	0.305	0.120
	11	0.146	0.322	0.426	0.298	0.142
	15	0.127	0.253	0.349	0.243	0.111
	21	0.084	0.151	0.295	0.177	0.107
	25	0.057	0.097	0.296	0.150	0.128
	39	0.047	0.060	0.600	0.236	0.315
	53	0.037	0.046	0.143	0.076	0.059
	81	0.033	0.040	0.041	0.038	0.004
	123	0.016	0.047	0.046	0.036	0.018

Appendix 15: Influence of water type and initial soluble P concentration on water TP at the end of each incubation period.

Floodwater	Initial SRP	Incubation period			TP		
	mg/L	days	1D 1	1D 2	1D 3	Mean	SD
			-------------	mg /L	-------------		
Distilled water	0	0-32	0.083	0.104	0.123	0.103	0.020
Lake water	0.01	32-62	0.216	0.148	0.424	0.263	0.144
Lake water	0.1	62-92	0.057	0.116	0.101	0.091	0.031
Lake water	1	92-125	0.031	0.174	0.125	0.110	0.073
Lake water	5	125-155	0.308	1.359	0.259	0.642	0.622
Lake water	0.01	155-187	0.059	0.342	0.179	0.194	0.142
Distilled water	0	187-310	0.044	0.194	0.165	0.134	0.080
			2E 1	2E 2	2E 3	Mean	SD
Distilled water	0	0-32	0.255	0.695	0.120	0.357	0.300
Lake water	0.01	32-62	0.578	0.265	0.148	0.330	0.222
Lake water	0.1	62-92	0.428	0.268	0.149	0.282	0.140
Lake water	1	92-125	0.212	0.306	0.144	0.220	0.082
Lake water	5	125-155	0.564	0.724	1.384	0.891	0.435
Lake water	0.01	155-187	0.323	0.418	0.377	0.373	0.047
Distilled water	0	187-310	0.286	0.254	0.362	0.301	0.055
			3D 1	3D 2	3D 3	Mean	SD
Distilled water	0	0-32	0.476	0.790	0.509	0.592	0.173
Lake water	0.01	32-62	0.199	0.177	0.700	0.359	0.295
Lake water	0.1	62-92	0.124	0.566	0.122	0.271	0.256
Lake water	1	92-125	0.379	0.095	0.119	0.198	0.157
Lake water	5	125-155	1.219	0.724	2.454	1.466	0.891
Lake water	0.01	155-187	0.712	0.437	0.298	0.482	0.211
Distilled water	0	187-310	1.834	0.183	0.244	0.754	0.936
			5C 1	5C 2	5C 3	Mean	SD
Distilled water	0	0-32	0.384	0.246	0.343	0.324	0.071
Lake water	0.01	32-62	0.064	0.062	0.108	0.078	0.026
Lake water	0.1	62-92	0.035	0.298	0.070	0.134	0.142
Lake water	1	92-125	0.012	0.171	0.064	0.082	0.081
Lake water	5	125-155	0.150	0.127	0.401	0.226	0.152
Lake water	0.01	155-187	0.112	0.093	0.176	0.127	0.044
Distilled water	0	187-310	0.113	0.062	0.052	0.076	0.033

Appendix 16: Influence of water type and initial soluble P concentration on water SRP at the end of each incubation period.

Floodwater	Initial SRP	Incubation period			SRP		
	mg/L	days	1D 1	1D 2	1D 3	Mean	SD
			-----------------------	-----------------------	mg/ L	-----------------------	-----------------------
Distilled water	0	0-32	0.044	0.103	0.204	0.117	0.081
Lake water	0.01	32-62	0.101	0.101	0.109	0.104	0.004
Lake water	0.1	62-92	0.081	0.043	0.033	0.052	0.025
Lake water	1	92-125	0.038	0.139	0.084	0.087	0.051
Lake water	5	125-155	0.118	0.606	0.165	0.296	0.269
Lake water	0.01	155-187	0.047	0.287	0.138	0.157	0.121
Distilled water	0	187-310	0.024	0.217	0.153	0.132	0.099
			2E 1	2E 2	2E 3	Mean	SD
Distilled water	0	0-32	0.315	0.648	0.097	0.354	0.278
Lake water	0.01	32-62	0.452	0.164	0.071	0.229	0.199
Lake water	0.1	62-92	0.151	0.201	0.076	0.143	0.063
Lake water	1	92-125	0.124	0.196	0.117	0.146	0.044
Lake water	5	125-155	0.271	0.341	0.958	0.523	0.378
Lake water	0.01	155-187	0.257	0.273	0.281	0.270	0.012
Distilled water	0	187-310	0.227	0.227	0.259	0.238	0.018
			3D 1	3D 2	3D 3	Mean	SD
Distilled water	0	0-32	0.424	0.626	0.412	0.487	0.121
Lake water	0.01	32-62	0.139	0.090	0.579	0.269	0.270
Lake water	0.1	62-92	0.055	0.406	0.070	0.177	0.198
Lake water	1	92-125	0.174	0.075	0.089	0.113	0.053
Lake water	5	125-155	0.947	0.617	1.858	1.141	0.643
Lake water	0.01	155-187	0.630	0.234	0.245	0.370	0.226
Distilled water	0	187-310	1.895	0.190	0.227	0.771	0.974
			5C 1	5C 2	5C 3	Mean	SD
Distilled water	0	0-32	0.130	0.137	0.145	0.137	0.007
Lake water	0.01	32-62	0.022	0.011	0.070	0.035	0.031
Lake water	0.1	62-92	0.017	0.040	0.019	0.025	0.013
Lake water	1	92-125	0.022	0.096	0.049	0.056	0.037
Lake water	5	125-155	0.135	0.118	0.265	0.173	0.080
Lake water	0.01	155-187	0.060	0.067	0.108	0.078	0.026
Distilled water	0	187-310	0.016	0.047	0.046	0.036	0.018

Appendix 17: Influence of water type and initial soluble P concentration on water pH at the end of each incubation period.

Floodwater	Initial SRP	Incubation period	pH				
	mg/L	days	1D 1	1D 2	1D 3	Mean	SD
Distilled water	0	0-32	7.5	7.8	8.0	7.7	0.2
Lake water	0.01	32-62	8.2	8.5	8.3	8.3	0.2
Lake water	0.1	62-92	8.0	8.2	8.0	8.1	0.1
Lake water	1	92-125	7.7	8.2	7.9	7.9	0.2
Lake water	5	125-155	8.0	8.2	8.0	8.1	0.1
Lake water	0.01	155-187	7.8	8.2	8.1	8.1	0.2
Distilled water	0	187-310	7.5	8.0	7.9	7.8	0.3
			2E 1	2E 2	2E 3	Mean	SD
Distilled water	0	0-32	7.9	7.6	7.9	7.8	0.2
Lake water	0.01	32-62	7.8	8.2	8.0	8.0	0.2
Lake water	0.1	62-92	8.0	8.2	8.1	8.1	0.1
Lake water	1	92-125	8.5	8.2	8.1	8.3	0.2
Lake water	5	125-155	8.2	8.3	8.3	8.2	0.1
Lake water	0.01	155-187	8.2	8.3	8.3	8.3	0.1
Distilled water	0	187-310	8.0	8.0	8.0	8.0	0.0
			3D 1	3D 2	3D 3	Mean	SD
Distilled water	0	0-32	7.5	7.1	7.6	7.4	0.3
Lake water	0.01	32-62	8.2	8.1	7.7	8.0	0.3
Lake water	0.1	62-92	8.0	8.0	7.9	8.0	0.1
Lake water	1	92-125	7.9	7.8	7.8	7.8	0.0
Lake water	5	125-155	8.1	8.0	7.9	8.0	0.1
Lake water	0.01	155-187	8.1	8.1	8.1	8.1	0.0
Distilled water	0	187-310	7.8	7.7	7.8	7.8	0.1
			5C 1	5C 2	5C 3	Mean	SD
Distilled water	0	0-32	8.2	8.1	8.0	8.1	0.1
Lake water	0.01	32-62	8.3	8.4	8.4	8.4	0.0
Lake water	0.1	62-92	8.1	8.1	8.2	8.1	0.0
Lake water	1	92-125	7.9	8.0	7.9	7.9	0.1
Lake water	5	125-155	8.3	8.3	8.3	8.3	0.0
Lake water	0.01	155-187	8.4	8.4	8.4	8.4	0.0
Distilled water	0	187-310	8.3	8.2	8.2	8.2	0.1

Appendix 18: Influence of water type and initial soluble P concentration on water conductivity at the end of each incubation period.

Floodwater	Initial SRP	Incubation period	Conductivity (mmho/cm)				
	mg/L	days	1D 1	1D 2	1D 3	Mean	SD
Distilled water	0	0-32	120	205	170	165	43
Lake water	0.01	32-62	295	350	325	323	28
Lake water	0.1	62-92	270	315	240	275	38
Lake water	1	92-125	310	310	250	290	35
Lake water	5	125-155	265	300	240	268	30
Lake water	0.01	155-187	280	290	240	270	26
Distilled water	0	187-310	160	175	180	172	10
			2E 1	2E 2	2E 3	Mean	SD
Distilled water	0	0-32	130	155	155	147	14
Lake water	0.01	32-62	300	320	240	287	42
Lake water	0.1	62-92	290	300	290	293	6
Lake water	1	92-125	290	310	300	300	10
Lake water	5	125-155	290	310	310	303	12
Lake water	0.01	155-187	290	290	300	293	6
Distilled water	0	187-310	170	180	190	180	10
			3D 1	3D 2	3D 3	Mean	SD
Distilled water	0	0-32	110	70	120	100	26
Lake water	0.01	32-62	285	245	250	260	22
Lake water	0.1	62-92	280	270	250	267	15
Lake water	1	92-125	290	270	210	257	42
Lake water	5	125-155	280	272	230	261	27
Lake water	0.01	155-187	260	270	260	263	6
Distilled water	0	187-310	150	120	170	147	25
			5C 1	5C 2	5C 3	Mean	SD
Distilled water	0	0-32	330	190	200	240	78
Lake water	0.01	32-62	340	335	300	325	22
Lake water	0.1	62-92	300	320	300	307	12
Lake water	1	92-125	320	300	300	307	12
Lake water	5	125-155	330	320	310	320	10
Lake water	0.01	155-187	340	330	320	330	10
Distilled water	0	187-310	280	250	220	250	30

Appendix 19: Influence of water type and initial soluble P concentration on water Ca at the end of each incubation period.

Floodwater	Initial SRP mg/L	Incubation period days	Ca				
			1D 1	1D 2	1D 3	Mean	SD
			mg /L				
Distilled water	0	0-32	18	35	29	27	8
Lake water	0.01	32-62	35	45	43	41	6
Lake water	0.1	62-92	46	39	24	36	11
Lake water	1	92-125	46	39	24	36	11
Lake water	5	125-155	39	43	22	35	11
Lake water	0.01	155-187	41	42	28	37	8
Distilled water	0	187-310	26	29	25	27	2
			2E 1	2E 2	2E 3	Mean	SD
Distilled water	0	0-32	22	22	25	23	2
Lake water	0.01	32-62	35	40	20	32	10
Lake water	0.1	62-92	41	46	39	42	4
Lake water	1	92-125	41	46	39	42	4
Lake water	5	125-155	42	48	47	46	3
Lake water	0.01	155-187	42	45	47	45	3
Distilled water	0	187-310	30	34	37	34	3
			3D 1	3D 2	3D 3	Mean	SD
Distilled water	0	0-32	11	4	14	10	5
Lake water	0.01	32-62	33	20	19	24	8
Lake water	0.1	62-92	38	33	26	32	6
Lake water	1	92-125	38	33	26	32	6
Lake water	5	125-155	39	37	19	32	11
Lake water	0.01	155-187	39	37	30	35	5
Distilled water	0	187-310	25	16	28	23	6
			5C 1	5C 2	5C 3	Mean	SD
Distilled water	0	0-32	30	26	37	31	5
Lake water	0.01	32-62	34	38	38	37	2
Lake water	0.1	62-92	43	51	40	45	6
Lake water	1	92-125	43	51	40	45	6
Lake water	5	125-155	55	53	49	52	3
Lake water	0.01	155-187	56	54	48	53	4
Distilled water	0	187-310	58	51	45	51	7

Appendix 20: Influence of water type and initial soluble P concentration on water Mg at the end of each incubation period.

Floodwater	Initial SRP	Incubation period			Mg		
	mg/L	days	1D 1	1D 2	1D 3	Mean	SD
			----------------------------	----------------------------	mg /L	----------------------------	----------------------------
Distilled water	0	0-32	5	9	6	6	2
Lake water	0.01	32-62	10	11	10	10	1
Lake water	0.1	62-92	11	11	12	11	0
Lake water	1	92-125	11	11	12	11	0
Lake water	5	125-155	9	10	13	11	2
Lake water	0.01	155-187	9	10	12	10	1
Distilled water	0	187-310	6	7	8	7	1
			2E 1	2E 2	2E 3	Mean	SD
Distilled water	0	0-32	5	6	6	5	0
Lake water	0.01	32-62	9	9	8	9	0
Lake water	0.1	62-92	10	10	11	10	1
Lake water	1	92-125	10	10	11	10	1
Lake water	5	125-155	9	9	10	9	0
Lake water	0.01	155-187	9	9	10	9	0
Distilled water	0	187-310	6	6	6	6	0
			3D 1	3D 2	3D 3	Mean	SD
Distilled water	0	0-32	4	3	5	4	1
Lake water	0.01	32-62	9	9	11	9	1
Lake water	0.1	62-92	10	11	13	11	1
Lake water	1	92-125	10	11	13	11	1
Lake water	5	125-155	9	9	11	10	1
Lake water	0.01	155-187	8	9	11	9	1
Distilled water	0	187-310	5	4	5	5	1
			5C 1	5C 2	5C 3	Mean	SD
Distilled water	0	0-32	32	12	7	17	13
Lake water	0.01	32-62	12	14	10	12	2
Lake water	0.1	62-92	10	10	11	11	0
Lake water	1	92-125	10	10	11	11	0
Lake water	5	125-155	10	9	10	10	1
Lake water	0.01	155-187	10	9	10	10	0
Distilled water	0	187-310	9	8	8	8	1

Mean of every 12 measurements

Appendix 21: Redox potential of soil 1D at the end of 310 days laboratory incubation study.

Depth mm	1D 4_Eh mV	Depth mm	1D 5_Eh mV	Depth mm	1D 6_Eh mV
-0.7	312.5	-0.6	197.3	0.0	27
-2.2	310.6	-2.0	185.6	-4.5	63
-3.7	233.8	-3.4	177.4	-9.0	-17
-5.3	172.0	-4.7	172.3	-13.5	-88
-6.8	132.0	-6.1	164.2	-18.0	-107
-8.3	86.4	-7.5	154.8	-22.5	-103
-9.8	21.2	-8.8	156.4	-27.0	-101
-11.3	-34.9	-10.2	147.6	-31.5	-101
-12.9	-42.2	-11.6	133.4	-36.0	-101
-14.4	-45.4	-13.0	124.0	-40.5	-104
-15.9	-39.8	-14.3	111.6	-45.0	-89
-17.4	-35.8	-15.7	102.9	-49.5	-70
-18.9	-35.4	-17.1	90.0	-54.0	-98
-20.5	-27.7	-18.4	81.6	-58.5	-101
-22.0	-24.2	-19.8	70.0	-63.0	-92
-23.5	-21.4	-21.2	56.7	-67.5	-91
-25.0	-16.9	-22.5	47.6	-72.0	-98
-26.5	-16.4	-23.9	45.0	-76.5	-98
-28.1	-14.7	-25.3	44.5	-81.0	-125
-29.6	-11.6	-26.7	44.0	-85.5	-114
-31.1	-8.0	-28.0	49.4	-90.0	-117
-32.6	-13.9	-29.4	44.5	-94.5	-119
-34.1	-12.3	-30.8	45.3	-99.0	-125
-35.7	-11.2	-32.1	44.6	-103.5	-133
-37.2	-18.8	-33.5	40.8	-108.0	-128
-38.7	-14.5	-34.9	39.0	-112.5	-129
-40.2	-20.4	-36.2	38.4	-117.0	-138
-41.7	-16.6	-37.6	36.7	-121.5	-149
-43.3	-21.1	-39.0	37.7	-126.0	-151
-44.8	-20.3	-40.4	33.9	-130.5	-145
-46.3	-20.2	-41.7	31.5	-135.0	-144
-47.8	-20.0	-43.1	32.8		
-49.3	-22.7	-44.5	29.7		
-50.9	-18.7	-45.8	21.2		
-52.4	-19.2	-47.2	32.7		
-53.9	-23.1	-48.6	29.8		
-55.4	-21.9	-49.9	27.3		
-56.9	-19.8	-51.3	27.2		
-58.5	-22.0	-52.7	31.6		
-60.0	-20.7	-54.1	26.1		
-61.5	-19.4	-55.4	26.1		
-63.0	-18.9	-56.8	18.6		
-64.5	-23.4	-58.2	21.9		
-66.1	-16.4	-59.5	21.6		
-67.6	-19.6	-60.9	20.1		
-69.1	-18.0	-62.3	20.5		

Appendix 21: Redox potential of soil 1D at the end of 310 days laboratory incubation study.

Depth	1D 4_Eh	Depth	1D 5_Eh	Depth	1D 6_Eh
mm	mV	mm	mV	mm	mV
-73.7	-22.0	-66.4	13.5		
-75.2	-17.7	-67.8	17.1		
-76.7	-20.3	-69.1	13.7		
-78.2	-17.9	-70.5	10.8		
-79.7	-17.9	-71.9	13.4		
-81.3	-18.8	-73.2	13.7		
-82.8	-12.3	-74.6	17.3		
-84.3	-17.0	-76.0	11.7		
-85.8	-16.6	-77.3	8.2		
-87.3	-21.5	-78.7	11.8		
-88.9	-18.3	-80.1	9.2		
-90.4	-19.0	-81.5	10.9		
-91.9	-21.0	-82.8	8.2		
-93.4	-19.3	-84.2	6.1		
-94.9	-19.1	-85.6	3.9		
-96.5	-22.8	-86.9	2.6		
-98.0	-14.5	-88.3	2.8		
-99.5	-17.2	-89.7	-0.3		
-101.0	-21.7	-91.0	-1.8		
-102.5	-23.5	-92.4	-3.7		
-104.1	-25.6	-93.8	-2.5		
-105.6	-26.0	-95.0	-7.3		
-106.8	-24.9				

Appendix 22: Redox potential of soil 2E at the end of 310 days laboratory incubation study.

Depth mm	2E 4_Eh mV	Depth mm	2E 5_Eh mV	Depth mm	2E 6_Eh mV
-0.6	194.4	-0.6	140.1	0.0	94.7
-1.9	200.2	-1.8	81.5	-1.2	84.4
-3.2	197.2	-3.0	36.5	-2.5	85.7
-4.4	183.2	-4.2	0.3	-3.7	53.4
-5.7	175.2	-5.4	-9.5	-4.9	62.7
-7.0	165.8	-6.5	-24.7	-6.2	36.7
-8.3	144.0	-7.7	-38.1	-7.4	32.0
-9.6	113.4	-8.9	-51.0	-8.6	33.0
-10.9	80.5	-10.2	-55.2	-9.9	13.4
-12.2	53.4	-11.4	-63.7	-11.1	-1.0
-13.4	25.6	-12.6	-70.8	-12.3	-9.3
-14.7	4.7	-13.8	-74.9	-13.6	-22.3
-16.0	-2.0	-15.0	-72.3	-14.8	-41.6
-17.3	-12.5	-16.2	-81.9	-16.0	-22.6
-18.6	-18.6	-17.4	-88.9	-17.3	-20.0
-19.9	-28.9	-18.6	-102.9	-18.5	-29.0
-21.2	-37.4	-19.8	-109.5	-19.7	-90.6
-22.1	-45.7	-21.0	-117.9	-21.0	-39.6
		-22.2	-125.1	-22.2	-94.9
		-23.4	-132.7	-23.4	-74.6
		-24.6	-131.6	-24.7	-60.6
		-25.8	-134.0	-25.9	-41.6
		-27.0	-138.9	-27.1	-55.3
		-28.2	-145.3	-28.4	-42.6
		-29.4	-146.4	-29.6	-53.0
		-30.6	-149.6	-30.8	-58.3
		-31.8	-154.3	-32.1	-69.9
		-33.0	-156.4	-33.3	-73.3
		-34.2	-164.9	-34.5	-67.6
		-35.4	-167.3	-35.8	-139.6
		-36.6	-169.6	-37.0	-116.9
		-37.8	-176.5	-38.2	-115.3
		-39.0	-183.1	-39.5	-129.6
		-40.2	-185.4	-40.7	-109.3
		-41.4	-193.5	-41.9	-115.3
		-42.6	-188.7	-43.2	-141.6
		-43.8	-193.8	-44.4	-138.6
		-45.0	-189.4	-45.6	-153.9
		-46.2	-192.6	-46.9	-147.6
		-47.4	-188.0	-48.1	-151.9
		-48.6	-189.3	-49.3	-144.9
		-49.8	-190.2	-50.6	-156.3
		-51.0	-189.0	-51.8	-160.6
		-52.2	-190.4	-53.0	-164.6
		-53.4	-191.7	-54.3	-146.6
		-54.6	-187.0	-55.5	-149.6

Appendix 22: Redox potential of soil 2E at the end of 310 days laboratory incubation study.

Depth mm	2E 4_Eh mV	Depth mm	2E 5_Eh mV	Depth mm	2E 6_Eh mV
		-58.2	-193.4	-59.2	-160.6
		-59.4	-188.5	-60.4	-173.9
		-60.6	-188.1	-61.7	-175.9
		-61.8	-192.3	-62.9	-161.6
		-63.0	-191.4	-64.1	-166.3
		-64.2	-191.1	-65.4	-176.9
		-65.4	-195.0	-66.6	-156.3
		-66.6	-186.6	-67.8	-162.3
		-67.8	-196.3	-69.1	-177.3
		-69.0	-194.9	-70.3	-161.6
		-70.2	-189.8	-71.5	-153.6
		-71.4	-192.1	-72.8	-175.6
		-72.6	-194.4	-74.0	-154.6
		-73.8	-193.2	-75.2	-161.9
		-75.0	-194.8	-76.5	-179.3
		-76.1	-191.0	-77.7	-170.6
		-77.3	-193.4	-78.9	-175.9
		-78.0	-192.7	-80.2	-180.6
				-81.4	-155.3
				-82.6	-173.3
				-83.9	-149.9
				-85.1	-158.6
				-86.3	-147.3
				-87.6	-143.6
				-88.8	-171.9
				-90.0	-163.3
				-91.3	-133.9
				-92.5	-128.9
				-93.7	-126.6
				-95.0	-121.3
				-96.2	-123.3
				-97.4	-133.3
				-98.7	-117.6
				-99.9	-119.3
				-101.1	-122.6
				-102.4	-127.9
				-103.6	-139.3
				-104.8	-123.6
				-106.1	-132.9
				-107.3	-132.3
				-108.5	-126.6
				-109.8	-129.6
				-111.0	-112.9
				-112.2	-102.3
				-113.5	-118.3
				-114.7	-120.3
				-115.9	-106.3
				-117.2	-107.9

Appendix 22: Redox potential of soil 2E at the end of 310 days laboratory incubation study.

Depth mm	2E 4_Eh mV	Depth mm	2E 5_Eh mV	Depth mm	2E 6_Eh mV
				-120.9	-126.3
				-122.1	-116.9
				-123.3	-122.3
				-124.6	-122.9
				-125.8	-125.3
				-127.0	-102.3
				-128.3	-110.3
				-129.5	-110.6
				-130.7	-117.9
				-132.0	-117.6
				-133.2	-121.3
				-134.4	-123.3
				-135.7	-117.9
				-136.9	-106.3
				-138.1	-105.9

Appendix 23: Redox potential of soil 3Dand 5C at the end of 310 days laboratory incubation study.

Depth mm	3D 5_Eh mV	Depth mm	3D 6_Eh mV	Depth mm	5C 6_Eh mV
-0.6	130.6	0.0	271	0.0	202.0
-1.9	123.0	-1.6	260	-0.7	146.7
-3.2	115.0	-3.2	207	-1.4	155.3
-4.4	110.5	-4.7	217	-2.2	100.7
-5.7	97.7	-6.3	127	-2.9	88.0
-7.0	78.7	-7.9	95	-3.6	110.4
-8.3	67.8	-9.5	20	-4.3	66.4
-9.6	57.7	-11.0	-36	-5.0	55.4
-10.9	37.5	-12.6	-69	-5.7	77.4
-12.2	21.2	-14.2	-30	-6.5	36.4
-13.4	8.3	-15.8	-80	-7.2	28.4
-14.7	10.8	-17.3	-87	-7.9	63.7
-16.0	-0.8	-18.9	-65	-8.6	21.0
-17.3	-4.3	-20.5	-100	-9.3	8.4
-18.6	-10.1	-22.1	-94	-10.0	4.7
-19.9	-14.4	-23.6	-88	-10.8	13.7
-21.2	-17.6	-25.2	-75	-11.5	-21.6
-22.4	-21.8	-26.8	-90	-12.2	-39.6
-23.7	-17.2	-28.4	-72	-12.9	-22.3
-25.0	-23.1	-29.9	-87	-13.6	-32.6
-26.3	-29.9	-31.5	-120	-14.3	-39.3
-27.6	-32.8	-33.1	-60	-15.1	-55.0
-28.9	-38.6	-34.7	-82	-15.8	-84.6
-30.2	-41.0	-36.2	-118	-16.5	-85.6
-31.4	-43.2	-37.8	-82	-17.2	-59.6
-32.7	-45.6	-39.4	-108	-17.9	-94.9
-34.0	-50.9	-41.0	-121	-18.6	-66.6
-35.3	-50.3	-42.5	-118	-19.4	-86.9
-36.6	-43.8	-44.1	-66	-20.1	-90.3
-37.9	-47.5	-45.7	-71	-20.8	-76.6
-39.2	-42.4	-47.3	-102	-21.5	-76.9
-40.4	-45.3	-48.8	-105	-22.2	-105.6
-41.7	-44.4	-50.4	-112	-22.9	-83.3
-43.0	-46.8	-52.0	-116	-23.7	-99.6
-44.3	-38.3	-53.6	-112	-24.4	-111.6
-45.6	-50.9	-55.1	-117	-25.1	-103.9
-46.9	-48.9	-56.7	-125	-25.8	-112.6
-48.2	-47.9	-58.3	-106	-26.5	-96.6
-49.4	-52.7	-59.9	-121	-27.2	-115.3
-50.7	-54.6	-61.4	-127	-28.0	-99.9
-52.0	-55.8	-63.0	-119	-28.7	-95.3
-53.3	-68.7	-64.6	-114	-29.4	-96.9
-54.6	-65.2	-66.2	-116	-30.1	-111.3
-55.9	-66.1	-67.7	-133	-30.8	-100.3
-57.2	-74.0	-69.3	-134	-31.5	-118.9
-58.4	-75.6	-70.9	-137	-32.3	-120.6

Appendix 23: Redox potential of soil 3Dand 5C at the end of 310 days laboratory incubation study.

Depth mm	3D 5_Eh mV	Depth mm	3D 6_Eh mV	Depth mm	5C 6_Eh mV
-62.3	-78.8	-75.6	-130	-34.4	-119.3
-63.6	-80.4	-77.2	-139	-35.1	-121.6
-64.9	-78.5	-78.8	-127	-35.8	-118.3
-66.2	-80.4	-80.3	-125	-36.6	-112.3
-67.4	-81.6	-81.9	-136	-37.3	-118.9
-68.7	-80.9	-83.5	-146	-38.0	-131.6
-70.0	-80.5	-85.1	-135	-38.7	-127.6
-71.3	-83.3	-86.6	-152	-39.4	-140.3
-72.6	-84.5	-88.2	-159	-40.1	-133.9
-73.9	-82.7	-89.8	-162	-40.9	-132.3
-75.2	-81.4	-91.4	-156	-41.6	-137.3
-76.4	-86.1	-92.9	-157	-42.3	-140.3
-77.7	-90.5	-94.5	-158	-43.0	-119.9
-79.0	-89.7	-96.1	-161	-43.7	-118.6
-80.3	-85.2	-97.7	-146	-44.4	-126.6
-81.6	-92.7	-99.2	-159	-45.2	-134.9
-82.9	-92.4	-100.8	-158	-45.9	-137.3
-84.2	-92.7	-102.4	-143	-46.6	-138.6
-85.4	-89.6	-104.0	-139	-47.3	-135.3
-86.7	-93.3	-105.5	-149	-48.0	-144.3
-88.0	-96.4	-107.1	-149	-48.7	-151.9
-89.3	-93.5	-108.7	-149	-49.5	-153.6
-90.0	-84.9	-110.3	-150	-50.2	-145.3
		-111.8	-142	-50.9	-141.6
		-113.4	-155	-51.6	-146.9
		-115.0	-137	-52.3	-141.9
		-116.6	-150	-53.0	-158.6
		-118.1	-137	-53.8	-145.6
		-119.7	-148	-54.5	-166.6
				-55.2	-154.3
				-55.9	-161.9
				-56.6	-157.9
				-57.3	-166.3
				-58.1	-156.6
				-58.8	-164.6
				-59.5	-158.3
				-60.2	-152.6
				-60.9	-153.6
				-61.6	-168.6
				-62.4	-171.9
				-63.1	-175.9
				-63.8	-156.9
				-64.5	-173.6
				-65.2	-167.9
				-65.9	-179.9
				-66.7	-164.3
				-67.4	-175.3
				-68.1	-177.9

Appendix 23: Redox potential of soil 3Dand 5C at the end of 310 days laboratory incubation study.

Depth mm	3D 5_Eh mV	Depth mm	3D 6_Eh mV	Depth mm	5C 6_Eh mV
				-70.2	-189.3
				-71.0	-169.3
				-71.7	-177.6