STABILITY AND BIOAVAILABILITY OF RECENTLY ACCRETED PHOSPHORUS IN STORMWATER TREATMENT AREAS

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1.0 Introduction

Constructed wetlands used as buffers to retain nutrients and other contaminants are usually managed to improve their overall performance, and to maintain expected water quality. The extent of management required depends upon the nutrient/contaminant retention capacity of the wetlands and the desired effluent quality. Management scenarios can vary, depending on type of wetland and hydraulic loading rate. For example, small-scale wetlands can be managed efficiently by altering the hydraulic loading or integrating them with conventional treatment system while large-scale systems can be managed by controlling nutrient/contaminant loads.

Phosphorus (P) retention by soils and sediments includes surface adsorption on minerals, precipitation, microbial immobilization, and plant uptake. In treatment wetlands, these processes may be combined into two distinct P retention pathways: sorption and burial. Phosphorus sorption in sediments is defined as the removal of phosphate from the soil solution to the solid phase, and includes both adsorption and precipitation reactions. When plants and microbes die off, the P contained in cellular tissue may either recycle within the wetland, or may be buried with refractory organic compounds.

Accretion of organic matter has been reported as a major mechanistic sink for phosphorus in wetlands. Wetland soils tend to accumulate organic matter due to the production of detrital material from biota and the suppressed rates of decomposition. Soil accretion rates for constructed wetlands are on the order of millimeters per year, although accretion rates in productive natural systems such as the Everglades have been reported as high as one centimeter or more per year. The genesis of this new soil is a relatively slow process, which may affect the P sorption characteristics of the wetland. With time, productive wetland systems will accumulate organic matter (which ultimately forms peat) that has different physical and biological characteristics than the underlying soil. Eventually, this new material settles and compacts to form new soil with perhaps different P sorption characteristics than the original soil. As the wetland ages, steady accumulation of organic matter can potentially decrease the efficiency of wetland to assimilate additional P and alter the hydraulic flow paths, as organic accretion is seldom uniform throughout space. These conditions can result in elevated effluent P concentrations. However, management of newly accreted material by consolidation or removal can improve the overall P retention capacity of wetland.

At present several treatment technologies are being evaluated by the South Florida Water Management District for their effectiveness to reduce total P (TP) levels to 10 ug L^{-1}. The treatment train integrates biological systems such as wetlands with cattails, submersed aquatic vegetation, periphyton, with chemical treatment systems. In all these systems, P removal mechanism involves accretion of organic and inorganic material through settling. The composition and the stability of the P stored in the accreted material depend on the type of aquatic vegetation, and associated biogeochemical processes. Thus, it is important to understand the composition and stability of the newly accreted material to determine the long-term effectiveness of these technologies.

2.0 Project Objectives

The objectives of this study were to: (1) review soil P data collected during pre- and post construction of Stormwater Treatment Area-1 West (STA-1W), (2) determine the physio-chemical characteristics of the newly accreted floc material, as compared to the native soil in select test cells currently used to evaluate various green technologies, (3) determine the relative proportion of labile organic P and inorganic P in the floc material, and (4) evaluate the stability of P compounds stored in the newly accreted material. Experimental methodologies and results of studies conducted to accomplish above described objectives are presented below.

3.0 Long-term Soil Phosphorus Accretion in the Storm Water Treatment Area – 1 W of the Everglades

3.1 Abstract

Plant uptake and the subsequent accretion of organic matter is a primary mechanism for the removal of phosphorus (P) from surface waters in constructed wetlands. The Stormwater Treatment Area – 1 W (formerly known as the Everglades Nutrient Removal Project) is a 1,545 hectare constructed wetland located along the northern edge of the Everglades. This wetland was created on former agricultural land and treats nutrients in surface waters flowing out of the Everglade Agricultural Area before discharging into the northern Everglades. Total P of the original agricultural soil has significantly decreased over the past 10 years during which the soil has been flooded while the accreting detrital surface layer has become enriched with respect to total P, averaging 427 mg kg^{-1}. The aquatic plants have mobilized approximately 1/3 of the total P once stored in the 0-30 cm soil interval by mining the soil for P required for growth. Total P removed from the surface water makes up 6.15 % of the total P of the surface detrital layer. This mechanism of P translocation or "mining" of the underlying P in soil by the aquatic plants may lead to decreased water quality performance of the wetland over the long term, as the relatively stable P is brought to the surface and potentially released into the water column.

3.2 Introduction

Constructed wetlands are often used as "buffer zones" between agricultural areas and adjacent water bodies to trap and store sediments and nutrients shed from the upland soil. The ability of these wetlands to store P in stable form over the long-term depends upon several interactive biogeochemical processes in the water column, detrital layer and soil. Recognizing that detrital tissue and soil organic matter are the most dynamic and dominant components of these wetlands, the breakdown of this material and release of its nutrients has direct bearing on water quality and productivity of the ecosystem. There are several basic questions to be asked when evaluating P storage in constructed wetlands: (1) what is the relative bioavailability of various P forms stored in soil and water column? (2) how stable is the stored P and under what conditions will it be released back into water column?

Phosphorus in soils can be found in both organic and inorganic forms. The relative proportion of each form depends on the nature and origin of the soils. Inorganic P compounds are associated with amorphous and crystalline forms of Fe, Al, Ca and other

elements. Organic P is associated with living organisms and is generally comprised of: (1) easily decomposable organic P compounds (e.g., nucleic acids, phospholipids and sugar phosphates), and (2) slowly decomposable organic P compounds (e.g., inositol phosphates - phytin).

Organic soils in the Everglades are derived from the accumulation of emergent reed and sedge-like plants over a long period of time. Since the soils developed from relatively uniform stands of these plant species, primarily sawgrass, spatial variability of soil characteristics in the original soils was likely relatively small. The soil forming processes affecting soil variability, such as climate, mineral and organic parent material, and water level would appear to have a uniform affect over the area of interest. However, soil variability in the Everglades Agricultural Area (EAA) has likely been enhanced by man's activities including drainage, tillage and fertilization, and construction of roads and canals.

Phosphorus removal in wetlands primarily occurs through physical, chemical, and biological processes functioning in the soil-water column. Phosphorus (P) retention in wetland soils may include processes including surface adsorption on soil minerals, precipitation reactions, microbial immobilization, and plant uptake (Reddy et al., 1995). These processes may be combined into two distinct P retention pathways for wetlands: sorption and burial (Reddy et al., 1999). Phosphorus sorption includes both adsorption and precipitation reactions as mechanisms for the removal of phosphate from the soil solution to the solid phase, and includes both adsorption and precipitation reactions. As plants senesce, some of the P contained in detrital tissue can be recycled within the wetland, and released into the water column. The remaining refractory detrital tissue may eventually become incorporated as organic matter in the wetland soil profile.

Accretion of organic matter has been reported as a major sink for P in wetlands (Craft and Richardson, 1993; Reddy et al., 1993; Gale et al., 1994). Wetlands tend to accumulate organic matter due to the production of detrital material from biota and experience relatively low rates of decomposition under flooded conditions (DeBusk and Reddy, 1998). Soil accretion rates for constructed wetlands are on the order of millimeters per year, although accretion rates in productive natural systems such as the Everglades have been reported as high as one centimeter or more per year (Reddy et al., 1993). Over time, productive constructed wetland systems will accumulate organic matter that has different physical and biological characteristics than the original pre-construction soil. Eventually, this new material settles and compacts to form new soil, which may exhibit a different P removal capacity than the original soil. Phosphorus accretion increases with P loading to the wetland (Reddy et al., 1993). However, an increase in accretion does not assure low surface water outflow P concentrations, especially for intermittently flooded wetland systems where decomposition of organic detritus can release available P back into the water column.

The objectives were to measure: (1) the soil total P and forms of P stored in soils of the STA – 1 W site prior to flooding in 1990 to be compared with (2) the soil total P and forms of P in detritus and soils as influenced by five years of P loading and 9 years of continuous flooding (1999).

3.3 Materials and Methods

3.3.1 Site description

The Stormwater Treatment Area – 1 W (formerly known as the Everglades Nutrient Removal Project) wetland was constructed on 1,545 ha of agricultural land formerly known as Knight's Farm (Figure 3.1). The soils at the STA – 1 W site have been used for crop production (sugar cane, vegetables) for the previous four decades and the site is located west of Water Conservation Area 1 (Arthur R. Marshall Loxahatchee National Wildlife Refuge). The taxonomic classifications of the soils at this site are: euic, hyperthermic, lithic Medisaprists (Cox et al., 1988).

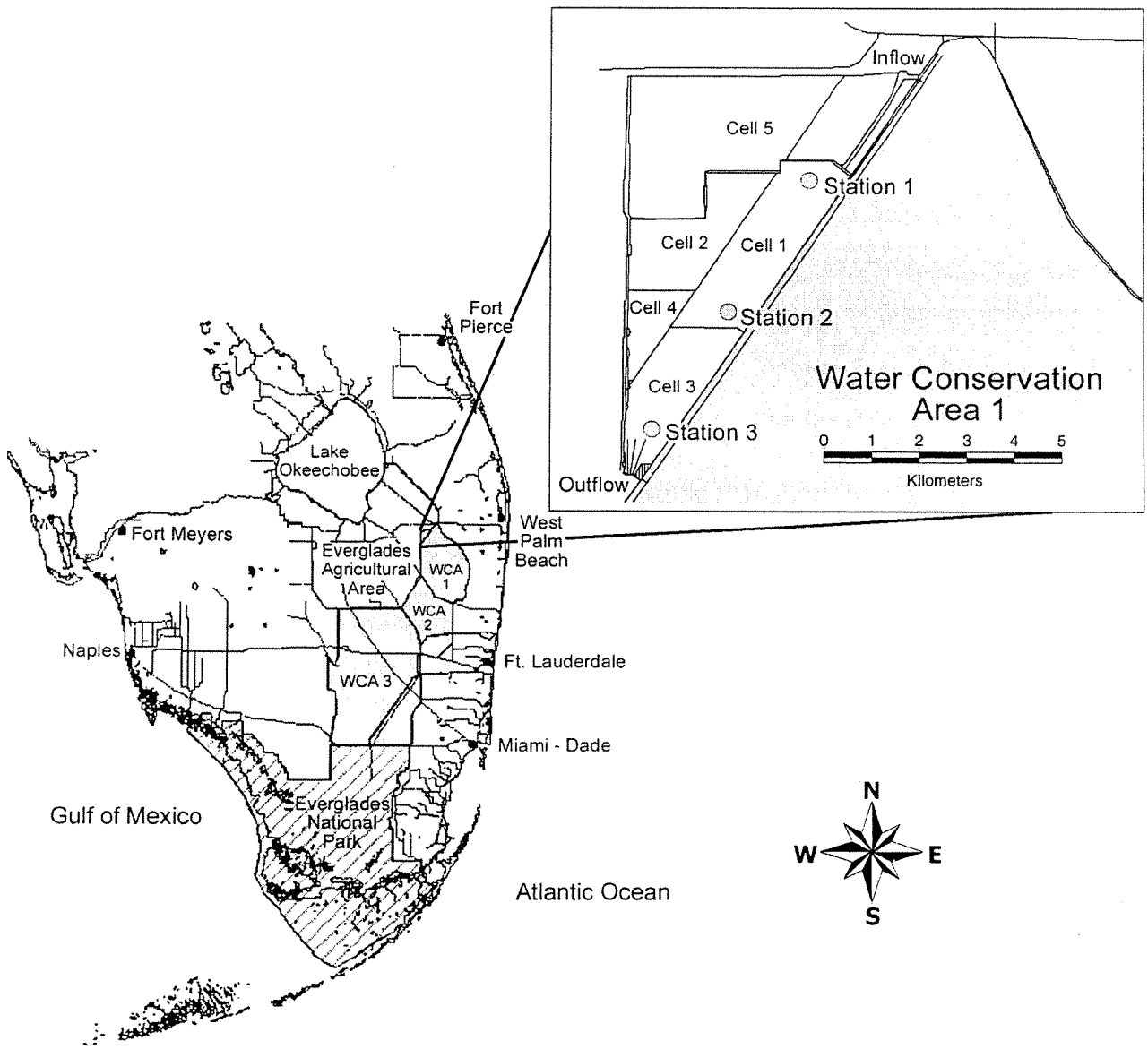

Figure 3.1. Sampling sites within the Everglades Nutrient Removal Project wetland located west of Water Conservation Area 1 in South Florida.

3.3.2 Field Sampling

In 1989, sixteen fields were sampled in a grid pattern prior to flooding in 1990 (Figure 3.2). Soil cores were taken to a depth of 30 cm by driving a 7.5 cm i.d. PVC pipe into the soil with a mallet (Reddy and Graetz, 1991). After extraction from the surrounding soil with a shovel, the columns were sealed and transported to the Wetland Biogeochemistry Laboratory, University of Florida for analyses.

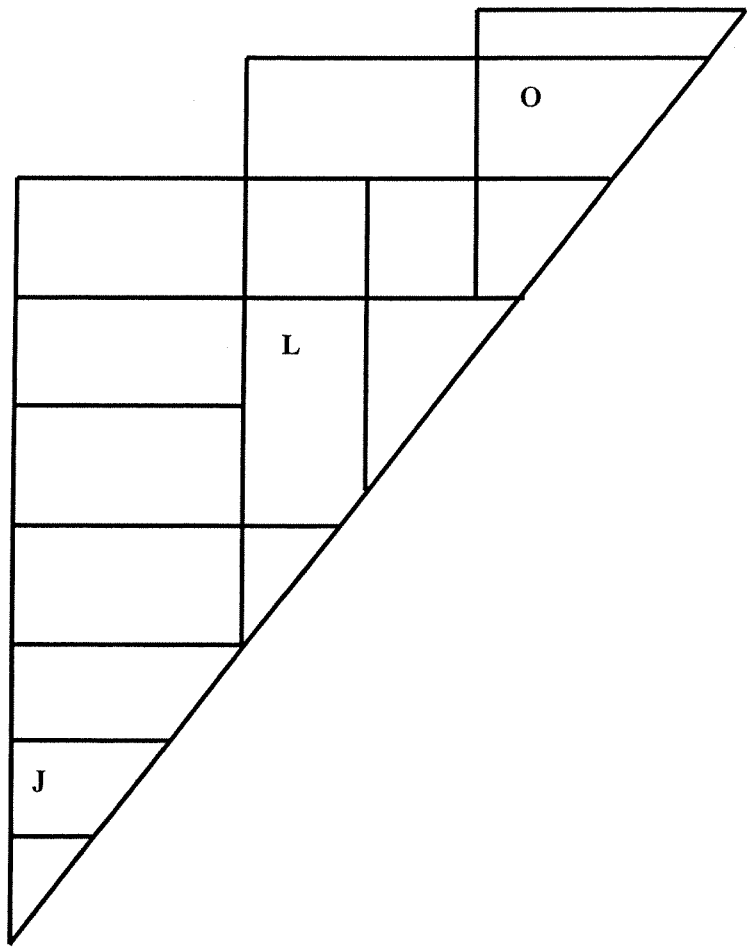

Figure 3.2. Sixteen agricultural fields sampled at Knight's Farm for total P in 1990. Fields O, L and J are the same as stations 1, 2 and 3 from the 1999 sampling.

Soil samples were collected at three stations in the STA – 1 W during 1999 (Figure 3.1). This sampling period corresponded to 5 years after initiation of P loading during operation of the constructed wetland and 9 years since initial flooding of the soil. Soils were collected using a 10 cm aluminum pushcore driven in October, 1999. Three replicate sediment cores within a 3 m^2 area, were collected from three stations 1; the north part of cell 1, 2; south portion of cell 1, and 3; the south part of cell 3 (Figure 3.1). Samples were separated into 3 layers; detritus/floc, 0-10 cm and 10-30 cm depths intervals. The detritus/floc was separated from the more compact, underlying organic

soil, comprising the newly accreted wetland soil since the inception of flooding. The 0-30 cm soil interval was considered to be the former agricultural soil.

3.3.3 Soil characterization

The soils were characterized for pH, total P and were subjected to a chemical fractionation to determine relative availability of several P pools. Soil pH was determined from 1:1 soil-water ratio samples using a combination glass electrode and pH meter. Total P was determined by weighing approximately 0.2 g of oven-dried, finely ground soil which was combusted at 550° C for 4 hours. The ash was digested with 6 *M* HCl, with continuous heating on a hot plate. The solutions were further diluted and analyzed colorimetrically for total P on an autoanalyzer (Anderson, 1976).

The soils were also analyzed for various organic and inorganic P fractions following the sequential inorganic P fractionation scheme developed for histisols (Reddy et al., 1998). The following P fractions were determined from field moist soils (0.5 g dry weight equivalent):

KCl extractable P (KCl-P_i).

Phosphorus in soil extracted with a 1 *M* KCl solutions (soil to solution ratio of 1:50) represents the readily available pool of P (water soluble + exchangeable pool). Soil suspensions were equilibrated for a period of 1 hour by continuously shaking on a mechanical shaker, followed by centrifugation at 6000 rpm for 10 minutes. Supernatant solutions were filtered through a 0.45 μm membrane filter and the filtrates were refrigerated at 4° C. Solutions were analyzed for SRP. The residual soil sample was then used in the following sequential extraction scheme.

NaOH extractable P (NaOH-P_i and NaOH-P_o).

The residual soil obtained from the KCl extraction was treated with 0.1 *M* NaOH to obtain a soil to solution ratio of 1:50. Soil suspensions were allowed to equilibrate for a period of 17 hours by continuously shaking on a mechanical shaker, followed by centrifugation at 6000 rpm for 10 minutes. The supernatant solution was filtered through a 0.45 μm membrane filter and the residual solution was used in the following sequential extraction. Filtered solutions were analyzed for both SRP and total P (TP) and these fractions are referred as NaOH-P_i and NaOH-TP, respectively. NaOH-P_i represents Fe-/Al-bound P. Extraction with 0.1 *M* NaOH also removes the P associated with humic and fulvic acids. The difference between NaOH-TP and NaOH-P_i is organic P (NaOH-P_o) associated with fulvic and humic acids.

HCl extractable P (HCl-P_i).

The residual soil obtained from the NaOH extraction was treated with 0.5 *M* HCl to obtain a soil to solution ratio of 1:50. Soil solutions were allowed to equilibrate for a period of 24 hours by continuously shaking on a mechanical shaker, followed by centrifugation at 6000 rpm for 10 minutes. The supernatant solution was filtered through a 0.45 μm membrane filter and the residual soil was transferred to 50 ml beakers for ashing. Filtered solutions were analyzed for SRP (Method 365.1, USEPA, 1993). This fraction will be referred to as HCl-P_i, representing Ca-bound P. The P extracted with acid

represents the P tied up in apatite minerals, essentially as calcium phosphate. Phosphorus can also be present in transitional forms such as monocalcium, dicalcium and octacalcium phosphate. Under most soil conditions, apatite P does not readily desorb, except under very acidic conditions.

Residual phosphorus.

The residue P was determined by ashing at 550°C for 4 hours and subsequent hydrochloric acid digestion (Anderson, 1976) followed by analysis of P by an automated ascorbic acid method (Method 365.1, USEPA, 1993). The residual P fraction was assumed to represent both refractory organic P and any other mineral P fractions not extracted with KCl, NaOH, or HCl reagents.

3.3.4 Statistical Analyses

Data were checked for homogeneity of variances and log transformed prior to statistical comparisons when appropriate. Analysis of variance (ANOVA), student's t-test and Fisher's least significance difference tests were used to compare data from sampling time, by depth and distance using the StatGraphics software program (Manugistics, Rockville, MD).

3.4 Results and Discussion

The pH of the 0-30 cm soil interval has changed over time averaging 5.36 ± 0.40, 5.31 ± 0.36 and 5.69 ± 0.34 at stations 1, 2 and 3 respectively in 1989 (Reddy and Graetz, 1991). These values are significantly lower than mean pH values of 6.92 ± 0.17, 6.51 ± 0.12 and 6.92 ± 0.07 determined at the same locations in 1999 (sites 1, 2 and 3) for the 0-30 cm soil interval. The mean pH values in the detrital layer, present only in 1999, were 7.16 ± 0.08, 7.44 ± 0.14 and 7.36 ± 0.06 at sites 1, 2 and 3, respectively.

The detrital layer ranged in thickness from 5 to 15 cm in 1999, comprised of decomposed emergent plant matter and algae. The thickest accumulations of detritus were concentrated in the station in the northern section of cell 1, nearest the surface water inflow point (station 1) and the southern section of cell 3 (station 3), both stations dominated by emergent macrophytes. The least amount of detritus was found at station 2, located at the south of cell 1 dominated by submerged aquatic vegetation (*Najas sp.*).

3.4.1 Total soil phosphorus

The total P of all stations in the 1989 sampling averaged 287 ± 49 mg P kg^{-1} (Reddy and Graetz, 1991). This value is not significantly different from the mean of all the data combined from the three stations and all soil intervals determined in 1999 at 289 ± 122 mg P kg^{-1} (Table 3.1). However, there was significant spatial heterogeneity across fields in 1990 as well as with depth for the data from 1999. Therefore, we compared each soil interval separately and compared only those data from 1989 which corresponded with the 1999 sampling stations.

The average total P for the 0-30 cm soil interval in 1989 was 288 ± 39.8, 234± 55.9 and 267 ± 42.9 mg kg^{-1} for stations 1, 2 and 3, respectively. The total P at these three stations was significantly higher when compared with the same soil interval in 1999 at 224 ± 6.4, 225 ± 0.74 and 210 ± 18.2 mg kg^{-1}. This suggests that over time, P once

stored in the 0-30 cm soil interval has been lost either through uptake by macrophytes or flux into the overlying water column.

The total P concentrations decreased with depth in 1999 averaging 426, 247, and 192 mg kg^{-1} in the detritus, 0-10 cm, and 10-30 cm layers respectively. There was no significant decrease with depth for the 1989 sampling likely due to plowing activities related to agricultural which constantly mixed the soil. There was also a decrease in total P concentrations with increasing distance from the inflow (Table 3.2). Data from the recent (1999) sampling event suggests that the native soil (0-30 cm) may have stabilized with respect to P flux to the water column. This assertion is based upon the development of a thicker detrital layer which now covers the native soil preventing interaction of the water column with the native soil. In addition, the significantly higher TP concentrations of the detritus suggest that this recently accreted organic soil is likely to be the major source/sink of water column P. There was no detrital layer present at the 0-30 cm layer in 1989. The detrital layer present on top of the compact organic soil in 1999 represents the total accretion to the wetland since the inception of flooded soil conditions.

Table 3.2. Total P with depth for the 1999 sampling of the Everglades Nutrient Removal Project wetland (n=3).

Station	Depth	Total P concentration
		mg kg^{-1}
1	detritus	472 + 48
1	0-10 cm	268 ± 18
1	10-30 cm	181 ± 6
2	detritus	396 + 143
2	0-10 cm	250 ± 8
2	10-30 cm	200 ± 8
3	detritus	414 + 169
3	0-10 cm	224 + 29
3	10-30 cm	197 ± 9

3.4.2 Inorganic P fractionation

Soil P forms were determined using an operationally defined chemical fractionation scheme. Soil P forms were grouped into: (i) KCl-extractable P_i (labile P_i), (ii) NaOH extractable P_i (Fe- and Al- bound P_i), (iii) NaOH-extractable P_o (alkali hydrolyzable organic P), (iv) HCl-extractable P_i (Ca- and Mg- bound P_i), and (v) residual organic P (Reddy et al., 1998). Soil inorganic P fractionation was performed on soils collected during both the 1989 and 1999 sampling event.

Labile P_i included dissolved porewater P and P_i extracted with 1 *M* KCl. This pool of P is readily available to plants. These forms showed no particular trend either with soil depth in 1989 or 1999 (Figures 3.3 and 3.4) or distance from inflow in 1999. The porewater P and KCl-extractable P_i accounted for 4.8 and 5.0 % of sum total P in the 0-10 and 10-30 cm soil intervals in 1989. This fraction was 1% of total P in the detrital layer, 1.3% in the 0-10 cm soil, and 3.4% in 10-30 cm soil for the 1999 samples. This fraction can be expected to vary over the year as plant nutrients requirements vary seasonally as well.

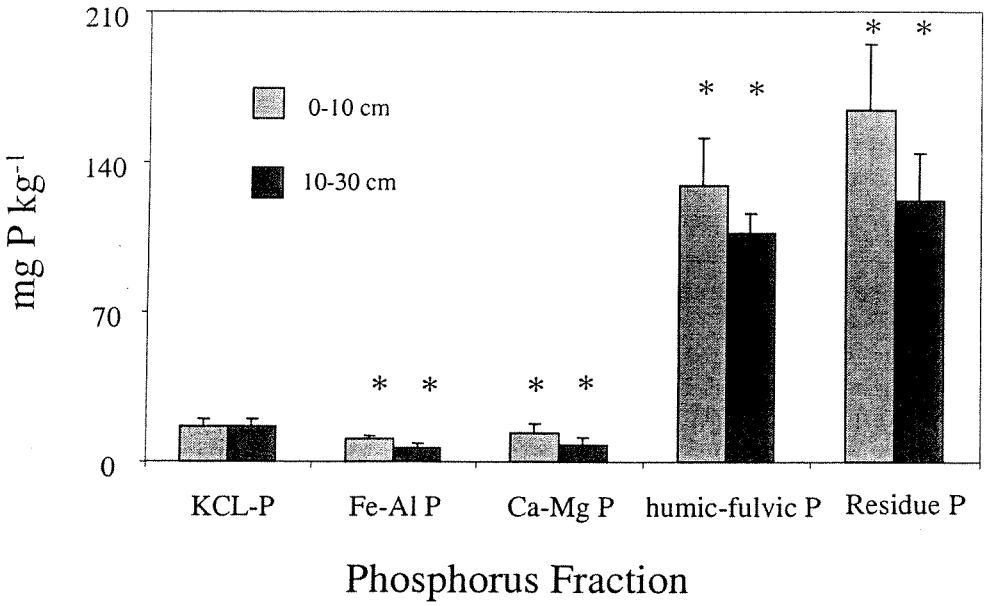

Figure 3.3. Soil phosphorous fraction with depth for the 1989 sampling of the Everglades Nutrient Removal Project wetland. Data are mean values plus one standard deviation. Asterisks indicate significant difference between depth intervals for each fraction.

Inorganic P extracted with 0.1 *M* NaOH represented P associated with Fe and Al. The NaOH-P_i was significantly higher in the surface detritus averaging 36.3, 15.6, and 9.4 mg P kg^{-1} for the detritus, 0-10 cm, and 10-30 cm soil layers, respectively in 1999 Figure 3.4) while in 1989, the 0-10 and 10-30 cm soil interval has mean concentrations of 10.6 and 6.2 mg P kg^{-1}, respectively (Figure 3.3). While the overall concentration decreased with depth, there was little difference of the amount of the pool with respect to depth (NaOH-P_i as a % of total P) ranging from 4.9-8.5% in 1999 while only making up 1.9-3.2 % in 1989. These ranges were significantly higher than the labile P_i fraction in 1999 suggesting that the P bound to Fe and Al may significantly control P availability to the labile pool.

P_i extracted with 0.5 *M* HCl represented P bound to Ca and Mg compounds. In 1989, the HCL-Pi pool was small averaging 13.5 mg P kg^{-1} for the 0-10 cm layer and 8.1 mg P kg^{-1} for the 10-30 cm interval (Figure 3.3). These concentrations made up only 2.4 – 4.1 % of sum total P. The HCL-Pi concentrations were highest in the detritus and not significantly different among stations averaging 102 mg P kg^{-1} and made up 24 % of the sum total P in 1999 (Figure 3.4). The 0-10 cm interval averaged 39.7 mg P kg^{-1} and the 10-30 cm interval averaged 9.5 mg P kg^{-1}. The corresponding percentages of HCL-P_i as a % of total P were 16.1 and 5.0% for the 0-10 and the 10-30 cm soil intervals, respectively. These results demonstrate that the Ca and Mg bound P pool is the significant inorganic mechanism for retention in the most recently accreted wetland soils, while comprising a relatively insignificant portion of the overall total P in the underlying native soil (0-30 cm) and former agricultural soils. The mechanism of calcium phosphate precipitation seems to be active throughout the wetland now since all three stations show a large accumulation of HCL-P_i in the detrital and the 0-10 cm soil interval.

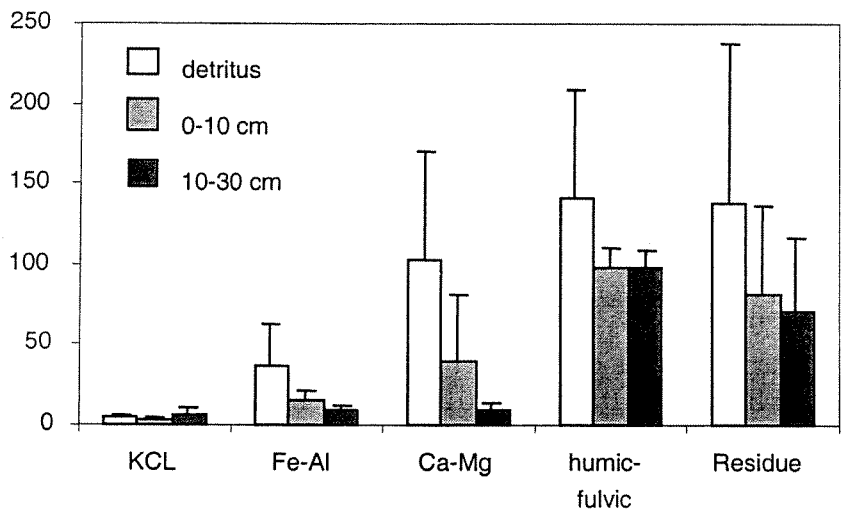

Figure 3.4. Soil phosphorus fractions with depth for the 1999 sampling of the Everglades Nutrient Removal Project wetland. Data are mean values of all sites plus one standard deviation.

Continuous P inputs through agricultural drainage water supports active algal and macrophyte communities. The biological uptake of P_i and chemical precipitation as Ca-P can result in the accumulation of P at the soil-water interface. The stability of chemically precipitate Ca-P is dependent on both the long-term and diurnal fluctuations in soil and floodwater pH. The lower pH of the agricultural soils (< 6) was not favorable for Ca-P stability while the circumneutral pH of the wetland soils in 1999 allowed for the accumulation of Ca-bound P.

Organic P extracted with 0.1 *M* NaOH includes P associated with fulvic and humic acids. The NaOH-P_o fraction accounted for 39 and 32 % of sum total P with mean

concentration of 129 and 107 mg P kg^{-1} in the 0-10 and 10-30 cm soil intervals in 1989 (Figure 3.3). In 1999, this fraction also accounted for a large percentage of total P at 33, 40, and 51% of total P in the detritus, 0-10 cm, and 10-30 cm soil respectively (Figure 3.4). A general trend of high concentrations in the surface layer and a decrease with depth was observed at all sampling stations. Although a significant portion of this P is biodegradable, a major portion can be relatively stable. The NaOH-P_o is composed of both humic and fulvic acids. Data from the 1990 initial soil characterization study demonstrated that Knight's Farm agricultural drained soils contained 41% of the more stable humic acid P and 59% of the relatively more available fulvic acid P for 8 soils samples (0-30 cm depth). Once these soils became flooded, a survey of 12 samples displayed a shift of only 27% of total NaOH-P_o present as stable humic acid, while the remainder (73%) of the NaOH-P_o was present as fulvic acid P suggesting an increase in bioavailability due to flooding.

The residual P_o was determined as the total P of the residual material at the end of the sequential extraction as determined by digestion. This residual P is made up of the most resistant organic P incorporated into the soil organic matter. Residue P was significantly higher in the surface, averaging 164 and 122 mg P kg^{-1} in the 0-10 cm and 10-30 cm soil layers in 1989 (Figure 3.3). This pool made up the largest pool of P in both soil intervals ranging from 37 – 49 % of sum total P. In 1999, residual P content was also higher in surface layers and decreased with depth averaging 137, 80.6, and 70.2 mg P kg^{-1} for the detritus, 0-10, and 10-30 cm soil layers respectively and represented a consistent percentage between 32% and 36% of the total P regardless of soil depth or location (Figure 3.4). Therefore, it appears that one-third to one half of all soil P was incorporated into the most stable fractions of the soil organic matter. There is a significant decrease in residual P of both soil layers over 10 years to almost ½ of the original concentration. This suggests that the residual P pool may not be as stable as previously thought and biotic mechanisms over time have converted this P into more bioavailable forms.

Total organic P, or total P_o, is the sum of P_o extracted with NaOH and the residual P not extracted with salts, acids, and alkali. The total P_o estimated using this procedure represents 65, 72, and 88% of the total P for detritus, 0-10, and 10-30 cm soil intervals. The vast majority of native soil's P stores are present in organic forms while the percentage of the most recently accreted soils accounts for two-thirds of all P.

The total P of the 0-30 cm soil interval is significantly lower 10 years after flooding. Bulk density of the soil interval has not changed significantly over time and therefore the storage of P in the surface soil has been changed over time based upon the drop in concentration. Approximately 69 % of the total P from the original 1989 0-30 cm soil interval still resides in that same 0-30 cm soil interval 9 years after flooding (Figure 3.5). Nearly 34% of the original soil P has been translocated from the 0-30 cm soil interval to the overlying detrital layer. This movement of P was due to plant growth requirements of the aquatic vegetation in the wetland as they "mined" P from the organic soil. Over time, the detrital layer increased in thickness as macrophytes senesced and the plant matter was deposited on the surface of the soil. The amount of P removed from the surface water during the first 5 years of flow through surface water operation (1994-1999) made up approximately 6.15 % of the total soil P or 25 % of the total P stored

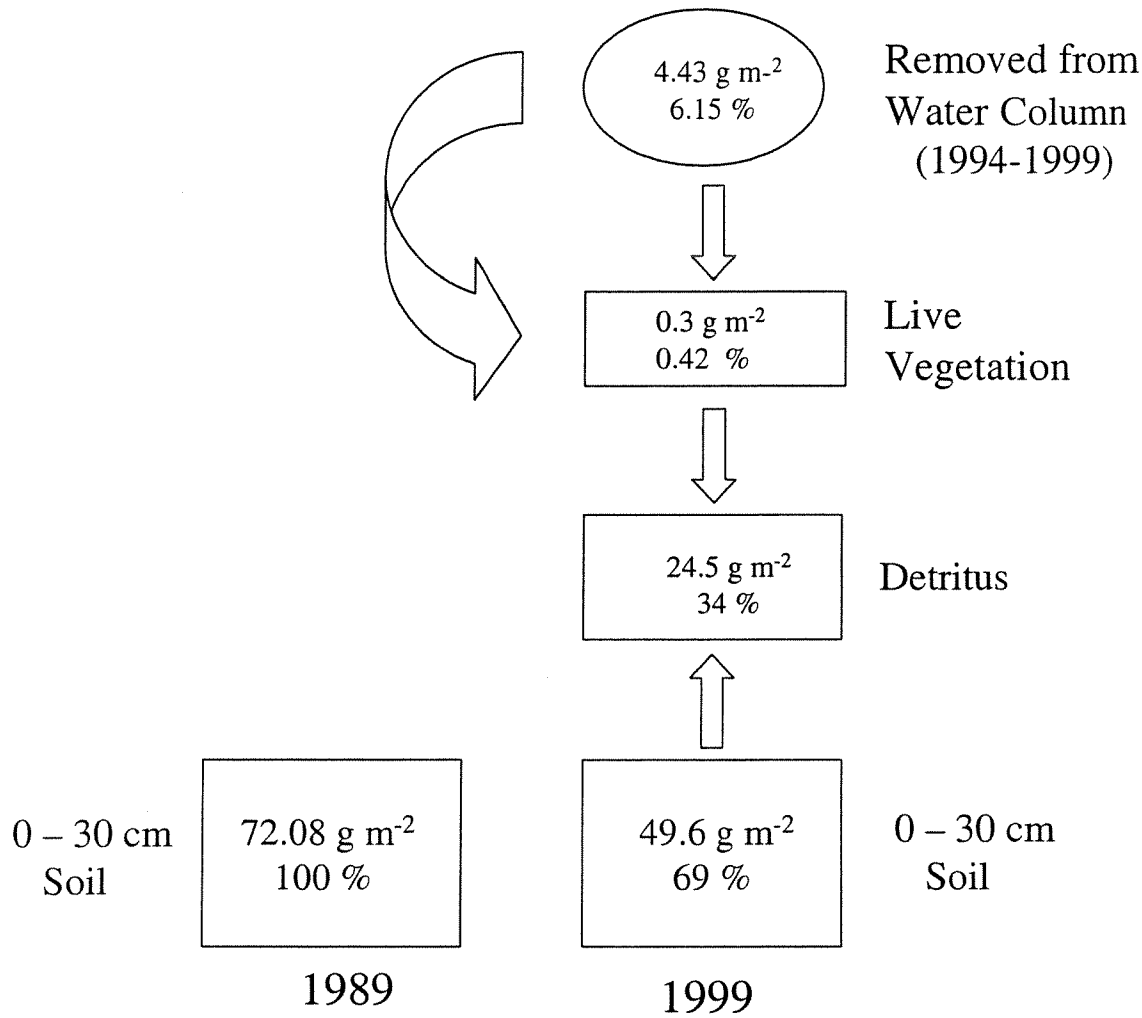

Figure 3.5 Total phosphorus pools (g m^2) in the soil in 1989 and 1999 after ten years of flooding. Percentages are relative to the original total P of the soil in 1989 and arrows depict the relative direction of movement for each compartment.

within the detritus, which further demonstrates that the vast majority of the detrital layer is composed of P translocated by the aquatic plants from the underlying soil (Figure 3.5). These results agree with mesocosm experiments conducted at low surface water total P concentrations which demonstrated that emergent macrophytes "mined" over 50% of their total P requirements from the underlying peat soil as the surface waters contained low levels (<100 ug L^{-1}) of total P (White et al, 2003a; White et al, 2003b).

Total inorganic P content of the STA-1W soils was low, reflecting their low mineral matter content and ash content. Approximately one-third of all P stored in the detrital layer was in the inorganic form while organic forms make up the remaining two-

thirds of the total P. The native soil contained a higher percentage of total P as organic P, from 72 - 88% of sum total P. The bioavailability of P in these organic soils is therefore dependent on the rate of decomposition processes and the supply of electron acceptors. For example, P availability in wetland soils can be increased by hydrologic fluctuations as soils undergo wet and dry cycles. A water table below the soil surface introduces oxygen into the system resulting in an increased rate of organic matter decomposition (McLatchey and Reddy, 1998, DeBusk and Reddy, 1998).

Results of total P of these former agricultural soils have shown a decrease in the amount of P stored in the 0-10 and 10-30 cm interval during the 10 years of flooding. In addition, P fractionation also found that a majority of the P reduction has come from the stable residual P pool, generally thought to be the most stable form of organic P. Over time, as wetland macrophytes have colonized the wetland, storage of P through plant uptake and Ca precipitation have led to the formation of a P enriched detrital layer which ranges from 5 – 15 cm thick covering the former agricultural soils. Recent studies have shown that macrophyte P requirements cannot be met by the reduction of the surface water P at these low (< 200 ug L^{-1}) concentrations (White et al., 2003a; White et al. 2003b). Macrophytes have been found to "mine" their additional P requirement for growth from the underlying stable peat material, taking up to 50% of biomass P from this compartment. Consequently, P is released back into the water column during senescence with potential implications for degradation of the P removal efficiency of the constructed wetland.

It appears that a significant portion of P in the detrital layer is stored in the Ca-Mg bound fraction, even though the more recalcitrant residual soil P pools were accessed by macrophytes and translocated to the surface as detritus. This Ca-Mg P fraction is twice as large as the former agricultural soil and potentially stable over the long term as pH remains circumneutral, maintaining low water column concentrations of SRP.

The performance of this constructed wetland may be affected as the aquatic plants continue to translocate P from the underlying soil to the detrital layer. This P-enriched surface detrital layer is likely to release a portion of this P into the surface water flowing out of the wetland into the northern Everglades, especially during dry periods of the year when the soil is exposed to the atmosphere and decomposition is increased. This increase in decomposition could hinder the performance of this constructed wetland system in maintaining the low total P levels outflow concentrations over the long term, which ultimately are required to protect the oligotrophic Everglades ecosystem.

4.0 Influence of Chemical Pre-treatments and Vegetation Type on Phosphorus Forms of Newly Accreted Soil in Constructed Wetlands.

4.1 Introduction

Agricultural lands adjacent to ecologically sensitive aquatic systems are now being acquired by state and federal agencies, and in many cases, these areas are converted back to their natural conditions. Many of these lands were intensively used for agriculture with continuous application of fertilizers and pesticides for a number of years. First step in the restoration efforts of these lands is the re-establishment of hydrology through flooding in an attempt to convert them into wetlands. Initial flooding of these lands poses potential water quality problem as the residual fertilizer P stored in these soils is rapidly released into the water column. With time after flooding, hydrophytic vegetation becomes estabilished with macrophyte communities such as *Typha, Sagittaria, Polygonum*, *Panicum, Pontedaria,* and others, and may aid in reducing the bioavailable P through uptake into their tissue. In Florida, agricultural lands currently being considered for conversion into wetlands are dominated by organic soils. For example, approximately 15,000 ha of farmlands are in the process of being converted into wetland to treat agricultural drainage water from the Everglades Agricultural Area. Similarly, several thousand hectares of agricultural lands with organic and mineral soils are flooded in central Florida. The unique soil conditions created by flooding influences the transformation and availability of both soil organic and inorganic P. Earlier studies have shown that flooding and anaerobic decomposition processes increased the rate of soluble P production and release into surface water (Reddy, 1983, D'Angelo and Reddy, 1994). Macrophytes and periphyton can also convert labile inorganic P into organic P (P_o) through uptake and storage, and stabilize the soil porewater P and reduce the P concentrations of surface water. However, long-term stable storage of P in organic pool depends on the quality of detrital material accreted on the soil surface.

The biogeochemical processes occurring in a wetland soil are dependent on its chemical composition, mineral components, and physicochemical and biological factors. Phosphorus reactivity in soils, for example, changes drastically, depending on whether the soil is calcareous or non calcareous, as moisture regime and hydrology shifts from unsaturated to saturated and prolonged submerged conditions. The complexity of P biogeochemistry in wetlands is compounded by the presence of high organic matter. Hence, chemical characterization and quantification of soil P fractions (organic and inorganic) and other components in peat wetlands, such as those in ENR, constitute an important component in understanding P dynamics.

The objectives of this study were to: (1) determine the physico-chemical characteristics of the newly accreted floc material, as compared to the native soil in select test cells currently used to evaluate various green technologies for treating EAA drainage effluents (high P loading), (2) determine the relative proportion of labile organic P and inorganic P in the floc material, and (3) evaluate the stability of P compounds stored in the newly accreted material.

4.2 Materials and Methods

4.2.1 Site description

STA-1W is a 2,699 ha constructed wetland built on previously farmed agricultural land located 25 km west of the city of West Palm Beach in Palm Beach County and borders the northwest corner of WCA-1 (26° 38' N and 80° 25' W) (Fig. 4.1). The north test cells (NTC) are shallow, rectangular wetlands, approximately 0.2 ha in size located in the north (Cell 1) within STA-1W. The wetlands operate in parallel and are fully lined with about 0.61 m of sand capped with an equal depth of peat.

Inflow water for the test cells is obtained from the surrounding treatment cell. Water is first pumped into a storage cell, which is maintained at a stage several feet above that of the test cells. Water from the storage cell then flows into a 76.2-cm diameter distribution pipe and is delivered in parallel fashion to the test cells through 20.3-cm diameter lateral pipes, each fitted with one of several calibrated orifice caps (Chimney et al., 2000). The end of the inflow distribution pipe is equipped with an open orifice to ensure the water delivery system is well-flushed even if all the test cells are operating at low flow rates or are closed-off altogether. This feature was incorporated into the system design to prevent water within the feeder pipe from stagnating, which might cause large changes in water quality along the length of the pipe and effect experiments being conducted within the test cells. Changing the orifice cap regulates the rate of inflow, and an adjustable 90° v-notch weir controls outflow from each test cell. Raising or lowering the weir controls water depth within that cell.

The test cells consisted of the following treatments (Fig. 4.2):

- Unmanaged *Typha* wetland (NTC-5 and NTC-10)
- Managed *Typha* wetland with $FeCl_3$ pre-treatment of inflow water (NTC-2)
- Managed *Typha* wetland with poly $AlCl_3$ pre-treatment of inflow water (NTC-4)
- Unmanaged wetland with submersed aquatic vegetation (SAV) (NTC-1 and NTC-15)

The unmanaged *Typha* wetlands were allowed to become dominated by *Typha dominigensis*, Pers., (cattails) with 95% to 100% areal coverage and incidental populations of SAV and periphyton communities scattered throughout the cattail vegetation. The cattails were removed from the SAV wetlands and subsequently stocked with SAV dominated with *Najas guadalupensis* (Spreng.) Magnus in 1999.

The unmanaged *Typha* wetlands were operated to reflect the original design criteria for the STAs that were developed using water quality and sediment data collected from Water Conservation Area 2A (WCA-2A) that has been impacted by agricultural stormwater runoff (Walker, 1995). Water depth and HLR of the control wetlands were maintained at 0.6 m and 2.6 cm d^{-1}, respectively (Table 4.1).

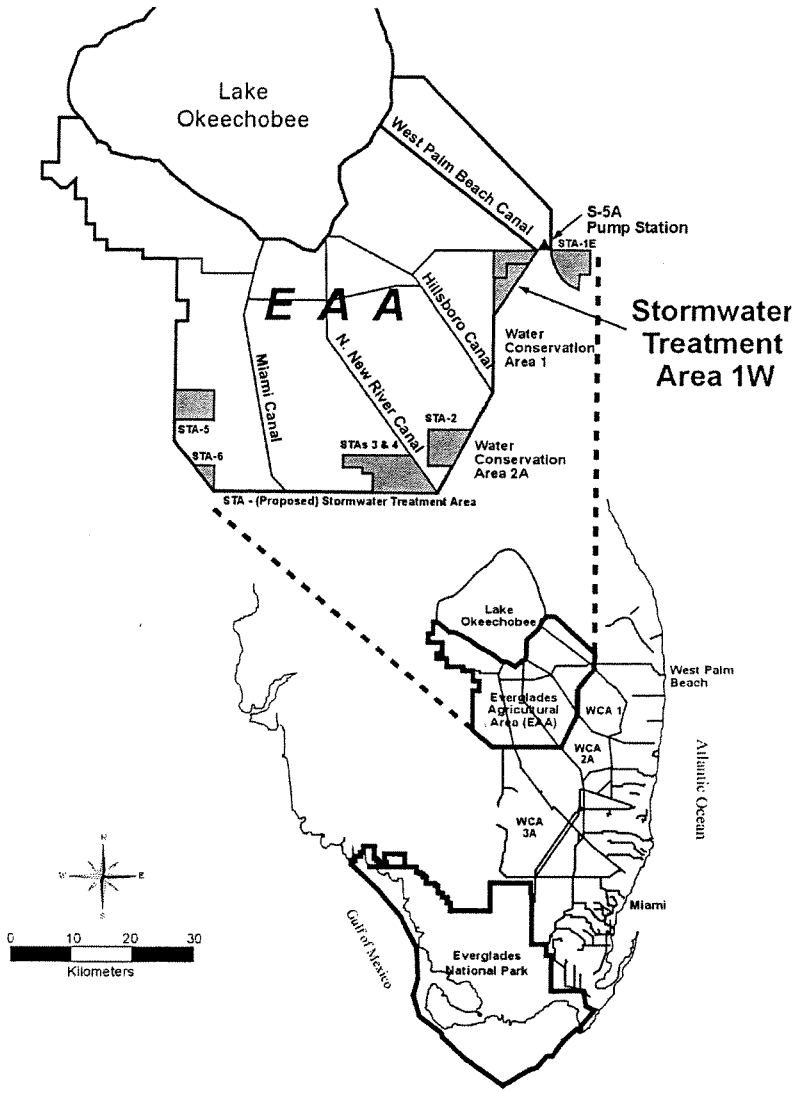

Figure 4.1. Location of STA-1W in relation to the Everglades Agricultural Area and Water Conservation Areas in South Florida.

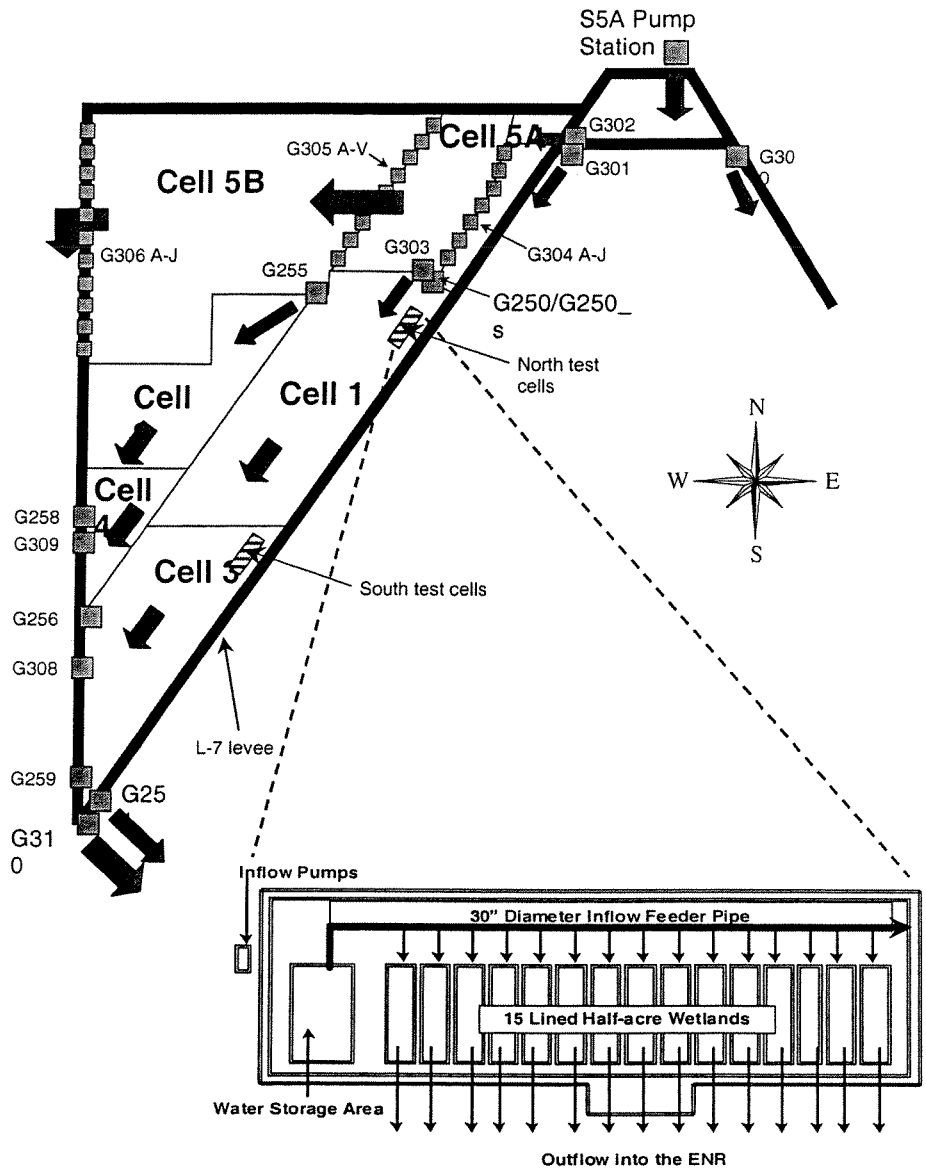

FIGURE 4.2. Map of Stormwater Treatment Area 1-West showing location of the test cells. Arrows indicate direction of flow. The old Everglades Nutrient Removal Project was comprised of Cells 1, 2, 3 and 4.

Table 4.1. Description of north experimental test cells sampled. These test cells were loaded with inflow water of STA-1W.

Treatment System	Cell Number	Hydraulic loading rate (cm/day)	Water depth (m)	System description
Control	NTC-5 NTC-10	2.6	0.6	Emergent aquatic vegetation-cattails.
Managed wetland – $FeCl_3$	NTC-2	10.1	0.3	Emergent aquatic vegetation-cattails. Inflow water treated with $FeCl_3$
Managed wetland – $AlCl_3$	NTC-4	10.0	0.3	Emergent aquatic vegetation-cattails. Inflow water treated with $AlCl_3$
SAV/Limerock	NTC-1 NTC-15	2.6-20.1	0.5-1.1	Submersed aquatic vegetation grown on limerock bed with underlying native peat soil

The managed *Typha* wetlands with chemical pre-treatment of inflow water were designed to determine which of two chemical coagulants (iron chloride and poly-aluminum chloride) in combination with a wetland would provide the best and most stable long-term phosphorus removal. These systems were operated with a target wetland HLR of 10 cm d^{-1} and a water depth of 30 cm (CH2MHill, 2001) (Table 4.1). These wetlands operated from July 1999 through December 2000, with baseline calibration on all test cells extending from July 1999 through January 2000.

The SAV wetland sampling began in September 1999 through September 2001. These studies were designed to determine the HLR that would provide the maximum P mass reduction with no degradation in outflow TP concentration, therefore, the HLRs and depths were periodically altered. The HLRs tested ranged from about 2.6 cm d^{-1} to 20.1 cm/d and the depths ranged from a low of 0.5 m to a high of 1.1 m at both sites (DB Environmental Labs, 2001) (Table 4.1). Beginning 5 April 2000, NTC-15 was taken off-line to retrofit the cells by adding a lime rock berm across each outflow. Sampling from the outflow of NTC-15 resumed 23 June 2000.

4.2.2 Water Sampling and Analysis

Weekly grab and/or composite water quality samples were collected, at the storage cell outlet (inflow source water) and the outflow of the test cells and analyzed for total phosphorus concentration. Beginning 1 January 2002 composite samplers were removed and biweekly grab samples were taken at the inflow storage areas and wetland

outflows. All collection and analyses have been conducted in accordance with South Florida Water Management District Comprehensive Quality Assurance Plan (SFWMD, 1995), which mandates the use of either Environmental Protection Agency (USEPA, 1983) or American Public Health Association (Association, 1989) approved analytical methods.

The samples were acidified in the field, and shipped on ice to either the District laboratory or a District certified contract laboratory for analysis. Values less than the minimum detection limits were reported as the method detection limit (MDL) and detection limit values were used in calculating other parameters. Laboratory MDL for phosphorus was 4 $\mu g\ L^{-1}$, except those samples analyzed by DB Environmental Lab, which reported an MDL of 2 $\mu g\ L^{-1}$ (Jorge et al., 2002).

4.2.3 Soil sampling and analysis

Intact soil cores (three replications) were taken near the inflow and near the outflow of the experimental test cells. A visual estimation of the boundary between the recently accreted soil (floc) and the native peat soil was made based upon color and textural changes in the soil. Depth of this floc layer was recorded. The soil below this layer was separated and analyzed separately.

Both floc and soil samples were also characterized for pH, oxalate extractable Fe and Al, exchangeable Ca and Mg, TC, TN, TP, TPi, bulk density and loss on ignition (ash content). Two approaches were used to determine labile and non-labile pools of P in floc and soils collected from various treatment wetlands. First approach involved analysis of samples for various inorganic P forms including: (1) bicarbonate extractable P_i, (2) Fe-/Al-bound P, (3) Ca-bound P, and (4) residual P (Reddy et al. 1998; Appendix I).

Second approach involved fractionation of floc and soil in various organic P into four major components: (1) readily labile (water soluble, bicarbonate, microbial); (2) moderately labile (acid hydrolyzable P); (3) moderately resistant (fulvic acid P); and (4) highly resistant (humic acid and residual organic P) (Ivanoff et al (1998; Appendix II).

4.3 Results and Discussion

Median inflow TP concentrations during these time periods were 93 and 95 $\mu g\ L^{-1}$ at the north site for baseline and during the study period, respectively (Table 4.2). Median outflow TP concentration during these time periods ranged 20 to 63 $\mu g\ L^{-1}$ during 1999-2000 year and 17 to 28 $\mu g\ L^{-1}$ during 2000-01 year sampling, respectively.

Depth of floc near the inflow point of the wetlands was significantly higher than the floc depth near the outflow in both control and MW-$FeCl_3$ system ($p < 0.006$). Pretreatment of water with poly-aluminum chloride generated large amount of floc at the inflow (maximum thickness = 32 cm), while the pretreatment with $FeCl_3$ generated least amount of floc material (mean depth = 6 cm). High floc generation in MW-$AlCl_3$ system was the result of overflow of solids from pre-treatment reactor into the wetland. In the SAV-Limerock system, the depth of floc at the inflow and outflow were 19 and 14, respectively. For samples near inflow, bulk density of floc from SAV-Limerock system was 2-3 times higher than the bulk density of floc from wetlands with cattail vegetation (Table 4.3). In cattail wetlands, floc generally contained more mineral matter than the underlying peat soil.

In SAV wetlands, material underlying the floc was primarily lime rock with pore spaces filled with floc material. Concentrations of TC, LOI, and TN were lower in the floc than the underlying soil. High mineral matter in the floc of SAV wetland was likely due to photosynthetically-mediated $CaCO_3$ precipitation.

The TP concentration of the floc was significantly higher than underlying soil ($p < 0.0001$) among all treatment systems. The highest TP concentrations of the at the MW-$FeCl_3$ and MW-$AlCl_3$ at the inflow was 1012 and 950 mg kg^{-1}, respectively while the highest TP of the soil was 406 mg kg^{-1} while the the TP of the soil in other systems ranged from 176-238 mg kg^{-1}.

Table 4.2. Inflow and outflow median total phosphorus concentrations for the north experimental test cells sampled. The District Water Year (WY) extends from 1 May of a calendar year through 30 April of the subsequent year, except for NTC-2 and NTC-4 (managed wetland test cells), where start and end of experimental trials did not conform to WY breaks. Therefore, data summarized for NTC-2 and NTC-4 in WY99-00 extends from July 1999 through January 2000, and represents the baseline (no chemical addition) trial, and WY00-01 extends from February 2000 through December 2000, and represents data reflected of chemical treatment.

Sampling Site	WY99-00 (μg/L)	WY00-01 (μg/L)	WY01-02 (μg/L)
Inflow Concentration	74.0	62.0	66.0
Control	28.0 35.0	27.0 25.5	28.0 24.0
Managed wetland – $FeCl_3$	63.0	28.0	No Sampling
Managed wetland – $AlCl_3$	51.0	24.0	No Sampling
SAV/Limerock	26 19.5	19.5 16.5	34.0 23.0

There was significantly higher TC, LOI and TN of the floc at the inflow site of the MW-$FeCL_3$ when compared with outflow site, with no detectable differences for TN, TC and LOI for the other treatments. Total P content of the floc near the inflow was higher than near the outflow site only for MW- $AlCl_3$ and SAV (Table 4.4). Pretreatment of inflow water with $AlCl_3$ and $FeCl_3$ resulted in high P concentration in the floc material. This was probably due to the colloidal material from the chemical reactors released into the wetlands. This was clearly evident in wetlands with $AlCl_3$ pretreatment of inflow water, containing a large accumulation of floc material. Total inorganic P (TP_i) content estimated by single 1 M HCl extraction (Reddy et al. 1998) of the floc was significantly higher in wetlands receiving chemically treated water and in SAV wetland as compared to cattail unmanaged wetland (Table 4.4). In the floc near inflow TP_i content ranged from 45 to 62% of total P, with high values observed in the floc MW-$AlCl_3$ wetland. Approximately 55% of TP in the floc of SAV wetland was in TP_i pool. The TP_i content of the floc material near outflow ranged from 41 to 53% of TP with high values observed

in SAV wetland. In all wetlands, pH of the water column was near neutral or higher, abundant Ca in the inflow water probably promoted the precipitation reactions of inorganic P. In wetlands receiving chemically treated water, a higher proportion of inorganic P in the floc was due to release of colloidal Al-P or Fe-P into wetlands. The TP of the soil was not significantly different between the inflow and outflow samples in any of the treatments. The total P of the soil was not significantly different between the inflow and outflow for all treatments.

Concentrations of TC, LOI and TN were lower in the floc when compared with the underlying peat soils in the control and MW-$AlCl_3$ wetland systems.

4.3.1 Inorganic P forms in floc and soil:

Soil and floc inorganic (P_i) P forms are grouped into: labile P_i; Fe- and Al-bound P; and Ca-and Mg-bound P (Fig. 4.3 - 4.6). Residual P includes P_i not extracted either by NaOH or HCl plus organic P. Labile P_i forms were significantly higher in the floc near inflow than the outflow for all systems except MW-$FeCl_3$ wetland ($p = <0.05$). Fe and Al-bound P in the floc and the soil near inflow was significantly higher than the floc and the soil near outflow for only in MW-$FeCl_3$, while other systems showed no significant differences. Calcium and Mg bound P was significantly higher ($p = <0.05$)in the floc at the inflow site than the outflow site for SAV and MW-$AlCl_3$ wetlands, while soils showed no significant difference.

Floc (recently accreted soil):

Inorganic P forms in recently accreted floc material were influenced by chemical pretreatment of inflow water and vegetation type (Fig. 4.3). Labile P_i ($NaHCO_3$ extractable inorganic P) represented 21% of the total P in the floc materials near inflow site of SAV wetland, as compared to 2-3% of the total P in the floc collected from two wetlands receiving chemically treated water, and 6% of the total P in unmanaged cattail wetland. These results suggest that high proportion of inorganic P is loosely bound to $CaCO_3$ in SAV wetland that can be potentially available for plant uptake or release into water column.

Iron and Al-bound P accounted for 21% of the total P in the floc of a wetland receiving water pretreated with $FeCl_3$, as compared to 9% of the total P in unmanaged cattail wetland, 3% in SAV wetland, and 4% in MW-$AlCl_3$ wetland, respectively. However in MW-$AlCl_3$ wetland, only 4% of the total P was recovered in Fe and Al-bound P. These results suggest that Al had very little or no effect on P retention. This was probably due to lack of Al^{3+} availability in the floc at near neutral pH to react with inorganic P and complexation of Al with organic matter. In addition, P added as Al-P through colloidal material in the treated water into the wetland was probably solubilized in the floc and re-precipitated with Ca. Calcium and Mg bound P accounted for 23-65% of total P. Recovery in this pool was highest in MW-$AlCl_3$ with 65% of TP, as compared to 26% of TP in unmanaged cattail wetland, 23% of TP in MW-$FeCl_3$ wetland, and 32% of TP in SAV wetland, respectively. High levels of Ca and alkaline pH are ideal for retention of inorganic P in this pool. Residual P including organic P ranged from 27-32% of TP, with high values noted in unmanaged cattail wetland and low values observed in MW-$AlCl_3$ wetland.

Table 4.3: Selected characteristics of the floc and soil/ of north test cells (NTC) in STA-1W

Test Cell	Type		Inflow						Outflow					
			Depth	BD	pH	LOI	TN	TC	Depth	BD	pH	LOI	TN	TC
			cm	g cm^{-3}		%	g kg^{-1}	g kg^{-1}	cm	g cm^{-3}		%	g kg^{-1}	g kg^{-1}
Control	Floc	Mean	10	0.038	7.4	47.4	13.2	254	5	0.047	7.6	50.3	13.7	263
		SD	3	0.016	0.1	11.1	2.5	54	1	0.018	0.1	12.0	3.8	57
MW-$FeCl_3$	Floc	Mean	6	0.026	7.2	65.1	18.5	324	8	0.056	7.6	67.6	17.4	342
		SD	1	0.012	0.0	5.0	1.6	25	3	0.025	0.2	4.5	1.3	25
MW-$AlCl_3$	Floc	Mean	32	0.021	7.3	55.8	13.4	197	8	0.059	7.4	55.2	13.1	277
		SD	3	0.001	0.1	1.4	2.7	3	2	0.003	0.0	6.3	1.7	29
SAV	Floc	Mean	19	0.066	7.8	29.9	9.7	196	14	0.058	7.5	39.8	12.3	236
		SD	5	0.019	0.2	7.2	2.0	23	2	0.021	0.2	8.2	2.2	25
Control	Soil	Mean	10	0.163	7.5	64.1	17.4	344	10	0.233	7.6	54.0	14.3	303
		SD	0	0.049	0.1	9.3	3.1	42	0	0.094	0.1	15.2	5.7	72
MW-$FeCl_3$	Soil	Mean	10	0.106	7.4	63.2	19.8	348	10	0.155	7.6	60.0	17.0	329
		SD	0	0.051	0.0	16.3	5.5	73	0	0.046	0.1	6.0	1.7	27
MW-$AlCl_3$	Soil	Mean	10	0.158	7.4	59.2	16.1	312	10	0.142	7.5	68.8	19.1	361
		SD	0	0.047	0.1	11.4	4.4	61	0	0.021	0.2	8.2	3.4	43
SAV	Soil	Mean	10	0.325	7.4	39.1	11.0	216	10	0.220	7.4	55.3	15.9	296
		SD	0	0.150	0.1	17.2	6.1	98	0	0.074	0.1	16.2	4.9	93

Table 4.4: Inorganic and organic P content of floc and soil/substrates north test cells (NTC) of STA-1W

Test Cell	Type		Inflow			Outflow		
			TP	TPi	TPo	TP	TPi	TPo
			mg kg $^{-1}$	mg kg $^{-1}$	mg kg $^{-1}$	mg kg $^{-1}$	mg kg $^{-1}$	mg kg $^{-1}$
Control	Floc	Mean	726	350	376	549	227	322
		SD	148	138	98	140	43	107
MW-$FeCl_3$	Floc	Mean	1012	557	456	559	279	280
		SD	172	143	35	282	147	143
MW-$AlCl_3$	Floc	Mean	950	588	362	500	207	293
		SD	48	37	20	41	11	30
SAV	Floc	Mean	677	374	302	534	286	249
		SD	117	62	58	97	76	30
Control	Soil	Mean	238	94	144	212	100	112
		SD	36	15	36	25	22	46
MW-$FeCl_3$	Soil	Mean	406	193	214	227	122	105
		SD	101	55	53	66	57	17
MW-$AlCl_3$	Soil	Mean	223	113	110	274	105	169
		SD	36	9	32	58	44	17
SAV	Soil	Mean	176	90	86	209	96	112
		SD	63	43	28	116	105	21

Soil or Limerock below Floc:

Soils below the floc in three wetlands (unmanaged cattail wetland, MW-$FeCl_3$ and MW-$AlCl_3$) were histosols, while in SAV wetland the material below the floc was 30 cm lime rock on native organic soil. Chemical analysis of limerock did not include materials greater than 0.5 cm. Approximately 5-8% of the TP was in $NaHCO_3$ extractable P_i for all wetlands, with high values observed in SAV wetland (Fig. 4.4 and 4.6). Pretreatment of water with Al and Fe compounds had minimal effect on soil P forms. Iron and Al-bound P accounted for 3 to 9% of the TP with high values observed in wetlands receiving

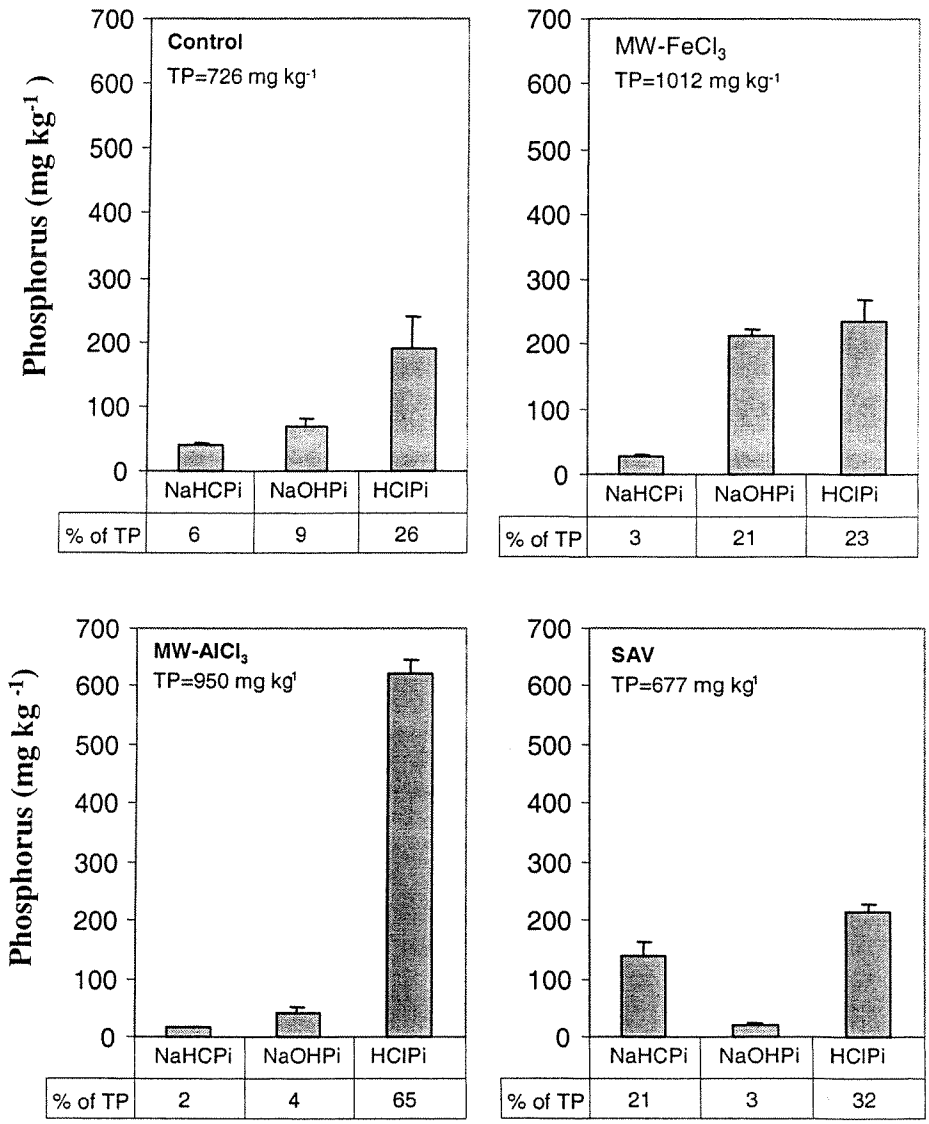

Fig.4.3. Inorganic phosphorus forms in the sediments (recently accreted material) at the inflow site of the north test cells.
NaHCPi = Bicarbonate extractable inorganic P or labile inorganic P; NaOHPi = Fe and Al-bound P; HCLPi = Ca and Mg-bound P.

chemically treated water. Calcium and Mg- bound P accounted 26-40% of the TP. Residual P including organic P ranged from 34-44% of the TP in wetlands with organic soils and 34% in SAV-limerock wetland, respectively.

In all wetland systems, the dominant form of inorganic P in the floc and the soil was Ca-and Mg-bound P. This was due to high Ca levels in floc and soils, which ranged from 5.7 to 24.4% (dry mass basis) (Table 4.5). In addition, pH of the floc and soil was around 7.5 (Table 4.3). These conditions favored the retention of inorganic P as Ca- and

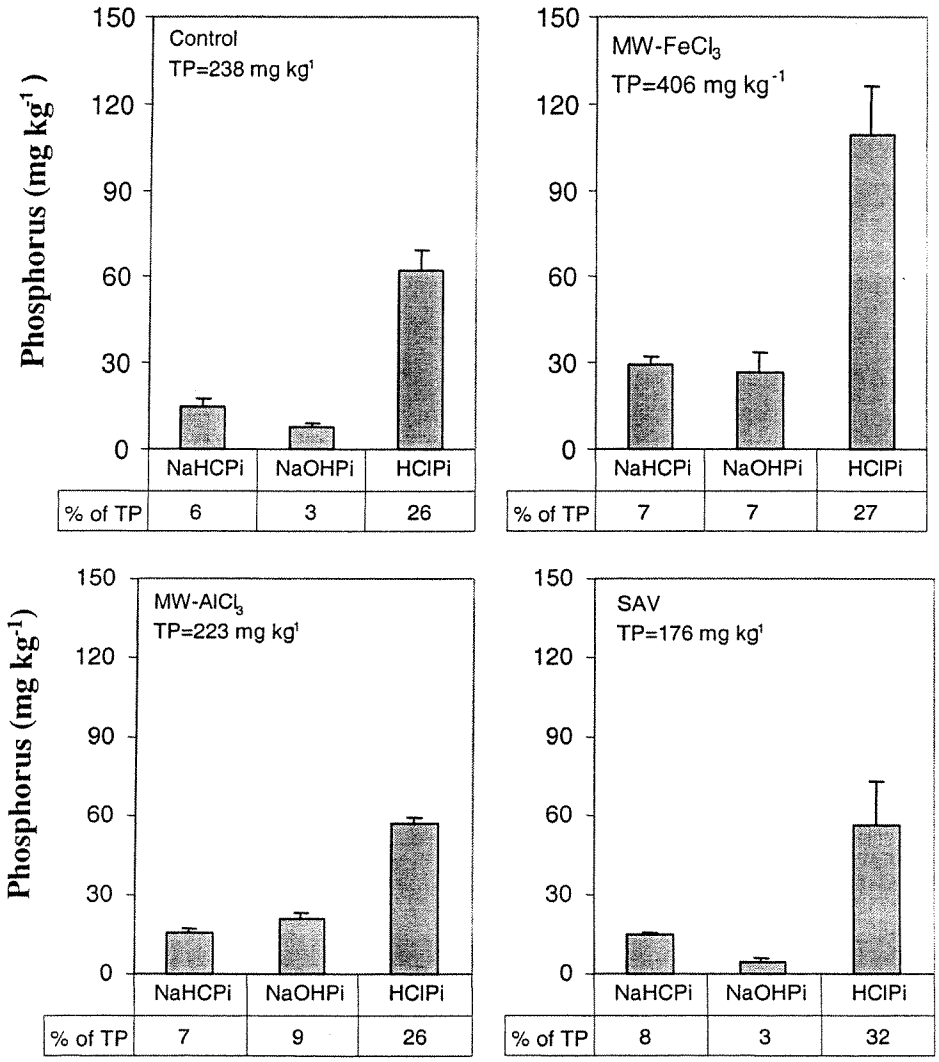

Fig.4.4. Inorganic phosphorus forms in the soils (0-10 cm) at the inflow site of the north test cells. NaHCPi = Bicarbonate extractable inorganic P or labile inorganic P; NaOHPi = Fe and Al-bound P; HCLPi = Ca and Mg-bound P.

Mg-bound P. In MW-$AlCl_3$ wetland, Al-P added through colloidal material in the inflow water was found to be unstable in the wetland. Results suggest that Al-P was solublized at near neutral pH, and P released was re-precipitated with Ca, resulting in high recovery (65% of the TP) as Ca- and Mg-bound P. Even though the acid extractable Al levels in the floc were very high (19% of the total dry mass), it did not promote the retention of P as Al-P. Under alkaline pH conditions, formation of $AlOH^-$ probably affected the retention of phosphate (HPO_4^{2-} and HPO_4^-) as Al-P.

In MW-$FeCl_3$ wetland, a major portion of P was recovered as Fe- and Al-bound P. The physico-chemical conditions in this wetland were similar to those present in MW-$AlCl_3$ wetland. Acid extractable Fe content of the floc was 1.6% (dry wet basis). However, acid

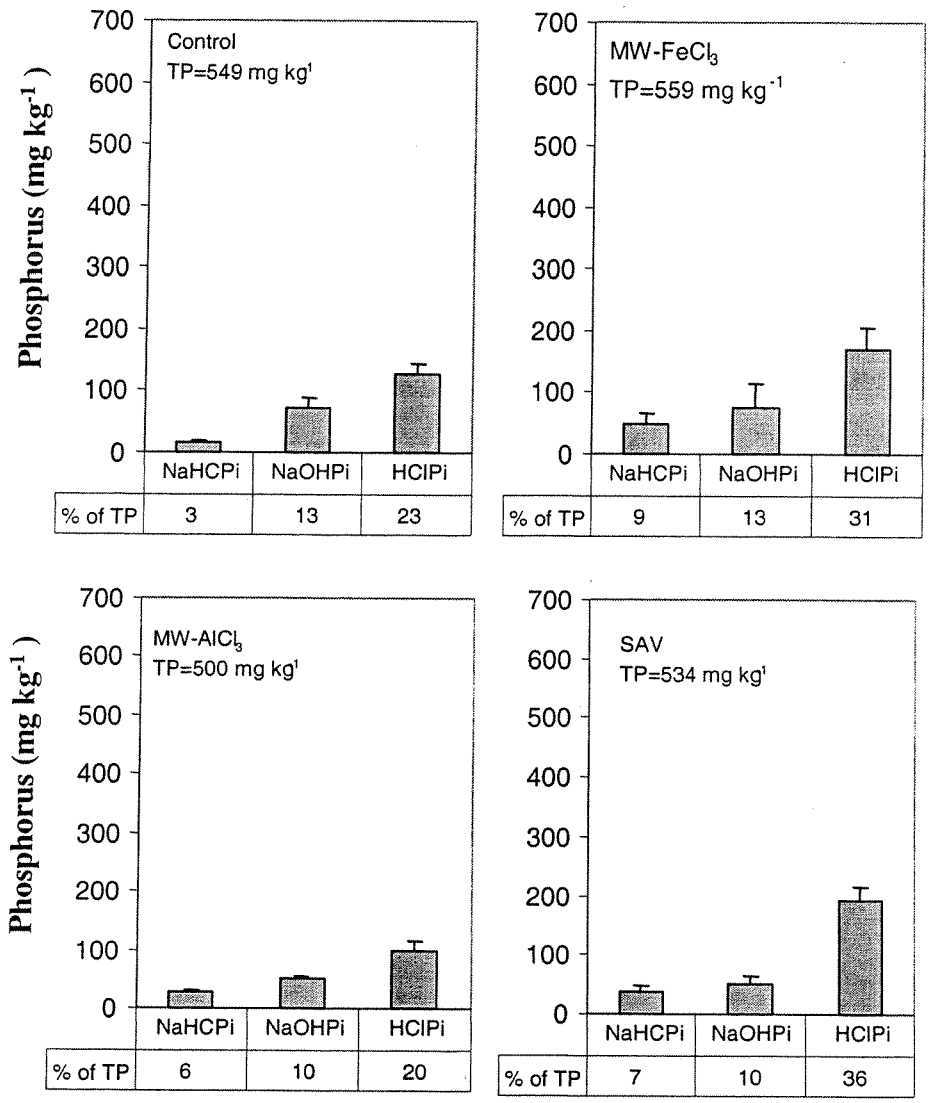

Fig.4.5. Inorganic phosphorus forms in the sediments (recently accreted material) at the outflow site of the north test cells.
NaHCPi = Bicarbonate extractable inorganic P or labile inorganic P; NaOHPi = Fe and Al-bound P; HCLPi = Ca and Mg-bound P.

extractable Al content was also high (2.2% dry wt basis), suggesting possible contamination of Al in the $FeCl_3$ chemical reactor. The inflow was probably contained both colloidal Fe and Al-P, which accumulated in the wetland. The inorganic P fractionation scheme used did not differentiate between Fe an Al-bound P. However, high P recovery in Fe- and Al-bound P suggests that much of the P was actually associated with Fe rather that Al. As mentioned earlier, Al-P was found to be unstable under slightly alkaline conditions.

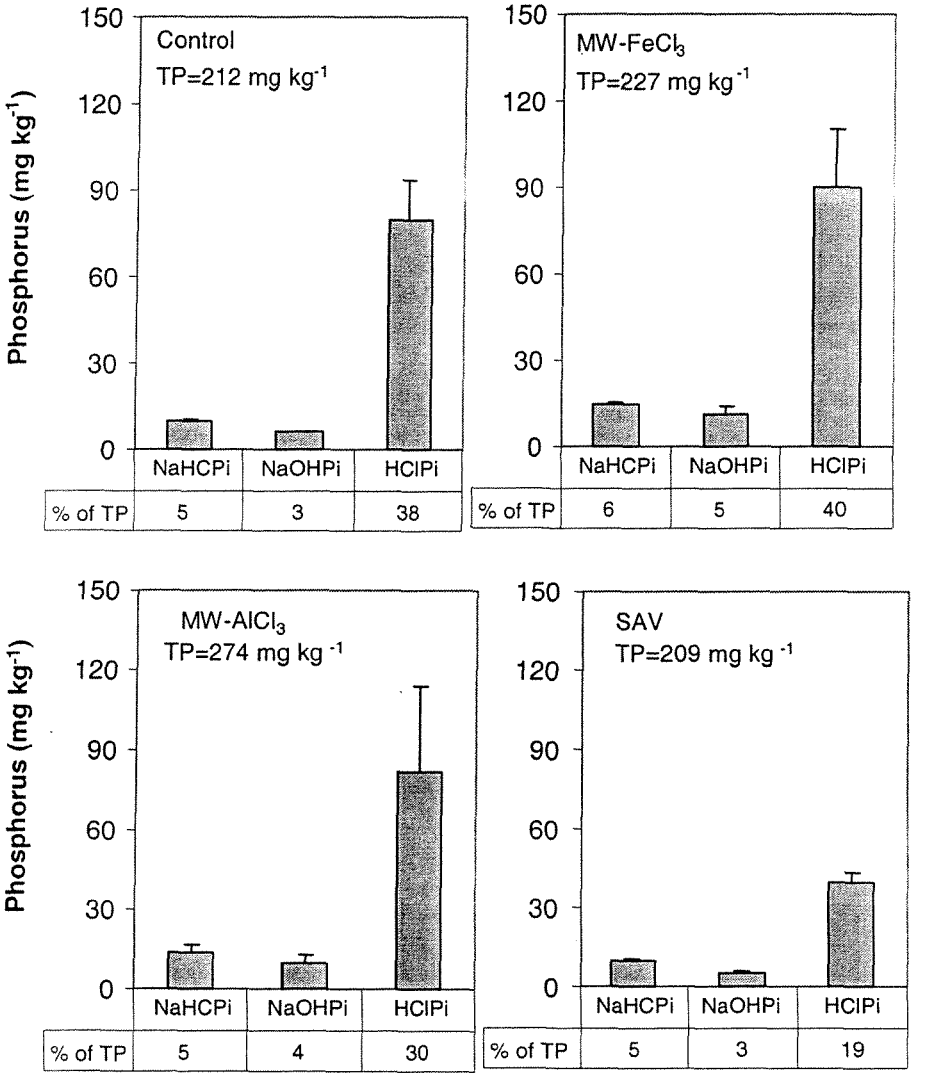

Fig.4.6. Inorganic phosphorus forms in the soils (0-10 cm) at the outflow site of the north test cells. NaHCPi = Bicarbonate extractable inorganic P or labile inorganic P; NaOHPi = Fe and Al-bound P; HCLPi = Ca and Mg-bound P.

In SAV wetland, a large proportion of inorganic P in the floc was recovered in labile pool. Iron and Al have very little effect on P retention. High Ca levels in this wetland associated with alkaline pH maintained inorganic P in stable pool. The underlying limerock and inflow water provided a steady source of Ca to the floc. Much of the Ca in this wetland is precipitated as $CaCO_3$, with co-precipitation of inorganic P as Ca-P.

In unmanaged cattail wetland, approximately 41% of the TP was recovered in inorganic P pool, with two-thirds as Ca-and Mg-bound P. The source of Ca in this wetland was primarily inflow water. Chemical reactions in the water column of this

wetland are similar to those observed in the SAV wetland. The detrital material accumulated in this wetland was colonized with filamentous algae, which provided conditions for chemical precipitation of P as Ca-P.

4.3.2 Organic P forms in floc and soil:

Organic (P_o) forms are divided into the following groups: labile P_o; microbial biomass P (MBP); fulvic acid bound P (FAP); humic acid bound P (HAP); and residual P (Fig. 4.7-4.10). Labile P_o was significantly higher in the floc near inflow than the outflow

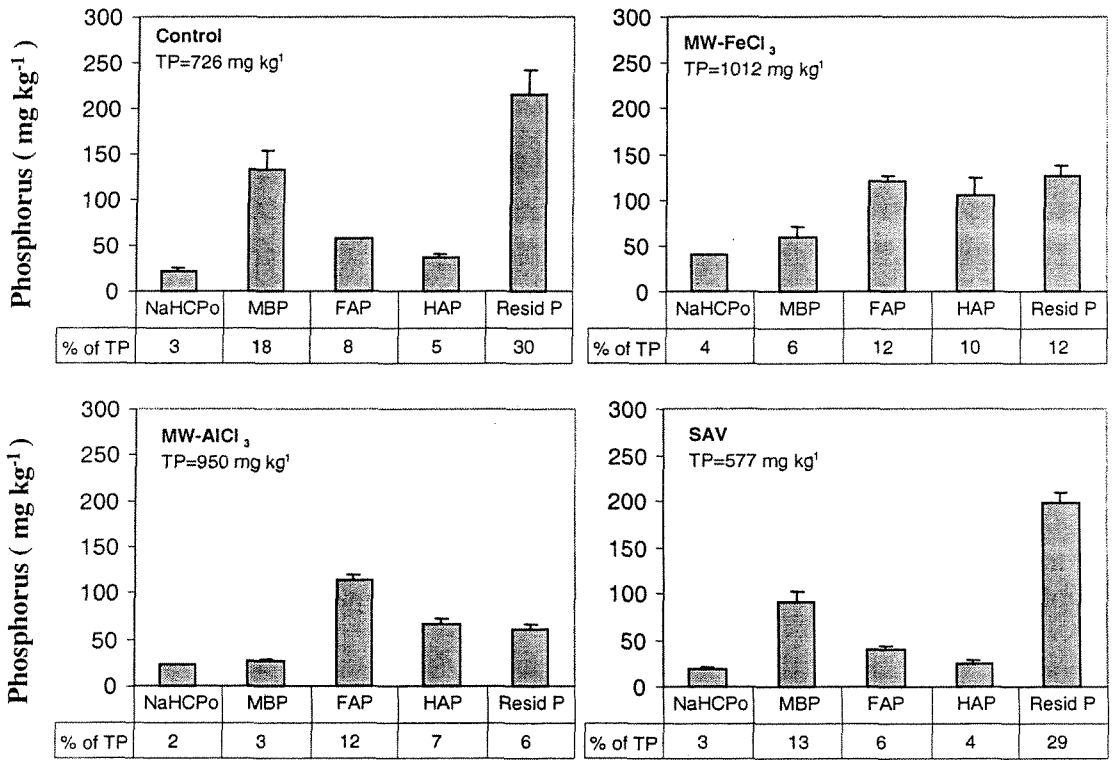

Fig.4.7. Organic phosphorus forms in floc sediments (recently accreted material) at the inflow site of the north test cells. NaHCPi = Bicarbonate extractable P or labile organic P; MBP = microbial biomass P; FAP = fulvic acid bound P; HAP = Humic acid bound P; Resid P = residual P or non-reactive P.

for MW-$AlCl_3$ and MW-$FeCl_3$ wetlands (p = <0.05). Microbial biomass P in the floc samples was higher in MW-$AlCl_3$ and SAV wetlands, while no significant differences were observed in other systems. Phosphorus associated with fulvic and humic acid was higher in the inflow floc and soil in unmanaged cattail wetland than the outflow site. In other wetland systems, no significant differences were observed between inflow and out flow.

Floc (recently accreted material):

Organic P forms were influenced by vegetation type and chemical pretreatment of inflow water (Fig. 4.7 and 4.8). Low levels (5 to 10% of total P) of labile $\mathbf{P_o}$ including MBP were measured in the floc at inflow sites of wetlands receiving chemically treated water as compared to SAV wetland (16% of total P) and unmanaged cattail wetland (21% of the TP)(Fig. 4.7).In unmanaged cattail wetland up to 13% of the TP was recovered in fulvic and humic bound P and 30% in residual fraction. This is in contrast to MW-$AlCl_3$ wetland, where 19% of the TP was recovered in fulvic and humic bound P and only 6% in the residual pool, as compared to 22% of the TP in fulvic and humic bound P and 12%

Table 4.5: Extractable metals of floc and soil/substrates north test cells (NTC) of STA-1W

Test Cell	Type		HCl-Ca	HCl-Mg	HCl-Fe	HCl-Al	Ox-Fe	Ox-Al
			mg kg $^{-1}$	mg kg $^{-1}$	mg kg $^{-1}$	mg kg $^{-1}$	mg kg $^{-1}$	mg kg $^{-1}$
Inflow								
Control	Floc	Mean	164,142	4,843	317	1,060	352	706
		SD	44,301	799	65	162	71	94
MW-$FeCl_3$	Floc	Mean	102,980	3,519	16,166	22,437	15,145	18,306
		SD	4,507	178	2,687	10,843	2,164	9,062
MW-$AlCl_3$	Floc	Mean	57,348	2,185	365	179,304	218	98,862
		SD	1,478	65	55	7,412	38	24,120
SAV	Floc	Mean	244,369	6,493	184	631	186	377
		SD	36,462	781	20	293	29	216
Outlow								
Control	Floc	Mean	142,290	4,417	334	1,138	335	809
		SD	31,122	558	76	441	63	278
MW-$FeCl_3$	Floc	Mean	102,152	3,921	1,062	2,671	1,228	2,441
		SD	12,751	111	874	2,012	1,133	1,915
MW-$AlCl_3$	Floc	Mean	103,533	3,388	359	4,081	349	3,503
		SD	33,134	329	34	1,176	55	778
SAV	Floc	Mean	213,791	5,769	181	548	190	352
		SD	49,717	913	32	180	51	139

residual P pools in MW-$FeCl_3$, respectively. In SAV wetland, 10% of the TP was recovered in fulvic and humic bound P and 29% in the residual pool. These results suggest that the presence of either Al or Fe enhanced the transformation of organic P pools into inorganic P.

Soil or Limerock below Floc:

Relative distribution of organic P pools was similar for samples collected from both inflow and outflow sites (Fig. 4.9 and 4.10). Labile P_o (including microbial biomass P) ranged from 9 to 13% of the TP, while P associated with fulvic and humic acid ranged

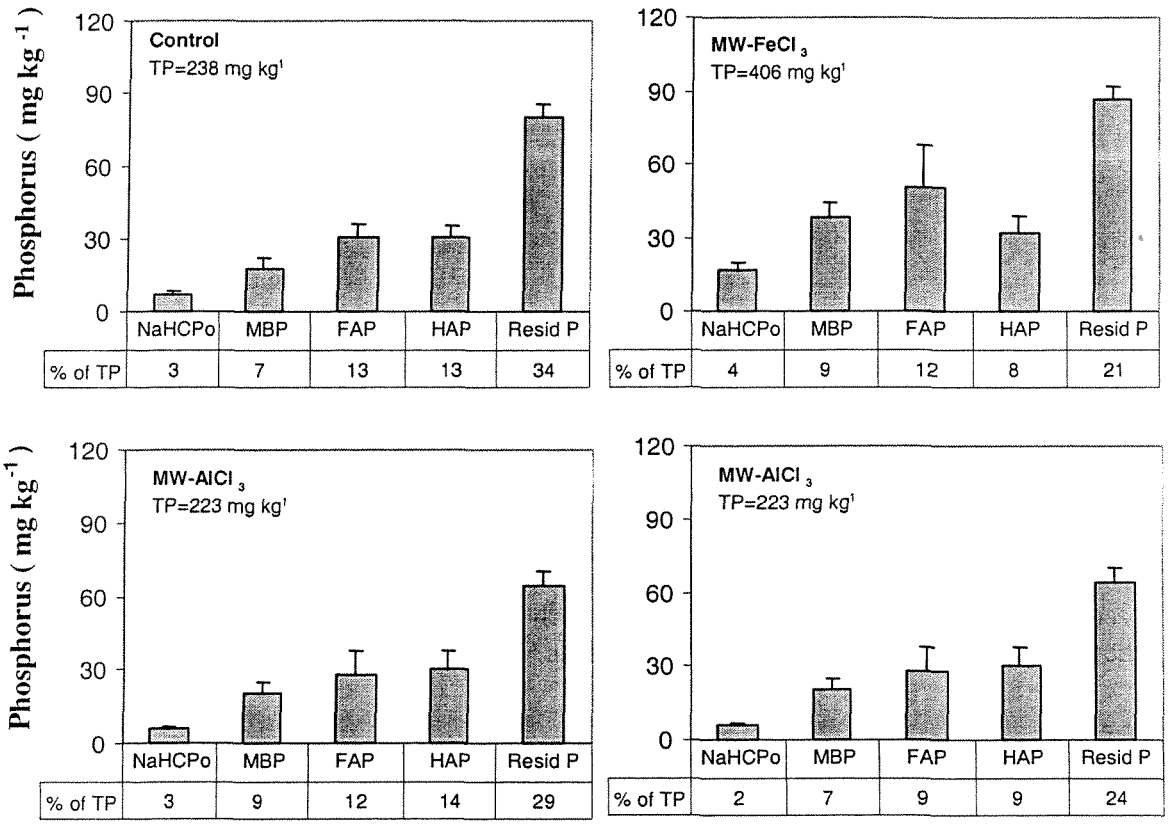

Fig.4.8. Organic phosphorus forms in soil (0-10 cm) at the inflow site of the north test cells. NaHCPi = Bicarbonate extractable P orlabile organic P; MBP = microbial biomass P; FAP = fulvic acid bound P; HAP =Humic acid bound P; Resid P = residual P or non-reactive P.

from 18 to 26% of the TP. Residual P (not extracted either with acids or alkali) ranged from 21 to 34% of the TP.

Conventionally, soil P_o stability is characterized on the basis of its extractability in alkali media (Bowman and Cole, 1978; Hedley et al., 1982; Tiessen et al., 1984; Cross and Schlesinger, 1995; Ivanoff et al., 1998). Different alkali media extract different fractions of P_o depending on the mechanism by which the P_o fraction interacts with other soil components. For example, P_o turnover studies have shown that $NaHCO_3$-extractable

Po in upland soils is easily mineralizable, and may contribute to plant-available P during one growing season (Bowman and Cole, 1978b; Gahoonia and Nielsen, 1992). Relatively more resistant forms of Po involved in long-term transformations of P in soils are extractable with NaOH (Batsula and Krivonosova, 1973). Hedley et al. (1982a) used a sequence of alkali extractions to quantify the range of soil P_o stability. During the last 15 years, various combinations of operationally defined, chemical extracts have been

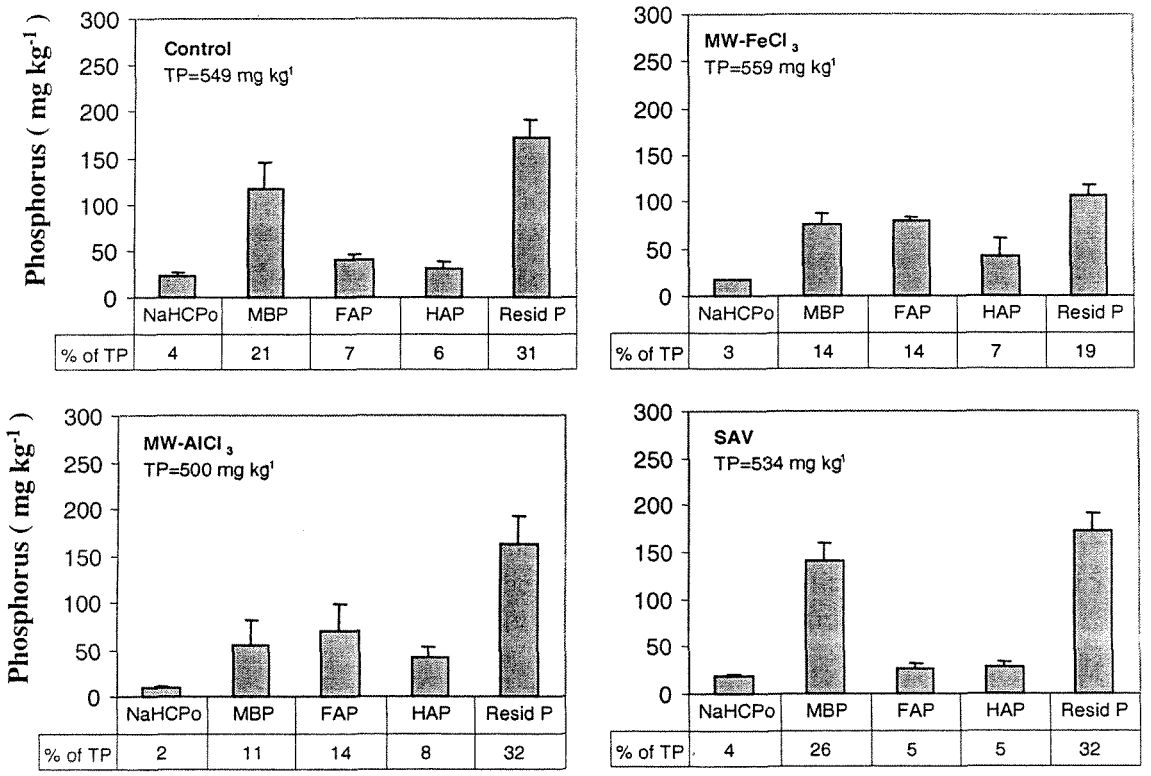

Fig.4.9. Organic phosphorus forms in floc sediments (recently accreted material) at the outflow site of the north test cells. NaHCPi = Bicarbonate extractable P or labile organic P; MBP = microbial biomass P; FAP = fulvic acid bound P; HAP = Humic acid bound P; Resid P = residual P or non-reactive P.

employed in sequence, to obtain more detailed information on P_o and P_i turnover in soils of varying pedogenesis and management (Hedley et al., 1982a,b; Tiessen et al., 1984; Sharpley, 1985; Ivanoff et al., 1998). Ivanoff et al. (1998) adapted the $NaHCO_3$-NaOH fractionation scheme for the evaluation of Po stability in Everglades Histosols. The chemical fractionation scheme tested in this study identifies organic P in several pools including: (1) labile P (microbial biomass P), (2) acid hydrolyzable P, (3) fulvic acid bound P, (4) humic acid bound P, and (5) residual organic P. The scheme is operationally defined and was applied successfully for selected wetland soils of Florida (Ivanoff et al. 1998). The major disadvantages of chemical fractionation schemes relate to

the chemical hydrolysis of Po compounds during extraction and its inability to provide any direct evidence of the structural components of Po compounds; this prevents the schemes from discriminating clearly and consistently between the major classes of Po.

4.3.3 Extractable metals

Acid (1 M HCl) extractable metal concentrations in the recently accreted floc were influenced by chemical pretreatment of inflow water, vegetation type, and underlying soil or limerock (Table 4.5 and 4.6). In the unmanaged cattail and SAV wetlands, dominant metals were Ca followed by Mg, Al, and Fe. In MW-$AlCl_3$ wetland, floc contained elevated levels of Al with concentrations of up to 17.9%, suggesting that the some of the poly-Al sludge from chemical reactors was discharged into wetland. This was indicated by large floc buildup in this wetland. In this floc Ca levels were lower than other wetlands, suggesting inhibition of $CaCO_3$ precipitation. Similarly, in MW-$FeCl_3$ wetland, Fe levels were high (1.6%) as compared to other wetlands. This suggests that some of the colloidal materials from the chemical reactors were discharged into wetland.

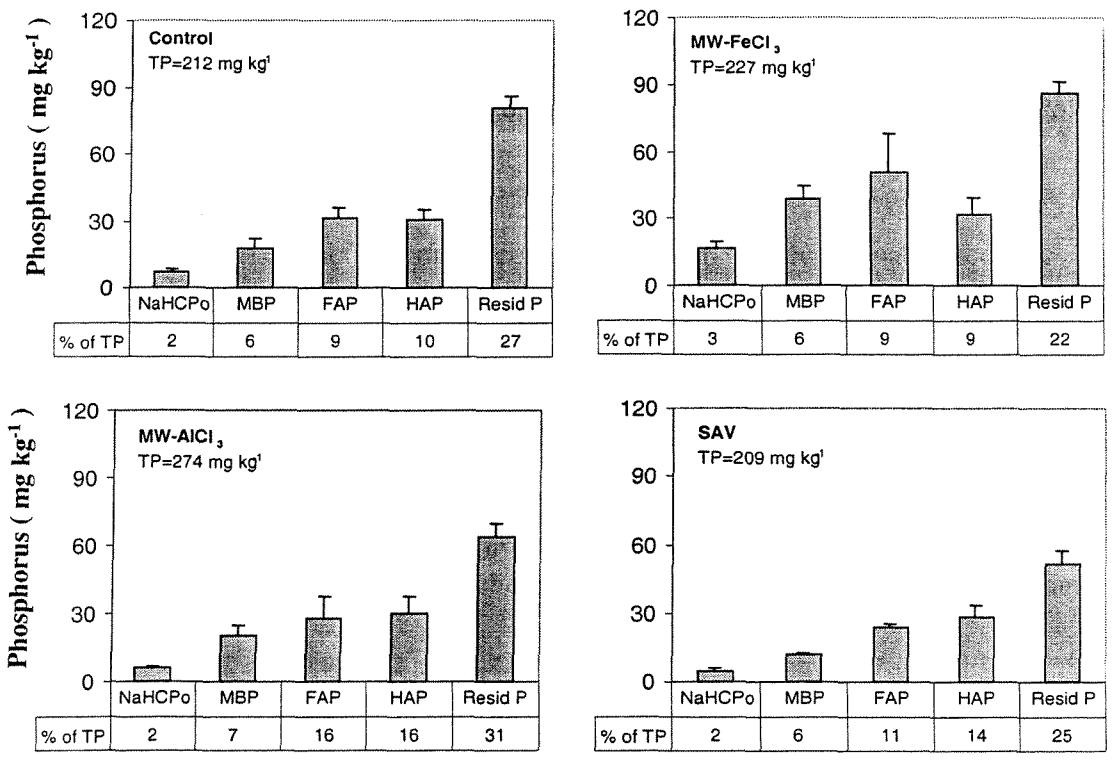

Fig.4.10. Organic phosphorus forms in soil (0-10 cm) at the outflow site of the north test cells. NaHCPi = Bicarbonate extractable P or labile organic P; MBP = microbial biomass P; FAP = fulvic acid bound P; HAP =Humic acid bound P; Resid P = residual P or non-reactive P.

However, in this wetland Al levels were also high (2.2%), suggesting that possible contamination of chemicals used for pretreatment of water before its discharge into the wetland. The floc material in SAV wetland contained 24% Ca. This is expected considering the underlying limerock substrate (one of the sources of Ca to floc) and high $CaCO_3$ precipitation on surface SAV tissue.

Table 4.6: Extractable metals of soil/substrates north test cells (NTC) of STA-1W.

Test Cell	Type		HCl-Ca mg kg $^{-1}$	HCl-Mg mg kg $^{-1}$	HCl-Fe mg kg $^{-1}$	HCl-Al mg kg $^{-1}$	Ox-Fe mg kg $^{-1}$	Ox-Al mg kg $^{-1}$
Inflow								
Control	Soil	Mean	107,939	3,329	292	904	388	859
		SD	27,908	345	83	204	124	175
MW-$FeCl_3$	Soil	Mean	102,841	3,788	2,798	2,849	3,476	2,690
		SD	41,289	997	1,287	1,618	1,324	1,235
MW-$AlCl_3$	Soil	Mean	93,638	3,099	230	5,657	272	5,731
		SD	25,717	644	20	1,932	29	1,996
SAV	Soil	Mean	84,622	2,526	245	655	281	574
		SD	41,737	1,501	115	101	152	81
Outlow								
Control	Soil	Mean	147,464	3,894	338	791	391	757
		SD	59,036	1,195	119	260	102	247
MW-$FeCl_3$	Soil	Mean	114,949	4,081	295	637	332	625
		SD	11,134	1,187	41	121	58	135
MW-$AlCl_3$	Soil	Mean	90,276	4,266	283	1,276	338	1,190
		SD	25,983	2,204	92	299	85	299
SAV	Soil	Mean	70,946	2,623	199	711	209	614
		SD	27,248	1,085	25	117	25	118

4.3.4 Phosphorus storage:

Phosphorus storage in the floc and underlying soil was influenced pretreatment of water, vegetation type, and soil or limerock substrate (Table 4.7). In the floc material, high P storage was the result of high rate of floc accumulation. Both SAV and MW-$AlCl_3$ wetlands had largest amount of floc accumulation at the inflow site, resulting in high P storage (6.5 to 7.9 g P m^{-2}), as compared to 1.5 to 2.4 g P m^{-2} in MW-$FeCl_3$ and unmanaged wetland, respectively (Table 4.7). Phosphorus storage ratio between inflow and outflow ranged from 0.71 to 2.7, with low ratios observed in $FeCl_3$ wetland and while for other systems ratios ranged from 1.94 to 2.7. Although, the TP concentration of the floc at the inflow site in MW-$FeCl_3$ wetland was high, total P storage was lower than outflow site. This was due to high bulk density of the floc accreted near outflow site.

Table 4.7: Total phosphorus storage in floc and soils floc and soil/substrates north test cells (NTC) of STA-1W

Test Cell	Type		TP Storage	
			Inflow	Outflow
			mg m^{-2}	mg m^{-2}
Control	Floc	Mean	2402	1224
		SD	531	246
MW-$FeCl_3$	Floc	Mean	1558	2195
		SD	799	575
MW-$AlCl_3$	Floc	Mean	6589	2438
		SD	1129	476
SAV	Floc	Mean	7901	4077
		SD	1334	611
Control	Soil	Mean	3799	4758
		SD	858	1394
MW-$FeCl_3$	Soil	Mean	4168	3422
		SD	1847	969
MW-$AlCl_3$	Soil	Mean	3410	3868
		SD	428	855
SAV	Soil	Mean	5119	4123
		SD	1677	1404

These results showed that pretreatment of inflow water with $FeCl_3$ had minimal effect on overall P storage in the floc, suggesting that much of the P removal occurred in the chemical reactor. Phosphorus storage in the underlying soil or limerock reflects initial conditions. However, elevated levels of P storage in soil or limerock samples collected near inflow as compared to outflow, suggest the influence P loading on storage.

4.4 Conclusions

In this study recently accreted floc and the underlying soil or limerock samples were sequentially extracted with selected chemicals to determine inorganic and organic p pools. The inorganic P extracted with salt such as $NaHCO_3$ represents loosely absorbed P, which accounted for 2 to 21% of the total P. This pool of P is considered bioavailable as it is sufficiently labile to enter soil porewater for uptake by plants or potential flux into overlying water column. Although, recently accreted floc in SAV wetland showed large P fraction in this pool, it is likely that this pool will be incorporated into more stable pool as Ca-and Mg-bound P. The NaOH-P_i represents inorganic P associated with Fe and Al (included occluded P), and represents P not readily available. This pool is not a dominant factor except in wetlands receiving chemically ($FeCl_3$ or $AlCl_3$) treated water. The HCl-P_i represents P associated Ca/Mg, is relatively stable and not readily available. Alkali extractable organic P includes both readily available organic P (microbial biomass P) and slowly available organic P (P associated with fulvic and humic acids). Due to predominance of organic P in soils, and its existence in different forms of varying degrees of availability, mineralization of organic P can play an important role in contributing to the bioavailable pool. Residual P represents highly resistant organic P or unavailable mineral bound P not extracted either with alkali or acid. Long-term storage of P in recently accreted soil or floc of STAs is governed by the stability of Ca- and Mg-bound and organic matter.

Availability of inorganic P in these systems can be characterized as follows: labile P_i – readily available; Fe- and Al-bound P – moderately available, and Ca- and Mg-bound P – slowly available. Availability of organic P can be characterized as follows: labile P_o including microbial biomass P – readily available, fulvic acid bound P – moderately available, humic acid bound P – slowly available, and residual P – not available (permanent storage). Results suggest that SAV system is accreting P at a rapid rate than managed cattail system. Long-term sustainability of SAV in sequestering P needs further evaluation.

5.0 Influence of Emergent and Submersed Aquatic Vegetation and Periphyton on Phosphorus Forms of Newly Accreted Soil in Constructed Wetlands

5.1 Introduction

Stormwater treatment areas (STAs) are now used as buffers to reduce P in surface runoff discharged from the Everglades Agricultural Area (EAA). These are passive systems and usually not managed. At present, all technologies used are capable of decreasing total P concentrations to approximately 20 $\mu g\ P\ L^{-1}$. These technologies include: STAs with emergent aquatic vegetation (EAV), submersed aquatic vegetation (SAV), and periphyton (PSTA). The composition of the water leaving these systems is primarily in organic form. However, current regulatory requirements are to reduce TP concentrations below 10 $\mu g\ PL^{-1}$. Several abiotic and biotic processes in the soil and water column are involved in regulating the TP concentration of the STA effluents.

The objectives of this study were to: (1) determine the physico-chemical characteristics of the newly accreted floc material, as compared to the native soil in select test cells currently used to evaluate various green technologies for polishing treated effluents from STAs (low P loading), (2) determine the relative proportion of labile organic P and inorganic P in the floc material, and (3) evaluate the stability of P compounds stored in the newly accreted material.

5.2 Materials and Methods

5.2.1 Site description

The stormwater treatment area -1 west (STA-1W) formerly know as the Everglades Nutrient Removal (ENR) project is a 2,699 ha constructed wetland built on previously farmed agricultural land located 25 km west of the city of West Palm Beach in Palm Beach County and borders the northwest corner of WCA-1 (26° 38' N and 80° 25' W) (Fig. 5.1). The south test cells (STC) are shallow, rectangular wetlands, approximately 0.2 ha in size located within STA-1W. The wetlands operate in parallel and are fully lined with about 0.61 m of sand capped with an equal depth of peat, except for two of the Periphyton Stormwater Treatment Area (PSTA) test cells, which were lined with 30-cm of peat subsequently overlain with 30 cm of shellrock.

Inflow water for the test cells is obtained from the surrounding treatment Cell # 4. Water is first pumped into a storage cell, which is maintained at a stage several feet above that of the test cells. Water from the storage cell then flows into a 76.2-cm diameter distribution pipe and is delivered in parallel fashion to the test cells through 20.3-cm diameter lateral pipes, each fitted with one of several calibrated orifice caps (Chimney et al., 2000). The end of the inflow distribution pipe is equipped with an open orifice to ensure the water delivery system is well-flushed even if all the test cells are operating at low flow rates or are closed-off altogether. This feature was incorporated into the system design to prevent water within the feeder pipe from stagnating, which might cause large changes in water quality along the length of the pipe and effect experiments being conducted within the test cells. Changing the orifice cap regulates the

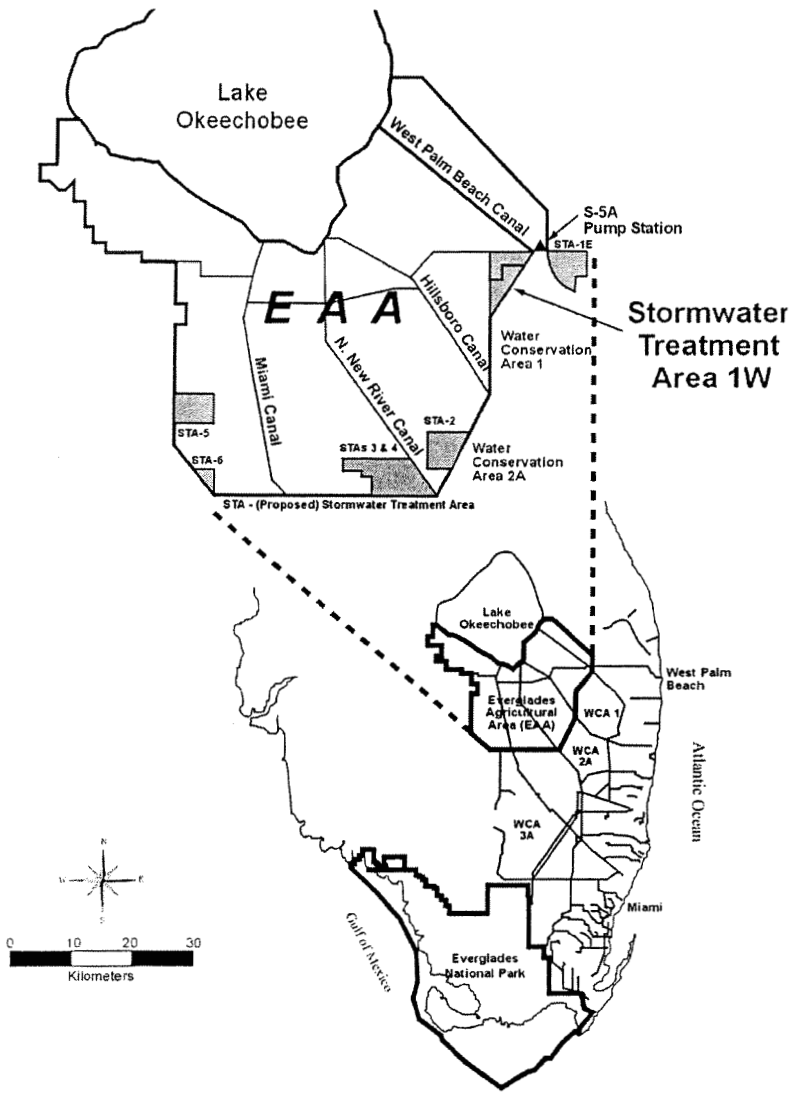

Figure 5.1. Location of STA-1W in relation to the Everglades Agricultural Area and Water Conservation Areas in South Florida.

rate of inflow, and an adjustable 90° v-notch weir controls outflow from each test cell. Raising or lowering the weir controls water depth within that cell.

The south test cells consisted of the following treatments (Table 5.1, Fig 5.2):

- Unmanaged *Typha* wetland (STC-1 and STC-15)
- Unmanaged wetland with submersed aquatic vegetation (SAV) (STC-4 and STC-9)
- PSTA-shellrock over native peat soil (STC-3 and STC-8)
- PSTA – native soil (STC-13)
- Managed *Typha* wetland with poly $AlCl_3$ pre-treatment of inflow water (STC-7)

The unmanaged *Typha* wetland were allowed to become dominated by *Typha dominigensis*, Pers., (cattails) with 95% to 100% areal coverage and incidental populations of SAV and periphyton communities scattered throughout the cattail vegetation. The cattails were removed from the four SAV test cells and subsequently stocked with SAV dominated with *Najas guadalupensis* (Spreng.) Magnus in 1999. Cattails were not allowed to colonize the three test cells dedicated to PSTA studies, but were instead planted with *Eleocharis cellulosa* Torr. and allowed to colonize with periphyton. However, the peat substrate PSTA test cell became quickly colonized with cattails.

Table 5.1. Description of south experimental test cells sampled. These test cells were loaded with outflow water of STA-1W.

Cell Number	Treatment System	Hydraulic loading rate (cm/day)	Water depth (m)	System description
STC-1	Control	2.6	0.6	Emergent aquatic vegetation-cattails
STC-15	Control	2.6	0.6	Emergent aquatic vegetation-cattails
STC-3	PSTA-shellrock	6.0	0.0-0.6	Periphyton with submersed aquatic vegetation grown on shellrock bed with underlying native peat soil. Variable water depth. Dry-down period from 3/01/00 to 5/17/00.
STC-8	PSTA-shellrock	6.0	0.3 & 0.6	Periphyton with submersed aquatic vegetation grown on shellrock bed with underlying native peat soil.
STC-13	PSTA-peat	6.0	0.3 & 0.6	Periphyton with submersed aquatic vegetation grown on native peat soil. Batch testing from 1/1/00 to 3/06/00; HLR = 0; Depth = 60 cm. System drained for cattail removal, hydrated lime application, and spike rush planting from 3/7/00 to 4/12/00.
STC-4	SAV/ Limerock	2.6-20.1	0.5-1.1	Submersed aquatic vegetation grown on limerock bed with underlying native peat soil
STC-9	SAV/ Limerock	2.6-20.1	0.5-1.1	Submersed aquatic vegetation grown on limerock bed with underlying native peat soil
STC-7	Managed wetland – $AlCl_3$	10.4	0.3	Emergent aquatic vegetation-cattails. Inflow water treated with $AlCl_3$

5.2.2 Water sampling and analysis

Weekly grab and/or composite water quality samples were collected, at the storage cell outlet (inflow source water) and the outflow of the test cells and analyzed for total phosphorus concentration. Beginning 1 January 2002 composite samplers were removed and biweekly grab samples were taken at the inflow storage areas and wetland outflows. All collection and analyses have been conducted in accordance with South Florida Water Management District Comprehensive Quality Assurance Plan (SFWMD, 1995), which mandates the use of either Environmental Protection Agency (USEPA, 1983) or American Public Health Association (APHA, 1989) approved analytical methods.

The samples were acidified in the field, and shipped on ice to either the District laboratory or a District certified contract laboratory for analysis. Values less than the minimum detection limits were reported as the method detection limit (MDL) and detection limit values were used in calculating other parameters. Laboratory MDL for phosphorus was 4 $\mu g\ L^{-1}$, except those samples analyzed by DB Environmental Lab, which reported an MDL of 2 $\mu g\ L^{-1}$ (Jorge et al., 2002).

5.2.3 Soil sampling and analysis

Intact soil cores (three replications) were taken near the inflow and near the outflow of the experimental test cells (south side of STA-1W). A visual estimation of the boundary of the recently accreted soil was be made based upon color and textural changes in the soil. The soil was sectioned based upon where this boundary exists in the soil. The soil above and below (0-10cm) this boundary was separated and homogenized into single bulk samples.

Initial soil characterization involved the pre-evaluated organic P fractionation and related soil properties. Soil organic P was fractionated into four major components: (1) readily labile (water soluble, bicarbonate, microbial); (2) moderately labile (acid hydrolyzable P); (3) moderately resistant (fulvic acid P); and (4) highly resistant (humic acid and residual organic P).

The soils was characterized for various inorganic P forms including: (1) bicarbonate extractable P_i, (2) Fe-/Al-bound P, (3) Ca-bound P, and (4) residual P. The soils were also analyzed for pH, oxalate extractable Fe and Al, extractable Ca and Mg, TC, TN, TP, TPi, bulk density and loss on ignition (ash content).

5.3 Results and Discussion

The median inflow TP concentration ranged from 21-33 $\mu g\ L^{-1}$ (Table 5.2). Outflow TP concentrations varied with values in the range of 16-22 $\mu g\ L^{-1}$ for SAV and PSTA systems. Unmanaged EAV system was not efficient in sequestering P at low inflow TP levels.

Table 5.2. *Inflow and outflow median total phosphorus concentrations for the north experimental* test cells sampled. The District Water Year (WY) extends from 1 May of a calendar year through 30 April of the subsequent year, except for STC-7 (managed wetland test cells), where start and end of experimental trials did not conform to WY breaks. Therefore, data summarized for STC-7 in WY99-00 extends from July 1999 through February 2000, and represents the baseline (no chemical addition) trial, and WY00-01 extends from March 2000 through December 2000, and represents data reflected of chemical treatment. Median values for STC-13 does not include values from the batch study or during cattail removal (1/1/00 to 4/12/00).

Sampling Site	WY99-00 (μg/L)	WY00-01 (μg/L)	WY01-02 (μg/L)
Inflow Concentration	25.0	21.0	33.0
STC-1 Outflow	32.0	33.0	44.5
STC-15 Outflow	26.0	20.0	16.0
STC-3 Outflow	21.0	21.0	No Samples
STC-8 Outflow	15.0	12.0	No Samples
STC-13 Outflow	20.0	18.0	No Samples
STC-4 Outflow	17.0	22.0	22.0
STC-9 Outflow	19.0	18.0	16.0
STC-7 Outflow	19.0	18.0	16.0

Floc depth near inflow sampling point was higher than outflow sampling point for only STC receiving inflow water treated with poly- $AlCl_3$ (Table 5.3). For other systems, floc depth ranged from 3-9 cm as compared to 12-25 cm for STC receiving inflow water treated with Al compounds. The bulk density of the floc material accreted in SAV and PSTA systems was higher than SAV systems. High mineral accumulation as a result of $CaCO_3$ precipitation probably increased the mineral content of the material. This is evidenced by lower LOI values for floc in SAV and PSTA systems, than SAV systems (Table 5.3).

Total P content of the floc near inflow and outflow sampling stations was approximately same (Table 5.4). Total P content of the floc in unmanaged STC (cattails) was significantly higher than other systems evaluated (Table 5.4). This was primarily due to removal of sub-surface P through uptake by cattails and deposition as detrital material on the surface. In addition, microbial colonization on detrital matter also resulted in accumulation of P in the floc. Pre-treatment of inflow water with $AlCl_3$ also resulted in accumulation of P in the floc. This was probably due to discharge water containing colloidal material from the reactor. High P accumulation in the floc material in PSTA-shellrock STC was due to native shellrock material consisted of high total P. The floc TP concentrations in PSTA-peat STC and SAV-STC were lower than other systems evaluated. This was due to TP content of peat or limerock substrate material was low in all systems except PSTA-shellrock.

Total inorganic P (TP_i) content estimated by single acid extraction (Reddy et al., 1998) of the floc was significantly higher in PSTA-STC than other STCs (Table 5.4). This was due to high TP levels of parent material. Approximately, one-third of TP was in TP_i pool in unmanged cattail STC, as compared to >50% of TP in inorganic pool in other systems evaluated (Table 5.4).

Table 5.3: Selected characteristics of the floc and soil/ of south test cells (NTC) in STA-1W.

Treatments	Type		Inflow						Outflow					
			Depth	BD	pH	LOI	TN	TC	Depth	BD	pH	LOI	TN	TC
			cm	g cm^{-3}		%	g kg^{-1}	g kg^{-1}	cm	g cm^{-3}		%	g kg^{-1}	g kg^{-1}
Control	Floc	Mean	6	0.028	7.6	45.5	12.1	219	7	0.032	7.6	46.1	14.2	206
		SD	2	0.012	0.0	11.1	2.4	49	2	0.018	0.1	6.4	1.7	29
PSTA-shellrock	Floc	Mean	6	0.108	7.6	22.6	7.1	143	3	0.186	7.7	21.2	5.7	127
		SD	2	0.088	0.1	3.9	2.5	33	0	0.109	0.1	6.4	2.4	38
PSTA - peat	Floc	Mean	7	0.103	7.6	25.8	7.9	180	7	0.096	7.7	25.9	9.1	168
		SD	1	0.030	0.1	2.9	0.9	8	3	0.038	0.1	0.6	1.2	4
SAV	Floc	Mean	7	0.093	7.6	25.3	7.9	152	9	0.047	7.8	37.1	12.8	200
		SD	3	0.029	0.1	3.8	2.2	32	1	0.014	0.1	5.0	2.1	29
MW-$AlCl_3$	Floc	Mean	25	0.040	7.8	48.4	11.2	210	12	0.050	7.5	36.7	11.3	199
		SD	1	0.011	0.0	7.8	1.8	26	4	0.019	0.0	5.1	2.4	23
Control	Soil	Mean	10	0.468	7.6	32.3	8.0	167	10	0.829	7.6	21.2	5.0	108
		SD	0	0.220	0.2	19.8	6.1	101	1	0.243	0.2	8.6	2.5	44
PSTA-shellrock	Soil	Mean	10	1.472	7.4	4.5	0.2	60	9	1.424	7.9	5.1	2.8	58
		SD	0	0.314	0.6	0.6	0.0	2	2	0.365	0.2	0.9	6.3	5
PSTA - peat	Soil	Mean	10	0.465	7.5	31.3	7.3	198	10	0.701	7.5	21.7	4.7	153
		SD	0	0.199	0.1	14.9	4.9	71	0	0.016	0.1	0.7	0.1	3
SAV	Soil	Mean	10	0.642	7.6	23.1	6.3	133	10	0.533	7.6	24.8	6.3	143
		SD	0	0.178	0.1	10.6	3.1	59	0	0.156	0.2	5.9	1.8	47
MW-$AlCl_3$	Soil	Mean	10	0.450	7.8	32.8	8.1	182	10	0.602	7.5	23.0	5.1	134
		SD	0	0.085	0.2	3.2	1.0	12	0	0.070	0.1	4.3	1.8	32

Table 5.4: Selected characteristics of floc and soil/substrates of south test cells of STA-1W

Test Cell	Type		Inflow			Outflow		
			TP	TPi	TPo	TP	TPi	TPo
			mg kg $^{-1}$	mg kg $^{-1}$	mg kg $^{-1}$	mg kg $^{-1}$	mg kg $^{-1}$	mg kg $^{-1}$
Control	Floc	Mean	667.6	209.8	457.8	690.4	231.8	458.5
		SD	222.9	92.3	138.2	146.1	70.9	82.2
PSTA-shellrock	Floc	Mean	501.1	371.1	130.0	613.5	509.2	104.3
		SD	113.6	118.4	43.6	164.3	166.8	39.7
PSTA - peat	Floc	Mean	385.8	221.4	164.4	428.1	243.9	184.2
		SD	84.6	37.2	47.4	103.1	49.9	56.9
SAV	Floc	Mean	338.4	138.1	200.3	551.3	233.2	318.0
		SD	107.3	30.9	78.3	88.4	55.7	44.9
MW-$AlCl_3$	Floc	Mean	514.5	254.2	260.2	542.5	239.1	303.4
		SD	58.4	18.4	42.7	169.7	69.5	103.5
Control	Soil	Mean	152.1	62.2	89.9	126.2	55.3	70.9
		SD	44.8	32.7	42.7	57.2	25.7	34.8
PSTA-shellrock	Soil	Mean	744.6	728.4	16.1	779.8	779.3	0.5
		SD	84.8	75.3	24.3	96.7	102.8	24.6
PSTA - peat	Soil	Mean	210.1	174.0	36.2	242.0	220.7	21.3
		SD	15.7	28.0	23.6	53.6	50.7	4.2
SAV	Soil	Mean	115.4	54.3	61.0	138.5	74.9	63.6
		SD	16.5	12.4	14.7	6.8	9.5	7.1
MW-$AlCl_3$	Soil	Mean	140.3	77.7	62.6	155.7	110.9	44.8
		SD	11.3	13.5	6.7	19.6	26.8	17.4

5.3.1 Inorganic P forms in floc and soil:

Soil and floc inorganic (P_i) P forms are grouped into: labile P_i; Fe- and Al-bound P; and Ca-and Mg-bound P (Fig. 5.3 – 5.4). Residual P includes P_i not extracted either by NaOH or HCl plus organic P. No significant differences were observed between floc and soils obtained from inflow and outflow stations. Because of low P loading to STC, changes in P forms were noted only in the recently accreted floc material and no changes were observed in the native substrate materials.

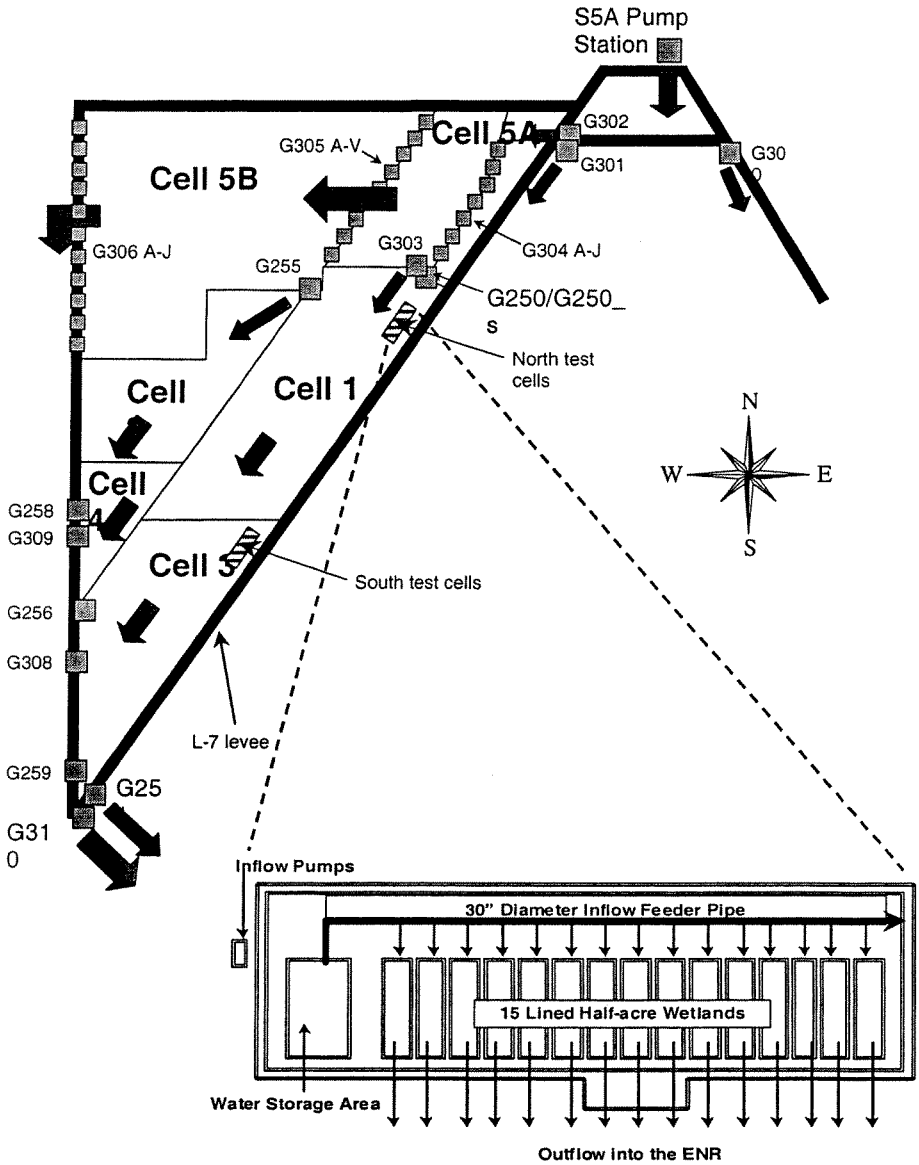

FIGURE 5.2. Map of Stormwater Treatment Area 1-West showing location of the test cells. Arrows indicate direction of flow. The old Everglades Nutrient Removal Project was comprised of Cells 1, 2, 3 and 4.

In addition to the measurement of TP on an oven dried samples, we also estimated TP by sum of all inorganic and organic pools measured by two different chemical fractionation schemes. No significant differences were observed between these two methods. The relative proportion of P forms, expressed as % of the TP were based on the TP measured independently on an oven dried samples.

Floc (recently accreted soil):

Inorganic P forms in recently accreted floc material were influenced by chemical pretreatment of inflow water and type of STC (Fig. 5.3). Labile P_i ($NaHCO_3$ extractable inorganic P) represented 1-6 % of the total P in the floc materials near inflow site, as compared to 1-7% of the total P in the floc collected from the outflow site. Low levels of labile were noted in STC receiving chemically treated water, while high levels observed in peat based PSTA-STC (Fig. 5.3 and 5.4).

At the inflow site, Fe and Al-bound P accounted for 7% of the total P in the floc of a STC receiving water pretreated with $AlCl_3$, as compared to 7% of the total P in unmanaged cattail STC, 5% in SAV wetland, and 3-5% in PSTA STCs, respectively (Fig. 5.1). These results suggest that Al had very little or no effect on P retention. This was probably due to low levels of inorganic P and lack of Al^{3+} availability in the floc at near neutral pH to react with inorganic P and complexation of Al with organic matter. Similar to NTC, P added as Al-P through colloidal material in the treated water into the wetland was probably solubilized in the floc and re-precipitated with Ca. Calcium and Mg bound P accounted for 17-69% of total P. Recovery in this pool was highest in PSTA-shellrock STC with 69% of TP, as compared to 17% of the TP in unmanaged cattail STC, 45% of the TP in PSTA-peat STC, and 33% of the TP in SAV -STC, respectively. High levels of Ca and alkaline pH are ideal for retention of inorganic P in this pool. At the outflow site, distribution of inorganic P in various pools was similar to inflow site samples (Fig. 5.4).

5.3.2 Organic P forms in floc and soil:

Organic (P_o) forms are divided into the following groups: labile P_o; microbial biomass P (MBP); fulvic acid bound P (FAP); humic acid bound P (HAP); and residual P (Fig. 5.5-5.6). Organic forms showed no significant differences between inflow and out flow. Because of low P loading to STC, changes in P forms were noted only in the recently accreted floc material and no changes were observed in the native substrate materials.

Floc (recently accreted material):

Organic P forms were influenced by wetland type and chemical pretreatment of inflow water (Fig. 5.5 and 5.6). Low levels (4% of the TP) of labile P_o including MBP were measured in the floc at inflow site of STC receiving chemically treated water as compared to SAV STC (27% of the TP), PSTA-STCs (20-25% of the TP) and unmanaged cattail STC (23% of the TP)(Fig. 5.5). High accumulation in this pool reflects P limitation result efficient sequestration of P by microbes and algae. In unmanaged cattail STC up to 22% of the TP was recovered in fulvic and humic bound P and 45% in residual fraction. This is in contrast to STC-$AlCl_3$, where 7% of the TP was recovered in fulvic and humic bound P and 38% in the residual pool. In SAV wetland, 12% of the TP was

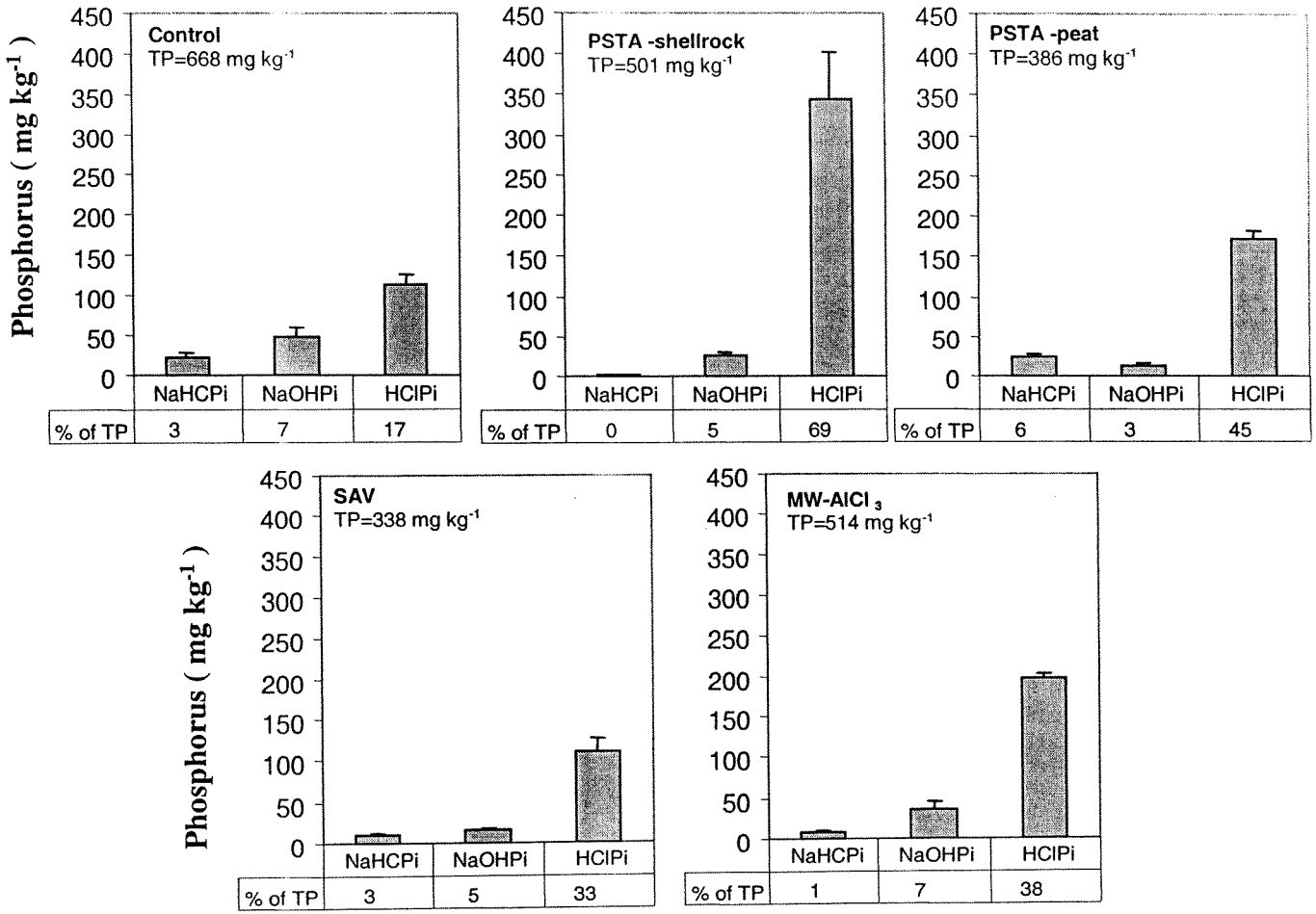

Fig 5.3. Inorganic phosphorus forms in the floc sediment (recently accreted material) at the inflow site of the south test cells. NaHCPi = Bicarbonate extractable inorganic P or labile inorganic P; NaOH Pi = Fe and Al bound P; HCL Pi = Ca and Mg bound P.

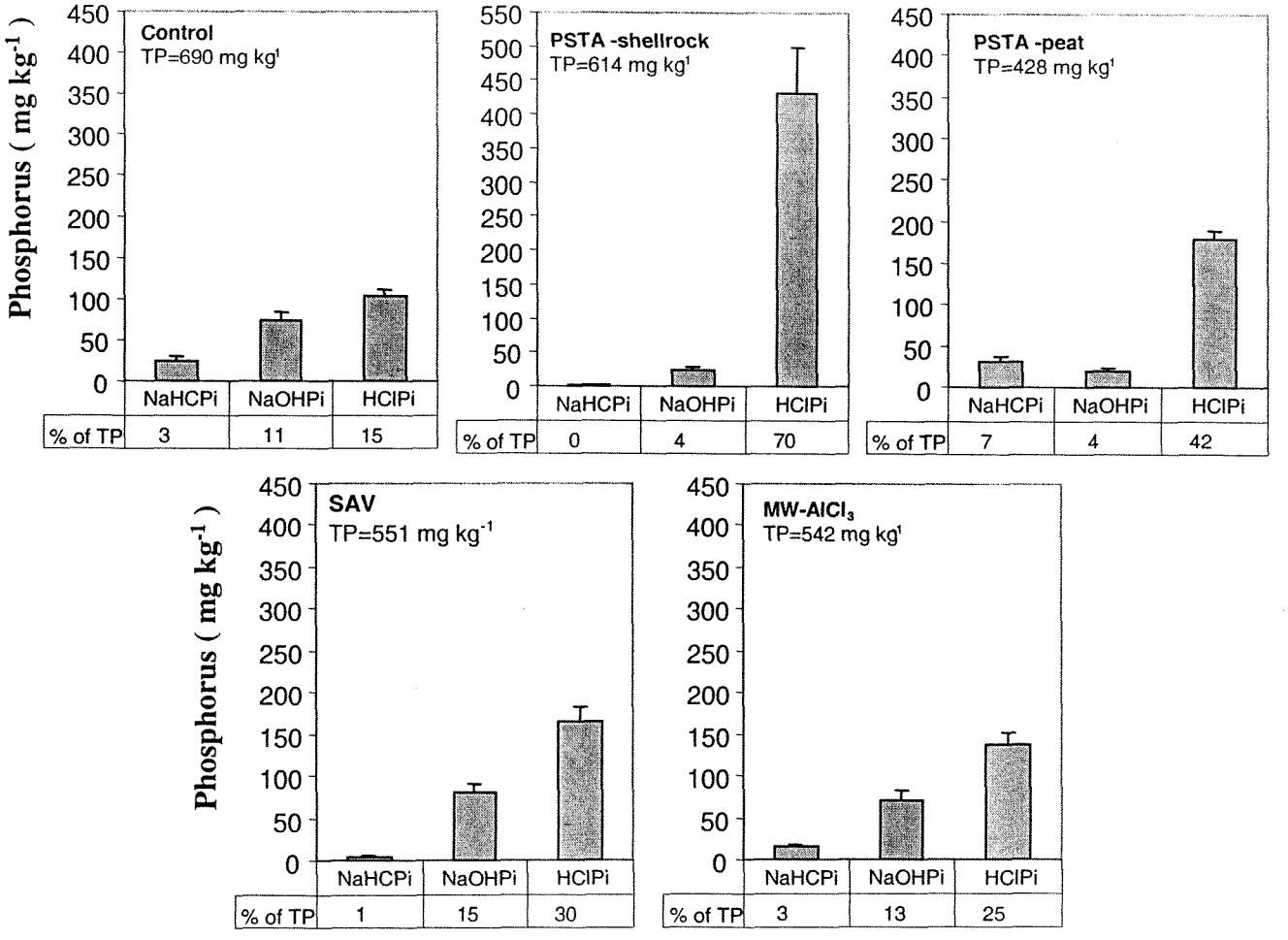

Fig 5.4. Inorganic phosphorus forms in the floc sediment (recently accreted material) at the outflow site of the south test cells. NaHCPi = Bicarbonate extractable inorganic P or labile inorganic P; NaOH Pi = Fe and Al bound P; HCL Pi = Ca and Mg bound P.

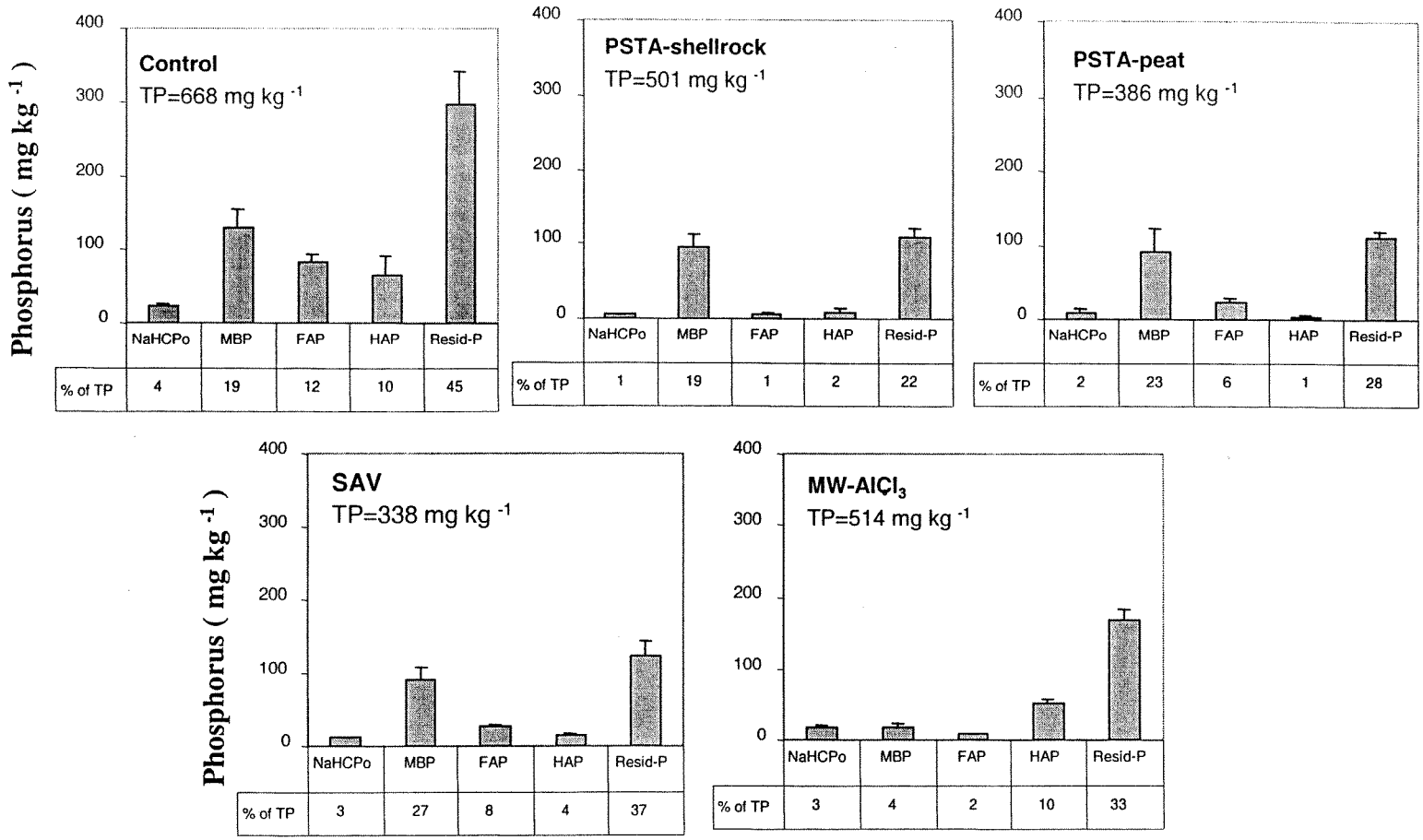

Fig 5.5. Organic phosphorus forms in the floc sediment (recently accreted material) at the inflow site of the south test cells. NaHCPo = Bicarbonate extractable organic P or labile organic P; MBP = microbial biomass P; FAP = fulvic acid bound P; HAP = humic acid bound P; Resid P =residual P or non-reactive P.

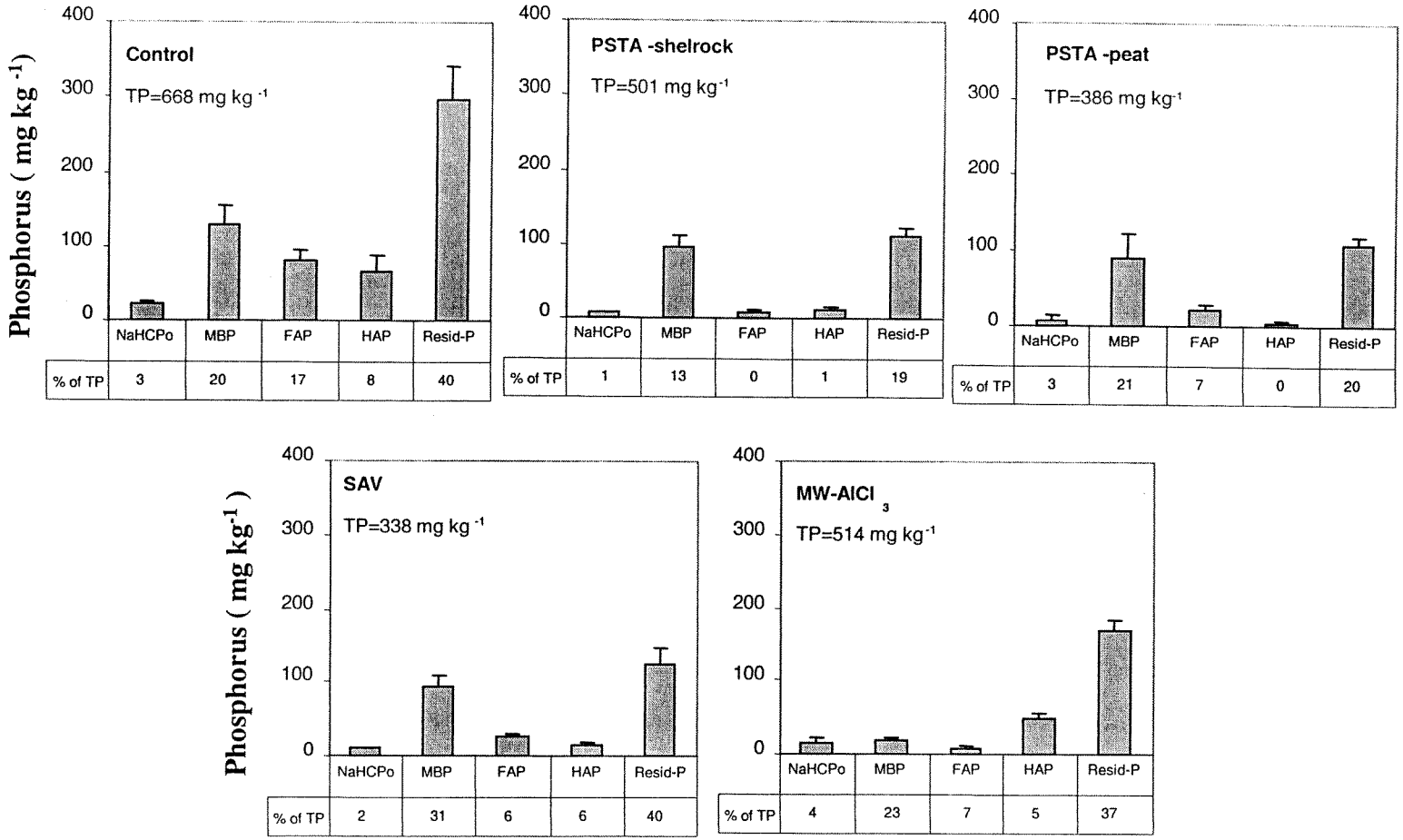

Fig 5.6. Organic phosphorus forms in the floc sediment (recently accreted material) at the outflow site of the south test cells. NaHCPo = Bicarbonate extractable organic P or labile organic P; MBP = microbial biomass P; FAP = fulvic acid bound P; HAP = humic acid bound P; Resid P =residual P or non-reactive P.

recovered in fulvic and humic bound P and 37% in the residual pool. In PSTA-STCs 3-7 % of the TP was recovered in fulvic and humic bound P and 22-28% in the residual pool.

The chemical fractionation scheme tested in this study identifies organic P in several pools including: (1) labile P (microbial biomass P), (2) acid hydrolyzable P, (3) fulvic acid bound P, (4) humic acid bound P, and (5) residual organic P. The scheme is operationally defined and was applied successfully for selected wetland soils of Florida (Ivanoff et al. 1998).

5.3.3 Extractable metals

Acid (1 M HCl) extractable metal concentrations in the recently accreted floc were influenced by chemical pretreatment of inflow water, wetland type, and underlying soil or limerock (Table 5.5 and 5.6). In the unmanaged cattail-STC, PSTA-STCs and SAV -STC, dominant metals were Ca and Mg, and relatively low levels of Al, and Fe. In MW-$AlCl_3$ wetland, floc contained elevated levels of Al with concentrations of up to 4.9%, suggesting that the some of the colloidal material from chemical reactors was discharged into the STC. The floc material in SAV and PSTA STCs contained up to 24% Ca. This was expected considering the underlying limerock or shell rock substrate (one of the sources of Ca to floc) and high $CaCO_3$ precipitation mediated by periphyton and SAV.

5.3.4 Phosphorus storage:

Phosphorus storage in the floc and underlying soil was influenced pretreatment of water, wetland type, and soil or limerock substrate (Table 5.7). In the floc material, high P storage was the result of high rate of floc accumulation. The MW-$AlCl_3$ wetlands had largest amount of floc accumulation at the inflow site, resulting in high P storage (3 to 5 g P m^{-2}), as compared to 2.1 to 2.6 g P m^{-2} in SAV and PSTA STCs (Table 5.7). Phosphorus storage ratio between inflow and outflow ranged from 0.69 to 1.6, with low ratios observed in PSTA-shellrock STC and high ratio observed in $AlCl_3$ - STC. These results showed that pretreatment of inflow water with $AlCl_3$ enhanced the accumulation of P in the floc. Phosphorus storage in the underlying soil or limerock reflects initial conditions.

5.4 Conclusions

In this study recently accreted floc and the underlying peat soil or limerock/shellrock samples were sequentially extracted with selected chemicals to determine inorganic and organic P pools. The inorganic P extracted with salt such as $NaHCO_3$ represents loosely absorbed P, which accounted for 1 to 7% of the total P. This pool of P is considered bioavailable as it is sufficiently labile to enter soil porewater for uptake by plants or potential flux into overlying water column. The NaOH-P_i represents inorganic P associated with Fe and Al (included occluded P), and represents P not readily available. This pool is not a dominant factor except in STCs receiving chemically ($AlCl_3$) treated water. The HCl-P_i represents P associated Ca/Mg, is relatively stable and not readily available. Alkali extractable organic P includes both readily available organic P (microbial biomass P) and slowly available organic P (P associated with fulvic and humic acids). Residual P represents highly resistant organic P or unavailable mineral bound P

Table 5.5: Extractable Metals of of floc and soil/substrates of south test cells of STA-1W.

Test Cell	Type		HCl-Ca mg kg $^{-1}$	HCl-Mg mg kg $^{-1}$	HCl-Fe mg kg $^{-1}$	HCl-Al mg kg $^{-1}$	Ox-Fe mg kg $^{-1}$	Ox-Al mg kg $^{-1}$
---------- Inflow ----------								
Control	Floc	Mean	103,525	3,639	608	2,441	640	1,224
		SD	35,413	996	237	997	286	549
PSTA-shellrock	Floc	Mean	217,903	4,186	1,254	619	1,349	307
		SD	44,601	1,701	1,101	537	1,292	306
PSTA - peat	Floc	Mean	247,347	6,838	279	529	168	291
		SD	29,300	1,618	116	252	91	177
SAV	Floc	Mean	200,439	5,905	193	484	150	232
		SD	65,095	1,976	14	131	42	78
MW-$AlCl_3$	Floc	Mean	117,874	3,597	175	49,497	101	50,807
		SD	24,452	363	21	8,388	13	12,311
---------- Outflow ----------								
Control	Floc	Mean	74,627	2,615	758	2,743	758	1,708
		SD	12,709	121	132	775	131	483
PSTA-shellrock	Floc	Mean	193,239	3,352	1,288	669	1,356	322
		SD	44,049	1,189	802	319	1,009	231
PSTA - peat	Floc	Mean	235,055	5,997	352	509	225	242
		SD	10,156	847	63	66	68	55
SAV	Floc	Mean	180,584	8,711	266	624	257	347
		SD	36,559	3,907	36	266	36	163
MW-$AlCl_3$	Floc	Mean	158,002	4,114	264	1,999	232	1,958
		SD	19,809	936	67	827	42	974

Table 5.6: Extractable Metals of soil/substrates of south test cells of STA-1W.

Test Cell	Type		HCl-Ca mg kg $^{-1}$	HCl-Mg mg kg $^{-1}$	HCl-Fe mg kg $^{-1}$	HCl-Al mg kg $^{-1}$	Ox-Fe mg kg $^{-1}$	Ox-Al mg kg $^{-1}$
				Inflow				
Control	Soil	Mean	73,789	1,962	608	973	676	762
		SD	36,886	572	228	137	276	126
PSTA-shellrock	Soil	Mean	201,110	1,368	1,064	360	1,144	233
		SD	6,549	191	333	16	435	9
PSTA - peat	Soil	Mean	220,671	3,250	640	532	671	456
		SD	58,896	485	85	81	53	89
SAV	Soil	Mean	71,380	1,466	426	700	469	559
		SD	16,716	440	111	230	172	158
MW-$AlCl_3$	Soil	Mean	108,841	2,369	597	885	723	827
		SD	9,742	335	40	316	36	323
				Outflow				
Control	Soil	Mean	69,911	1,288	624	1,036	686	818
		SD	21,197	288	329	337	366	196
PSTA-shellrock	Soil	Mean	193,488	1,210	912	474	944	310
		SD	17,440	166	144	145	186	90
PSTA - peat	Soil	Mean	243,869	3,152	717	563	681	465
		SD	1,588	115	58	43	61	33
SAV	Soil	Mean	113,720	1,994	419	645	415	549
		SD	53,222	616	80	245	76	149
MW-$AlCl_3$	Soil	Mean	145,471	2,389	665	604	681	524
		SD	25,339	212	139	100	129	87

Table 5.7. Phosphorus in floc and soil/substrates of south test cells of STA-1W.l

Test Cell	Type		TP Storage Inflow mg m^{-2}	TP Storage Outflow mg m^{-2}
Control	Floc			
		Mean	1076	1066
		SD	656	736
PSTA-shellrock	Floc			
		Mean	2659	3853
		SD	1896	2961
PSTA - peat	Floc			
		Mean	2765	2666
		SD	199	1047
SAV	Floc			
		Mean	2125	2191
		SD	1048	620
MW-$AlCl_3$	Floc			
		Mean	4917	3099
		SD	815	1128
Control	Soil			
		Mean	6928	9246
		SD	3466	2362
PSTA-shellrock	Soil			
		Mean	102653	106887
		SD	23988	40054
PSTA - peat	Soil			
		Mean	9741	17017
		SD	4253	4172
SAV	Soil			
		Mean	7243	7305
		SD	1439	1869
MW-$AlCl_3$	Soil			
		Mean	6369	9349
		SD	1650	1387

not extracted either with alkali or acid. Long-term storage of P in recently accreted soil or floc of STAs is governed by the stability of Ca- and Mg- bound and organic matter.

The SAV and PSTA STCs were efficient in sequestering P, with approximately 41 to 74% as inorganic P and most of this is present as Ca and Mg bound P. The inorganic P sequestered by unmanaged cattail STC is in the range of 27 to 29% of the total P. Chemical treatment of inflow water increased inorganic P sequestration in the floc materials. Availability of inorganic P in these systems can be characterized as follows: labile P_i – readily available; Fe- and Al-bound P – moderately available, and Ca- and Mg-bound P – slowly available. Availability of organic P can be characterized as follows: labile P_o including microbial biomass P – readily available, fulvic acid bound P – moderately available, humic acid bound P – slowly available, and residual P – not available (permanent storage). Results suggest that SAV and PSTA STCc are accreting P at a rapid rate than unmanaged cattail STC. Long-term sustainability of SAV and PSTA based systems in sequestering P needs further evaluation.

6.0 Influence of flooding and drying on P stability in newly accreted soil using chemical extraction methods.

6.1.1 Introduction

Water level fluctuations in wetlands can result in alternating flooded and drained conditions in the soil. In STAs water level drawdown and soil drainage are potential management techniques that can be used to consolidate detrital floc material, accelerate soil build up, and provide easy access for other maintenance operations. Chemical constituents in soils occur in a variety of forms and water level draw down can markedly influence the stability of accreted P. The objective of this study was to determine the influence of water level drawdown and consolidation of recently accreted material on P stability in experimental STAs (test cells) used to evaluate various wetland technologies.

6.2 Materials and Methods

Inorganic and organic P fractionation schemes were used to determine discrete pools of inorganic and organic P in floc and soils/substrates colleted from various test cells currently used to evaluate several wetland technologies to remove P from agricultural drainage effluents. Intact soil cores (three replications) were taken near the inflow and near the outflow of the experimental test cells located north and south side of STA-1W. A visual estimation of the boundary of the recently accreted soil was made based upon color and textural changes in the soil. The soil was sectioned based upon where this boundary exists in the soil. The soil above and below this boundary was separated and homogenized into single bulk samples.

One batch of samples was analyzed under ambient moisture (saturated) conditions for inorganic and organic P forms as described in sections 4.0 and 5.0. A second batch of samples was subjected to air-drying to simulated water level drawdown conditions. Samples were dried for a period of 30 days at room temperature (25 C) under laboratory conditions. All dried samples were analyzed for inorganic and organic P forms as described in sections 4.0 and 5.0.

Phosphorus forms measured in floc and soil/substrate under wet conditions represent flooded conditions typically encountered in STAs, while P forms determined on air-dried floc and soil/substrate samples represent conditions of water draw down in STAs. A "t" test was performed between wet and air-dried samples to test the significance in changes in labile and non-labile pools of inorganic and organic P.

6.3 Results and Discussion

North Test Cells – High Phosphorus Loading:

Inorganic and organic P fractionation schemes were used to determine the changes in discrete pools of P in floc and soil/substrate samples collected from various north test cells loaded with high influent TP concentration. Air-dry conditions of the floc significantly increased labile inorganic P and Fe an Al- bound P (Table 6.1). Increase in labile P under dry-down conditions was due to enhanced mineralization of organic P. Decrease in Ca and Mg-bound P was probably due to the decrease in pH resulting from aerobic conditions.

Table 6.1 Comparison of P forms at soil wet and air dry condition

	North Cell Floc			North Cell Soil		
P form	Wet	Air Dry	t-Test Prob.	Wet	Air Dry	t-Test Prob.
	n=36 mg kg^{-1}	n=32 mg kg^{-1}		n=36 mg kg^{-1}	n=36 mg kg^{-1}	
Inorganic PFRAC						
NaHCPi	48.9	74.9	0.036	14.2	16.1	NS
NaOHPi	67.1	29.9	0.0015	9.7	11.3	NS
0.5HClPi	214.8	191.1	NS	68	65.3	NS
SumTPi	330.8	295.9	NS	92	92.7	NS
NaHCPo	21	18.3	NS	5.8	3.4	0.007
NaOHPo	80.5	80.7	NS	20.3	26	0.035
Resid-P	208.3	152.3	NS	91.7	107.8	NS
Sum-TPo	309.8	251.8	0.0047	117.8	137.3	NS
Sum-TP	640.6	547.7		209.8	230	
Organic PFRAC						
NaHCPi	48.9	74.9	0.036	14.2	16.1	NS
HClPi	235	177.8	NS	76.7	81.4	NS
SumTPi	283.7	252.7	NS	90.9	97.5	NS
NaHCPo	21	18.3	NS	5.8	3.4	0.007
MBP	97.8	14.5	<0.0001	16.5	2.4	<0.0001
FAP	59.4	89.7	0.0003	26.9	38.1	0.007
HAP	41.7	66	0.0009	26.6	21	NS
Resid-P	163.9	151.7	NS	62.2	70.1	NS
Sum-TPo	383.9	340.8	NS	138	135	NS
Sum-TP	667.6	593.5		228.9	232.5	
TP ashing	666	666		233.2	233.2	

Labile organic P and microbial biomass levels decreased upon dry-down (Table 6-1). Microbial biomass P decreased by 85% upon dry-down of floc sediments. This is probably due to mineralization of organic P. Dry-down also resulted in incorporation of labile organic P pools into fulvic and humic acid fractions. Upon dry-down, the P associated with fulvic and humic acids increased by 50% (Table 6-1) in the floc. This suggests that dry-drawn of floc sediments may aid in stabilizing labile organic P pools, and potentially decrease P flux into overlying water column upon reflooding.

Drying of underlying soil or substrate resulted in minimal changes in P forms. Drying significantly decreased labile organic P pools in soils/substrates (Table 6-1). Drying of soil/substrate samples decreased microbial biomass P by 85%, and increased fulvic acid P by 42% (Table 6-1). However, a decrease (21%) humic acid bound P was noted in dried samples. This decrease was reflected in an increase in stable residual organic P.

South Test Cells – Low Phosphorus Loading:

Dry-down of floc sediments resulted in similar changes as those observed in floc samples collected from north test cells. Dry-down significantly decreased labile organic P, and microbial biomass P (Table 6-2). The microbial biomass decreased by 74%, while fulvic and humic acid P increased by 100 and 59%, respectively (Table 6-2). Changes in underlying soil/substrates were noted only labile inorganic P (increase by 16%), microbial biomass P (decrease by 98%), and labile organic P (increase by 188%) (Table 6-2).

Both soil P fractionation schemes adequately represented changes in discrete P pools resulting form drying. Mass balance showed that total P estimated by assessing all discrete pools of P (measured by both P fractionation schemes) was in close agreement with total P measured on independent samples (Fig. 6-3). Similarly, total inorganic P was in close agreement with total inorganic P measured on independent samples (Fig. 6-4). These results suggest that independent measurement of TP or TPi is not necessary when samples are subject to operationally defined chemical fractionation schemes to identify discrete P pools.

6.4 Conclusions

Dry-down of floc sediments in experimental test cells, used to evaluate various wetland technologies may aid in stabilizing labile organic pools. Dry-down increased labile inorganic P, which can be potentially released into water column upon reflooding. However, benefits of P stabilization and enhanced long-term storage, as a result of dry-down can be much greater than short-term P flux into overlying water column upon reflooding. Stability of P stored in the floc under alternate wet-dry cycles needs further evaluation.

Table 6.2 Comparison of P forms at soil wet and air dry condition

	South Cell Floc			South Cell Soil		
P Forms	Wet	Air Dry	t-Test Prob.	Wet	Air Dry	t-Test Prob.
	n=47 mg kg^{-1}	n=40 mg kg^{-1}		n=48 mg kg^{-1}	n=48 mg kg^{-1}	
Inorganic PFRAC						
NaHCPi	12	37.9	<0.0001	6.8	7.7	NS
NaOHPi	41.7	24.9	0.0036	4.7	3.2	0.0004
0.5HClPi	203.7	174.4	NS	273.3	238.7	NS
SumTPi	257.4	237.3	NS	284.8	249.6	NS
NaHCPo	13.6	20.1	0.0032	0.9	2.6	<0.0001
NaOHPo	65.2	65	NS	9	7.8	NS
Resid-P	178.4	176	NS	38.3	40.6	NS
Sum-TPo	257.2	261.1	NS	48.1	51	NS
Sum-TP	514.6	498.4		332.9	300.6	
Organic PFRAC						
NaHCPi	12	37.9	<0.0001	6.8	7.7	NS
HClPi	196.7	160.6	NS	272.1	269	NS
SumTPi	208.8	198.5	NS	278.9	276.7	NS
NaHCPo	13.6	20.1	0.0032	0.9	2.6	<0.0001
MBP	107.7	27.9	<0.0001	5.1	0.1	<0.0001
FAP	37.6	76	<0.0001	7.5	10.7	NS
HAP	26.8	42.6	0.025	5.2	3.3	NS
Resid-P	179.1	153.6	NS	43.5	45.7	NS
Sum-TPo	363	320.3	NS	61.8	62.4	NS
Sum-TP	571.8	518.8		340.7	339.1	
TP ashing	533.9	533.9		303.8	303.8	

7.0 Literature Cited

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8.0 Appendix Tables

Appendix 1: Selected characteristics of the floc sampled from Test Cells in October 2001.

Treatments	Cell #	Location	Rep	Type	Lab #	Depth	Moisture content	Bulk Density	pH	LOI	TN	TC
						cm	%	g cm^{-3}		%	g kg^{-1}	g kg^{-1}
SAV	1N	inflow	A	Floc	1	13	73.7	0.077	8.0	29.5	8.7	190.7
SAV	1N	inflow	B	Floc	2	15	78.6	0.085	7.9	42.9	13.7	237.7
SAV	1N	inflow	C	Floc	3	15	75.5	0.084	7.9	32.8	8.9	204.0
SAV	1N	outflow	A	Floc	4	16	82.6	0.072	7.9	49.1	12.7	260.5
SAV	1N	outflow	B	Floc	5	14	76.1	0.068	7.5	26.8	9.0	195.4
SAV	1N	outflow	C	Floc	6	10	80.2	0.088	7.3	36.2	11.8	232.9
MW-FeCl	2N	inflow	A	Floc	7	6	86.5	0.024	7.2	59.6	16.7	298.7
MW-FeCl	2N	inflow	B	Floc	8	5	90.3	0.016	7.2	69.3	19.7	349.4
MW-FeCl	2N	inflow	C	Floc	9	6	87.8	0.039	7.2	66.3	19.2	322.6
MW-FeCl	2N	outflow	A	Floc	10	10	84.7	0.084	7.7	71.3	18.8	362.9
MW-FeCl	2N	outflow	B	Floc	11	10	85.0	0.045	7.6	69.0	16.2	349.9
MW-FeCl	2N	outflow	C	Floc	12	5	88.5	0.038	7.4	62.6	17.1	314.4
MW-AlCl	4N	inflow	A	Floc	13	30	94.5	0.020	7.4	57.2	10.3	193.9
MW-AlCl	4N	inflow	B	Floc	14	36	95.1	0.022	7.1	55.8	14.7	198.0
MW-AlCl	4N	inflow	C	Floc	15	31	94.7	0.022	7.3	54.4	15.2	199.5
MW-AlCl	4N	outflow	A	Floc	16	7	82.4	0.055	7.4	60.5	14.7	304.8
MW-AlCl	4N	outflow	B	Floc	17	10	80.3	0.062	7.4	48.2	11.3	246.7
MW-AlCl	4N	outflow	C	Floc	18	8	82.3	0.059	7.4	57.0	13.2	280.4
Control	5N	inflow	A	Floc	19	13	83.5	0.049	7.4	60.0	16.2	320.3
Control	5N	inflow	B	Floc	20	8	79.5	0.034	7.5	29.4	9.6	174.0
Control	5N	inflow	C	Floc	21	11	84.7	0.033	7.4	41.7	10.9	224.5
Control	5N	outflow	A	Floc	22	4	85.9	0.046	7.6	56.5	15.6	280.1
Control	5N	outflow	B	Floc	23	8	88.7	0.027	7.5	71.4	18.8	360.7
Control	5N	outflow	C	Floc	24	5	89.1	0.030	7.7	49.5	16.6	282.6
Control	10N	inflow	A	Floc	25	5	85.4	0.063	7.5	55.6	14.5	299.7
Control	10N	inflow	B	Floc	26	12	87.7	0.026	7.5	53.1	13.9	271.6
Control	10N	inflow	C	Floc	27	10	85.5	0.021	7.4	44.8	14.4	233.0
Control	10N	outflow	A	Floc	28	5	82.8	0.051	7.6	41.9	10.0	225.8
Control	10N	outflow	B	Floc	29	5.5	77.1	0.076	7.5	40.8	10.2	223.3
Control	10N	outflow	C	Floc	30	4	81.1	0.052	7.6	41.4	11.0	207.8
SAV	15N	inflow	A	Floc	31	24	78.7	0.039	7.4	24.8	9.0	183.8
SAV	15N	inflow	B	Floc	32	26	78.2	0.049	7.7	23.7	9.6	181.3
SAV	15N	inflow	C	Floc	33	22	76.0	0.059	7.7	25.6	8.3	175.9
SAV	15N	outflow	A	Floc	34	17	83.5	0.036	7.3	39.6	13.8	231.9
SAV	15N	outflow	B	Floc	35	14	84.3	0.045	7.5	39.2	11.3	232.7
SAV	15N	outflow	C	Floc	36	13	86.4	0.042	7.4	48.0	15.3	264.2
Control	1S	inflow	A	Floc	37	8	86.3	0.029	7.6	53.2	12.6	244.4
Control	1S	inflow	B	Floc	38	4	80.7	0.023		44.0	13.0	207.8
Control	1S	inflow	C	Floc	39	9	93.1	0.012	7.6	62.9	15.8	300.2
Control	1S	outflow	A	Floc	40	7	81.0	0.043	7.4	51.5	14.0	229.0
Control	1S	outflow	B	Floc	41	4	86.0	0.060	7.6	51.8	12.9	230.2
Control	1S	outflow	C	Floc	42	5	88.2	0.019	7.5	48.3	15.5	214.6
SAV	4S	inflow	A	Floc	43	9	55.6	0.143	7.5	18.9	3.6	87.6
SAV	4S	inflow	B	Floc	44	4.5	73.7	0.104	7.6	27.1	8.2	158.8

Appendix 1: Selected characteristics of the floc sampled from Test Cells in October 2001.

Treatments	Cell #	Location	Rep	Type	Lab #	Depth	Moisture content	Bulk Density	pH	LOI	TN	TC
						cm	%	g cm^{-3}		%	g kg^{-1}	g kg^{-1}
SAV	4S	inflow	C	Floc	45	2	77.5	0.078	7.7	29.3	8.1	162.2
SAV	4S	outflow	A	Floc	46	6	81.8	0.038	7.7	37.4	12.6	198.2
SAV	4S	outflow	B	Floc	47	9.5	73.2	0.070	7.8	29.6	9.3	150.3
SAV	4S	outflow	C	Floc	48	9	82.9	0.030	7.9	32.4	11.8	183.5
MW-AlCl	7S	inflow	A	Floc	49	24	92.1	0.033	7.7	54.8	12.8	220.0
MW-AlCl	7S	inflow	B	Floc	50	26	89.0	0.033	7.8	50.7	11.6	228.4
MW-AlCl	7S	inflow	C	Floc	51	24	85.7	0.052	7.8	39.6	9.3	180.3
MW-AlCl	7S	outflow	A	Floc	52	10	87.4	0.029	7.6	40.0	13.6	214.6
MW-AlCl	7S	outflow	B	Floc	53	17	76.0	0.066	7.5	30.7	8.8	173.4
MW-AlCl	7S	outflow	C	Floc	54	10	79.7	0.056	7.5	39.2	11.5	209.6
Control	15S	inflow	A	Floc	55	8	79.3	0.040	7.6	33.3	9.7	160.8
Control	15S	inflow	B	Floc	56	4	74.4	0.042		35.5	9.1	180.4
Control	15S	inflow	C	Floc	57	3.5	84.1	0.022		44.0	12.3	219.0
Control	15S	outflow	A	Floc	58	16	82.0	0.021	7.6	37.1	12.4	161.1
Control	15S	outflow	B	Floc	59	8	87.4	0.018	7.6	41.7	16.3	193.9
Control	15S	outflow	C	Floc	60	9	41.2		7.8	6.2	1.3	27.3
PSTA-shelrock	3S	inflow	A	Floc	61	4	64.5	0.160	7.6	15.3	4.1	100.9
PSTA-shelrock	3S	inflow	B	Floc	62	4	71.3	0.100	7.6	23.9	5.5	126.3
PSTA-shelrock	3S	inflow	C	Floc	63	4	64.9	0.259	7.5	22.2	5.4	120.6
PSTA-shelrock	3S	outflow	A	Floc	64	3	57.9	0.269	7.6	14.6	2.9	90.4
PSTA-shelrock	3S	outflow	B	Floc	65	3	54.2	0.238	7.6	13.7	3.0	80.1
PSTA-shelrock	3S	outflow	C	Floc	66	3	67.5	0.336	7.6	20.0	5.7	112.4
PSTA-shelrock	8S	inflow	A	Floc	67	6	84.8	0.046	7.6	24.7	9.8	181.7
PSTA-shelrock	8S	inflow	B	Floc	68	8	79.5	0.041	7.7	22.8	7.6	150.4
PSTA-shelrock	8S	inflow	C	Floc	69	8	82.3	0.038	7.7	26.7	10.0	179.9
PSTA-shelrock	8S	outflow	A	Floc	70	3	80.4	0.079	7.7	30.1	8.7	173.6
PSTA-shelrock	8S	outflow	B	Floc	71	3	77.7	0.097	7.7	25.4	7.0	151.0
PSTA-shelrock	8S	outflow	C	Floc	72	3	79.0	0.099	7.7	23.2	7.1	153.3
SAV	9S	inflow	A	Floc	73	7	73.3	0.097	7.7	23.2	8.5	158.6
SAV	9S	inflow	B	Floc	74	11	76.4	0.076	7.6	25.1	9.2	168.5
SAV	9S	inflow	C	Floc	75	9.5	77.7	0.062	7.6	28.2	9.7	176.7
SAV	9S	outflow	A	Floc	76	9	81.4	0.053	7.9	41.1	13.3	220.9
SAV	9S	outflow	B	Floc	77	9	83.9	0.050	7.7	41.4	14.6	223.0
SAV	9S	outflow	C	Floc	78	9	86.0	0.043	7.7	40.7	14.9	224.3
PSTA - peat	13S	inflow	A	Floc	79	6	70.5	0.119	7.5	26.8	7.1	177.3
PSTA - peat	13S	inflow	B	Floc	80	8	67.6	0.123	7.6	28.1	7.8	188.2
PSTA - peat	13S	inflow	C	Floc	81	8	74.4	0.069	7.8	22.5	8.9	173.4
PSTA - peat	13S	outflow	A	Floc	82	4	70.8	0.140	7.7	25.8	7.9	165.8
PSTA - peat	13S	outflow	B	Floc	83	8	73.2	0.069	7.6	26.6	9.1	165.5
PSTA - peat	13S	outflow	C	Floc	84	9	73.1	0.080	7.7	25.4	10.4	171.8

Appendix 2: Selected characteristics of the soil (0-10 cm) sampled from Test Cells in October 2001.												
Treatments	Cell #	Location	Rep	Type	Lab #	Depth	Moisture content	Bulk Density	pH	LOI	TN	TC
						cm	%	g cm^{-3}		%	g kg^{-1}	g kg^{-1}
SAV	1N	inflow	A	Soil	85	0-10	81.9	0.161	7.6	56.3	16.8	308.0
SAV	1N	inflow	B	Soil	86	0-10	77.8	0.287	7.4	42.3	11.1	251.7
SAV	1N	inflow	C	Soil	87	0-10	85.0	0.140	7.4	62.3	19.7	344.9
SAV	1N	outflow	A	Soil	88	0-10	87.5	0.120	7.5	75.1	22.0	403.8
SAV	1N	outflow	B	Soil	89	0-10	87.3	0.156	7.4	65.7	18.8	354.2
SAV	1N	outflow	C	Soil	90	0-10	85.1	0.207	7.5	68.8	20.1	381.5
MW-FeCl	2N	inflow	A	Soil	91	0-10	83.9	0.152	7.4	47.0	14.4	281.0
MW-FeCl	2N	inflow	B	Soil	92	0-10	92.1	0.052	7.4	79.7	25.4	425.5
MW-FeCl	2N	inflow	C	Soil	93	0-10	88.0	0.115	7.4	62.9	19.6	336.0
MW-FeCl	2N	outflow	A	Soil	94	0-10	80.1	0.206	7.6	53.1	15.2	298.5
MW-FeCl	2N	outflow	B	Soil	95	0-8	84.2	0.116	7.8	63.5	18.5	351.5
MW-FeCl	2N	outflow	C	Soil	96	0-10	84.4	0.143	7.6	63.5	17.5	336.6
MW-AlCl	4N	inflow	A	Soil	97	0-10	81.7	0.212	7.4	48.3	11.6	253.5
MW-AlCl	4N	inflow	B	Soil	98	0-10	86.9	0.127	7.5	58.3	16.1	306.8
MW-AlCl	4N	inflow	C	Soil	99	0-10	87.4	0.135	7.4	71.0	20.5	374.3
MW-AlCl	4N	outflow	A	Soil	100	0-10	87.8	0.119	7.4	75.0	22.1	397.2
MW-AlCl	4N	outflow	B	Soil	101	0-10	85.0	0.147	7.5	59.5	15.4	313.2
MW-AlCl	4N	outflow	C	Soil	102	0-10	84.8	0.161	7.7	71.9	19.7	372.4
Control	5N	inflow	A	Soil	103	0-10	88.7	0.115	7.5	67.8	19.0	354.3
Control	5N	inflow	B	Soil	104	0-10	87.6	0.135	7.4	69.0	19.3	370.8
Control	5N	inflow	C	Soil	105	0-10	84.5	0.176	7.6	71.6	19.4	373.3
Control	5N	outflow	A	Soil	106	0-10	84.8	0.158	7.7	68.3	19.9	372.5
Control	5N	outflow	B	Soil	107	0-10	86.0	0.150	7.5	69.6	20.1	380.1
Control	5N	outflow	C	Soil	108	0-10	84.8	0.157	7.6	65.3	18.2	347.5
Control	10N	inflow	A	Soil	109	0-10	87.1	0.128	7.5	68.25	18.5	365.9
Control	10N	inflow	B	Soil	110	0-10	82.5	0.180	7.4	61.54	17.1	340.0
Control	10N	inflow	C	Soil	111	0-10	79.6	0.247	7.6	46.38	11.4	262.0
Control	10N	outflow	A	Soil	112	0-10	69.2	0.382	7.8	36.89	7.4	222.5
Control	10N	outflow	B	Soil	113	0-10	74.0	0.270	7.6	44.02	10.8	257.9
Control	10N	outflow	C	Soil	114	0-10	74.7	0.282	7.7	40.10	9.3	236.4
SAV	15N	inflow	A	Soil	115	0-10	61.3	0.460	7.5	23.56	5.6	121.0
SAV	15N	inflow	B	Soil	116	0-10	65.3	0.430	7.4	26.19	6.7	142.4
SAV	15N	inflow	C	Soil	117	0-10	63.5	0.470	7.3	23.90	5.9	130.0
SAV	15N	outflow	A	Soil	118	0-10	71.4	0.317	7.6	41.00	12.5	216.8
SAV	15N	outflow	B	Soil	119	0-10	73.9	0.268	7.3	41.06	11.1	210.5
SAV	15N	outflow	C	Soil	120	0-10	76.3	0.253	7.4	40.10	11.1	207.8
Control	1S	inflow	A	Soil	121	0-10	40.9	0.789	7.8	15.05	2.8	77.5
Control	1S	inflow	B	Soil	122	0-10	52.6	0.569	7.7	20.00	4.6	109.8
Control	1S	inflow	C	Soil	123	0-10	57.5	0.582	7.5	19.80	4.0	110.0
Control	1S	outflow	A	Soil	124	0-10	57.5	0.489	7.5	26.63	5.9	121.2
Control	1S	outflow	B	Soil	125	0-10	46.2	0.782	7.9	23.11	5.7	118.0
Control	1S	outflow	C	Soil	126	0-10	35.4	1.197	7.7	11.57	2.1	54.3
SAV	4S	inflow	A	Soil	127	0-10	47.2	0.767	7.7	14.49	3.4	85.2

Appendix 2: Selected characteristics of the soil (0-10 cm) sampled from Test Cells in October 2001.

Treatments	Cell #	Location	Rep	Type	Lab #	Depth	Moisture content	Bulk Density	pH	LOI	TN	TC
						cm	%	g cm^{-3}		%	g kg^{-1}	g kg^{-1}
SAV	4S	inflow	B	Soil	128	0-10	43.1	0.880	7.6	11.17	3.2	67.0
SAV	4S	inflow	C	Soil	129	0-10	51.9	0.695	7.6	16.59	4.3	91.9
SAV	4S	outflow	A	Soil	130	0-10	55.2	0.661	7.7	19.90	4.9	98.9
SAV	4S	outflow	B	Soil	131	0-10	54.1	0.633	7.7	19.14	4.7	103.4
SAV	4S	outflow	C	Soil	132	0-10	46.0	0.724	7.9	19.42	4.6	98.4
MW-AlCl	7S	inflow	A	Soil	133	0-10	62.4	0.386	7.9	29.85	7.1	169.0
MW-AlCl	7S	inflow	B	Soil	134	0-10	66.4	0.418	7.5	36.14	9.0	190.3
MW-AlCl	7S	inflow	C	Soil	135	0-10	61.1	0.547	7.9	32.51	8.2	187.3
MW-AlCl	7S	outflow	A	Soil	136	0-10	58.0	0.583	7.4	22.12	5.2	130.0
MW-AlCl	7S	outflow	B	Soil	137	0-10	48.7	0.679	7.5	19.14	3.4	103.5
MW-AlCl	7S	outflow	C	Soil	138	0-10	56.3	0.543	7.7	27.67	6.9	167.0
Control	15S	inflow	A	Soil	139	0-10	82.5	0.196	7.4	64.14	18.3	334.5
Control	15S	inflow	B	Soil	140	0-10	78.1	0.274	7.5	49.26	12.4	248.3
Control	15S	inflow	C	Soil	141	0-10	62.6	0.401	7.8	25.37	5.8	124.5
Control	15S	outflow	A	Soil	142	0-10	41.0	0.997	7.6	12.24	2.6	62.5
Control	15S	outflow	B	Soil	143	0-10	49.5	0.726	7.6	19.81	4.4	115.8
Control	15S	outflow	C	Soil	144	0-8	58.0	0.784	7.7	33.80	9.0	173.5
PSTA-shelrock	3S	inflow	A	Soil	145	0-10	18.1	1.554	6.7	5.39	0.2	58.1
PSTA-shelrock	3S	inflow	B	Soil	146	0-10	17.2	1.419	7.5	3.90	0.2	58.1
PSTA-shelrock	3S	inflow	C	Soil	147	0-7	19.5	1.845	6.6	4.52	0.2	61.3
PSTA-shelrock	3S	outflow	A	Soil	148	0-10	19.8	1.391	7.9	4.43	0.2	51.6
PSTA-shelrock	3S	outflow	B	Soil	149	0-9	19.3	1.872	7.7	3.88	0.2	53.4
PSTA-shelrock	3S	outflow	C	Soil	150	0-10	23.4	1.430	7.9	4.81	15.5	58.8
PSTA-shelrock	8S	inflow	A	Soil	151	0-10	23.0	1.425	7.8	4.78	0.2	60.6
PSTA-shelrock	8S	inflow	B	Soil	152	0-10	20.9	0.921	7.9	4.76	0.2	61.6
PSTA-shelrock	8S	inflow	C	Soil	153	0-10	18.0	1.669	7.8	3.88	0.2	59.0
PSTA-shelrock	8S	outflow	A	Soil	154	0-6	28.9	0.851	8.2	6.40	0.3	65.8
PSTA-shelrock	8S	outflow	B	Soil	155	0-10	19.2	1.749	7.8	5.34	0.2	56.6
PSTA-shelrock	8S	outflow	C	Soil	156	0-10	16.6	1.248	8.1	5.80	0.2	61.1
SAV	9S	inflow	A	Soil	157	0-10	54.0	0.622	7.6	27.27	8.4	175.1
SAV	9S	inflow	B	Soil	158	0-10	60.4	0.493	7.4	31.88	8.2	174.7
SAV	9S	inflow	C	Soil	159	0-10	67.1	0.397	7.4	37.44	10.5	207.0
SAV	9S	outflow	A	Soil	160	0-10	63.7	0.393	7.5	31.00	8.8	195.8
SAV	9S	outflow	B	Soil	161	0-10	66.0	0.395	7.4	28.72	6.9	174.7
SAV	9S	outflow	C	Soil	162	0-10	67.9	0.391	7.4	30.81	7.8	183.8
PSTA - peat	13S	inflow	A	Soil	163	0-10	58.3	0.554	7.5	26.47	5.7	172.8
PSTA - peat	13S	inflow	B	Soil	164	0-10	74.9	0.237	7.5	48.00	12.9	278.0
PSTA - peat	13S	inflow	C	Soil	165	0-10	50.0	0.604	7.6	19.50	3.5	142.0
PSTA - peat	13S	outflow	A	Soil	166	0-10	50.9	0.689	7.4	21.89	4.7	152.5
PSTA - peat	13S	outflow	B	Soil	167	0-10	46.6	0.695	7.4	22.27	4.8	155.9
PSTA - peat	13S	outflow	C	Soil	168	0-10	50.3	0.719	7.6	20.90	4.5	149.6

Appendix 3: Selected characteristics of the floc sampled from Test Cells in October 2001.

Treatments	Cell #	Location	Rep	Type	Lab #	TP	TPi	TPo
						mg kg^{-1}	mg kg^{-1}	mg kg^{-1}
SAV	1N	inflow	A	Floc	1	664.4	352.6	311.8
SAV	1N	inflow	B	Floc	2	499.1	270.9	228.2
SAV	1N	inflow	C	Floc	3	601.3	358.0	243.3
SAV	1N	outflow	A	Floc	4	402.8	179.9	222.9
SAV	1N	outflow	B	Floc	5	501.1	251.1	250.0
SAV	1N	outflow	C	Floc	6	462.8	256.5	206.3
MW-FeCl	2N	inflow	A	Floc	7	1203.3	708.7	494.6
MW-FeCl	2N	inflow	B	Floc	8	869.6	425.1	444.6
MW-FeCl	2N	inflow	C	Floc	9	964.5	536.1	428.4
MW-FeCl	2N	outflow	A	Floc	10	332.8	193.4	139.4
MW-FeCl	2N	outflow	B	Floc	11	468.6	195.3	273.3
MW-FeCl	2N	outflow	C	Floc	12	875.4	449.5	425.9
MW-AlCl	4N	inflow	A	Floc	13	920.7	581.9	338.8
MW-AlCl	4N	inflow	B	Floc	14	1004.5	627.5	377.0
MW-AlCl	4N	inflow	C	Floc	15	923.5	554.8	368.7
MW-AlCl	4N	outflow	A	Floc	16	496.4	208.8	287.6
MW-AlCl	4N	outflow	B	Floc	17	460.7	195.1	265.6
MW-AlCl	4N	outflow	C	Floc	18	542.3	217.3	325.0
Control	5N	inflow	A	Floc	19	474.7	216.1	258.7
Control	5N	inflow	B	Floc	20	641.1	281.1	360.0
Control	5N	inflow	C	Floc	21	724.7	256.0	468.7
Control	5N	outflow	A	Floc	22	534.5	228.9	305.6
Control	5N	outflow	B	Floc	23	507.4	184.4	323.0
Control	5N	outflow	C	Floc	24	781.0	272.3	508.7
Control	10N	inflow	A	Floc	25	858.8	597.9	260.9
Control	10N	inflow	B	Floc	26	812.9	349.9	463.0
Control	10N	inflow	C	Floc	27	842.4	400.2	442.1
Control	10N	outflow	A	Floc	28	612.5	284.2	328.3
Control	10N	outflow	B	Floc	29	358.4	183.9	174.5
Control	10N	outflow	C	Floc	30	500.3	207.6	292.7
SAV	15N	inflow	A	Floc	31	832.8	451.0	381.7
SAV	15N	inflow	B	Floc	32	751.5	407.8	343.7
SAV	15N	inflow	C	Floc	33	711.3	405.7	305.6
SAV	15N	outflow	A	Floc	34	665.0	405.3	259.6
SAV	15N	outflow	B	Floc	35	612.2	323.6	288.5
SAV	15N	outflow	C	Floc	36	561.4	297.1	264.4
Control	1S	inflow	A	Floc	37	865.9	246.5	619.4
Control	1S	inflow	B	Floc	38	749.0	226.5	522.5
Control	1S	inflow	C	Floc	39	949.3	363.7	585.6
Control	1S	outflow	A	Floc	40	755.5	266.0	489.5
Control	1S	outflow	B	Floc	41	548.9	197.9	351.1
Control	1S	outflow	C	Floc	42	906.2	339.2	567.0
SAV	4S	inflow	A	Floc	43	148.0	81.5	66.5
SAV	4S	inflow	B	Floc	44	368.8	133.1	235.7

Appendix 3: Selected characteristics of the floc sampled from Test Cells in October 2001.								
Treatments	Cell #	Location	Rep	Type	Lab #	TP	TPi	TPo
						mg kg^{-1}	mg kg^{-1}	mg kg^{-1}
SAV	4S	inflow	C	Floc	45	276.2	132.9	143.3
SAV	4S	outflow	A	Floc	46	547.0	190.8	356.3
SAV	4S	outflow	B	Floc	47	420.0	157.8	262.2
SAV	4S	outflow	C	Floc	48	656.5	303.3	353.2
MW-AlCl	7S	inflow	A	Floc	49	516.1	264.2	251.9
MW-AlCl	7S	inflow	B	Floc	50	572.0	265.6	306.5
MW-AlCl	7S	inflow	C	Floc	51	455.3	233.0	222.3
MW-AlCl	7S	outflow	A	Floc	52	723.9	318.4	405.5
MW-AlCl	7S	outflow	B	Floc	53	387.5	188.9	198.6
MW-AlCl	7S	outflow	C	Floc	54	516.1	210.0	306.1
Control	15S	inflow	A	Floc	55	546.8	177.2	369.6
Control	15S	inflow	B	Floc	56	371.5	99.8	271.7
Control	15S	inflow	C	Floc	57	523.3	145.3	378.0
Control	15S	outflow	A	Floc	58	571.6	162.6	409.1
Control	15S	outflow	B	Floc	59	669.5	193.5	476.0
Control	15S	outflow	C	Floc	60	96.3	35.4	60.9
PSTA-shelrock	3S	inflow	A	Floc	61	620.4	540.9	79.5
PSTA-shelrock	3S	inflow	B	Floc	62	614.6	420.1	194.4
PSTA-shelrock	3S	inflow	C	Floc	63	561.9	416.7	145.2
PSTA-shelrock	3S	outflow	A	Floc	64	697.2	608.3	88.9
PSTA-shelrock	3S	outflow	B	Floc	65	740.4	695.5	44.9
PSTA-shelrock	3S	outflow	C	Floc	66	817.1	660.2	156.9
PSTA-shelrock	8S	inflow	A	Floc	67	396.2	256.2	140.0
PSTA-shelrock	8S	inflow	B	Floc	68	456.3	374.9	81.4
PSTA-shelrock	8S	inflow	C	Floc	69	357.3	217.8	139.5
PSTA-shelrock	8S	outflow	A	Floc	70	399.2	294.9	104.4
PSTA-shelrock	8S	outflow	B	Floc	71	466.3	374.4	91.8
PSTA-shelrock	8S	outflow	C	Floc	72	560.5	421.7	138.8
SAV	9S	inflow	A	Floc	73	415.2	158.2	257.1
SAV	9S	inflow	B	Floc	74	418.0	158.2	259.7
SAV	9S	inflow	C	Floc	75	404.0	164.6	239.5
SAV	9S	outflow	A	Floc	76	498.0	235.5	262.5
SAV	9S	outflow	B	Floc	77	640.1	288.0	352.0
SAV	9S	outflow	C	Floc	78	546.0	223.9	322.1
PSTA - peat	13S	inflow	A	Floc	79	381.3	217.5	163.8
PSTA - peat	13S	inflow	B	Floc	80	303.5	186.3	117.2
PSTA - peat	13S	inflow	C	Floc	81	472.5	260.4	212.1
PSTA - peat	13S	outflow	A	Floc	82	333.0	189.9	143.1
PSTA - peat	13S	outflow	B	Floc	83	413.8	253.3	160.5
PSTA - peat	13S	outflow	C	Floc	84	537.6	288.5	249.1

Appendix 4: Selected characteristics of the soil (0-10 cm) sampled from Test Cells in October 2001.								
Treatments	Cell #	Location	Rep	Type	Lab #	TP	TPi	TPo
						mg kg^{-1}	mg kg^{-1}	mg kg^{-1}
SAV	1N	inflow	A	Soil	85	170.1	72.2	98.0
SAV	1N	inflow	B	Soil	86	254.0	165.5	88.5
SAV	1N	inflow	C	Soil	87	253.4	118.8	134.6
SAV	1N	outflow	A	Soil	88	212.4	70.1	142.4
SAV	1N	outflow	B	Soil	89	435.2	307.5	127.7
SAV	1N	outflow	C	Soil	90	192.8	75.4	117.4
MW-FeCl	2N	inflow	A	Soil	91	300.4	148.4	152.0
MW-FeCl	2N	inflow	B	Soil	92	415.5	175.4	240.1
MW-FeCl	2N	inflow	C	Soil	93	502.5	253.9	248.6
MW-FeCl	2N	outflow	A	Soil	94	174.3	89.4	84.9
MW-FeCl	2N	outflow	B	Soil	95	205.3	88.8	116.5
MW-FeCl	2N	outflow	C	Soil	96	300.2	187.2	113.0
MW-AlCl	4N	inflow	A	Soil	97	182.1	109.2	72.8
MW-AlCl	4N	inflow	B	Soil	98	237.4	105.9	131.4
MW-AlCl	4N	inflow	C	Soil	99	249.1	122.7	126.4
MW-AlCl	4N	outflow	A	Soil	100	276.2	98.0	178.2
MW-AlCl	4N	outflow	B	Soil	101	330.4	151.9	178.5
MW-AlCl	4N	outflow	C	Soil	102	215.0	65.8	149.2
Control	5N	inflow	A	Soil	103	305.7	106.9	198.8
Control	5N	inflow	B	Soil	104	241.5	85.3	156.2
Control	5N	inflow	C	Soil	105	239.0	78.6	160.4
Control	5N	outflow	A	Soil	106	240.6	82.4	158.2
Control	5N	outflow	B	Soil	107	219.7	87.2	132.4
Control	5N	outflow	C	Soil	108	239.9	71.5	168.3
Control	10N	inflow	A	Soil	109	220.0	89.1	130.9
Control	10N	inflow	B	Soil	110	207.7	86.4	121.3
Control	10N	inflow	C	Soil	111	213.5	119.3	94.2
Control	10N	outflow	A	Soil	112	182.7	117.5	65.2
Control	10N	outflow	B	Soil	113	193.8	117.8	76.1
Control	10N	outflow	C	Soil	114	194.2	121.9	72.3
SAV	15N	inflow	A	Soil	115	128.8	64.4	64.4
SAV	15N	inflow	B	Soil	116	125.4	64.1	61.4
SAV	15N	inflow	C	Soil	117	123.7	57.3	66.4
SAV	15N	outflow	A	Soil	118	125.1	38.9	86.3
SAV	15N	outflow	B	Soil	119	144.0	40.2	103.8
SAV	15N	outflow	C	Soil	120	142.5	46.7	95.8
Control	1S	inflow	A	Soil	121	137.5	81.6	55.9
Control	1S	inflow	B	Soil	122	174.0	90.3	83.6
Control	1S	inflow	C	Soil	123	161.7	99.2	62.5
Control	1S	outflow	A	Soil	124	229.9	96.4	133.5
Control	1S	outflow	B	Soil	125	144.2	72.8	71.4
Control	1S	outflow	C	Soil	126	96.8	46.3	50.6
SAV	4S	inflow	A	Soil	127	104.0	63.5	40.5
SAV	4S	inflow	B	Soil	128	93.6	41.0	52.6

Appendix 4: Selected characteristics of the soil (0-10 cm) sampled from Test Cells in October 2001.								
Treatments	Cell #	Location	Rep	Type	Lab #	TP	TPi	TPo
						mg kg^{-1}	mg kg^{-1}	mg kg^{-1}
SAV	4S	inflow	C	Soil	129	112.0	55.2	56.8
SAV	4S	outflow	A	Soil	130	132.3	59.7	72.6
SAV	4S	outflow	B	Soil	131	132.7	69.1	63.7
SAV	4S	outflow	C	Soil	132	134.4	74.5	59.9
MW-AlCl	7S	inflow	A	Soil	133	127.6	66.5	61.1
MW-AlCl	7S	inflow	B	Soil	134	144.0	74.1	69.9
MW-AlCl	7S	inflow	C	Soil	135	149.4	92.7	56.7
MW-AlCl	7S	outflow	A	Soil	136	135.5	80.9	54.6
MW-AlCl	7S	outflow	B	Soil	137	157.0	132.3	24.7
MW-AlCl	7S	outflow	C	Soil	138	174.6	119.6	55.0
Control	15S	inflow	A	Soil	139	218.1	48.9	169.2
Control	15S	inflow	B	Soil	140	138.0	33.6	104.5
Control	15S	inflow	C	Soil	141	83.5	19.6	64.0
Control	15S	outflow	A	Soil	142	64.4	26.0	38.5
Control	15S	outflow	B	Soil	143	102.6	54.3	48.2
Control	15S	outflow	C	Soil	144	119.4	36.0	83.4
PSTA-shelrock	3S	inflow	A	Soil	145	649.9	637.3	12.6
PSTA-shelrock	3S	inflow	B	Soil	146	712.0	709.7	2.2
PSTA-shelrock	3S	inflow	C	Soil	147	676.2	650.7	25.5
PSTA-shelrock	3S	outflow	A	Soil	148	882.6	897.1	0
PSTA-shelrock	3S	outflow	B	Soil	149	777.3	818.1	0
PSTA-shelrock	3S	outflow	C	Soil	150	851.7	823.6	28.1
PSTA-shelrock	8S	inflow	A	Soil	151	743.0	755.6	0
PSTA-shelrock	8S	inflow	B	Soil	152	813.1	802.6	10.5
PSTA-shelrock	8S	inflow	C	Soil	153	873.2	814.6	58.6
PSTA-shelrock	8S	outflow	A	Soil	154	605.1	592.0	13.2
PSTA-shelrock	8S	outflow	B	Soil	155	797.2	784.1	13.1
PSTA-shelrock	8S	outflow	C	Soil	156	764.5	760.7	3.9
SAV	9S	inflow	A	Soil	157	131.5	48.4	83.1
SAV	9S	inflow	B	Soil	158	137.2	73.5	63.7
SAV	9S	inflow	C	Soil	159	113.9	44.3	69.5
SAV	9S	outflow	A	Soil	160	146.7	84.4	62.3
SAV	9S	outflow	B	Soil	161	137.4	84.5	52.9
SAV	9S	outflow	C	Soil	162	147.2	77.1	70.1
PSTA - peat	13S	inflow	A	Soil	163	192.5	163.4	29.1
PSTA - peat	13S	inflow	B	Soil	164	215.2	152.7	62.5
PSTA - peat	13S	inflow	C	Soil	165	222.7	205.7	16.9
PSTA - peat	13S	outflow	A	Soil	166	217.7	194.7	23.1
PSTA - peat	13S	outflow	B	Soil	167	204.9	188.3	16.6
PSTA - peat	13S	outflow	C	Soil	168	303.5	279.2	24.3

Appendix 5: Inorganic phosphorus fractionation of the floc sampled from Test Cells in October 2001.

Treatments	Cell #	Location	Rep	Type	Lab #	NaHCO3 Pi	NaOH Pi	0.5M HCl Pi	SumTPi	NaHCO3 Po	NaOH Po	Residue P	SumTPo
						mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}
SAV	1N	inflow	A	Floc	1	103.2	20.1	199.4	322.8	13.1	66.8	174.8	254.7
SAV	1N	inflow	B	Floc	2	62.5	26.1	180.7	269.2	16.9	60.4	178.1	255.5
SAV	1N	inflow	C	Floc	3	117.7	16.7	236.0	370.4	19.3	72.6	173.9	265.8
SAV	1N	outflow	A	Floc	4	19.6	29.8	125.1	174.4	17.6	49.8	179.4	246.8
SAV	1N	outflow	B	Floc	5	65.6	25.0	140.7	231.3	17.7	76.0	140.3	234.0
SAV	1N	outflow	C	Floc	6	75.8	28.0	155.1	258.9	22.4	66.5	145.0	234.0
MW-FeCl	2N	inflow	A	Floc	7	28.8	234.0	251.3	514.1	37.8	105.0	284.1	426.9
MW-FeCl	2N	inflow	B	Floc	8	30.7	205.9	171.8	408.4	41.6	210.7	256.0	508.3
MW-FeCl	2N	inflow	C	Floc	9	27.3	202.3	286.7	516.4	39.3	131.7	266.9	437.8
MW-FeCl	2N	outflow	A	Floc	10	23.6	22.5	166.2	212.4	9.8	25.1	129.1	163.9
MW-FeCl	2N	outflow	B	Floc	11	39.5	50.1	109.2	198.8	16.5	74.4	185.9	276.9
MW-FeCl	2N	outflow	C	Floc	12	83.8	151.7	236.9	472.4	17.9	125.5	252.0	395.4
MW-AlCl	4N	inflow	A	Floc	13	15.6	50.2	638.4	704.1	22.8	30.3	259.4	312.5
MW-AlCl	4N	inflow	B	Floc	14	14.0	25.0	652.0	691.1	23.2	17.9	302.0	343.0
MW-AlCl	4N	inflow	C	Floc	15	17.4	50.5	575.4	643.4	22.1	32.1	261.9	316.1
MW-AlCl	4N	outflow	A	Floc	16	24.6	42.0	74.8	141.4	10.8	54.7	183.6	249.0
MW-AlCl	4N	outflow	B	Floc	17	27.7	49.9	127.7	205.3	6.7	38.2	169.1	214.1
MW-AlCl	4N	outflow	C	Floc	18	33.0	59.4	93.9	186.3	8.4	35.3	197.4	241.1
Control	5N	inflow	A	Floc	19	40.0	33.2	83.1	156.2	9.4	86.9	203.2	299.6
Control	5N	inflow	B	Floc	20	46.8	48.8	139.6	235.2	21.8	121.4	233.6	376.8
Control	5N	inflow	C	Floc	21	47.8	91.7	128.1	267.6	24.2	99.9	254.4	378.5
Control	5N	outflow	A	Floc	22	21.8	64.3	128.8	215.0	17.7	49.7	198.6	266.0
Control	5N	outflow	B	Floc	23	2.5	74.4	95.3	172.1	23.8	72.0	179.0	274.8
Control	5N	outflow	C	Floc	24	11.7	154.3	103.6	269.6	38.9	141.2	241.9	422.0
Control	10N	inflow	A	Floc	25	31.9	35.8	426.0	493.8	10.3	51.1	162.4	223.8
Control	10N	inflow	B	Floc	26	26.8	76.5	158.2	261.5	27.5	131.8	288.8	448.1
Control	10N	inflow	C	Floc	27	50.9	119.9	206.8	377.6	36.8	140.2	259.8	436.7
Control	10N	outflow	A	Floc	28	28.0	64.0	170.7	262.7	26.6	63.3	191.4	281.2
Control	10N	outflow	B	Floc	29	14.0	34.1	100.1	148.2	14.6	59.4	116.4	190.3
Control	10N	outflow	C	Floc	30	14.2	34.6	172.6	221.4	13.0	47.3	151.1	211.4
SAV	15N	inflow	A	Floc	31	233.5	21.2	255.2	509.9	15.4	107.2	251.0	373.5
SAV	15N	inflow	B	Floc	32	179.0	19.7	234.7	433.4	28.6	94.8	189.8	313.2
SAV	15N	inflow	C	Floc	33	138.5	27.6	177.7	343.9	22.6	121.9	178.9	323.4
SAV	15N	outflow	A	Floc	34	33.1	97.1	233.3	363.6	20.3	90.4	194.4	305.1

Appendix 5: Inorganic phosphorus fractionation of the floc sampled from Test Cells in October 2001.

Treatments	Cell #	Location	Rep	Type	Lab #	NaHCO3 Pi	NaOH Pi	0.5M HCl Pi	SumTPi	NaHCO3 Po	NaOH Po	Residue P	SumTPo
						mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}
SAV	15N	outflow	B	Floc	35	17.0	59.2	270.7	346.9	15.9	77.5	223.6	317.0
SAV	15N	outflow	C	Floc	36	13.6	69.4	227.7	310.6	23.5	70.1	241.4	335.1
Control	1S	inflow	A	Floc	37	32.1	71.1	125.1	228.3	26.8	272.9	376.3	676.0
Control	1S	inflow	B	Floc	38	28.4	48.0	127.5	204.0	30.4	152.2	319.3	501.9
Control	1S	inflow	C	Floc	39	41.7	86.2	161.7	289.6	33.8	310.4	366.5	710.7
Control	1S	outflow	A	Floc	40	37.8	59.5	111.5	208.8	30.7	155.9	280.0	466.6
Control	1S	outflow	B	Floc	41	26.0	46.9	96.6	169.5	25.5	154.8	245.5	425.8
Control	1S	outflow	C	Floc	42	43.7	103.9	131.3	279.0	21.1	233.5	323.0	577.7
SAV	4S	inflow	A	Floc	43	7.3	9.5	56.3	73.1	3.6	23.9	58.0	85.4
SAV	4S	inflow	B	Floc	44	8.7	12.7	101.3	122.7	10.0	56.0	167.2	233.2
SAV	4S	inflow	C	Floc	45	1.2	21.0	108.3	130.4	8.9	27.3	73.1	109.3
SAV	4S	outflow	A	Floc	46	0.9	65.5	176.7	243.1	10.4	49.5	215.1	275.0
SAV	4S	outflow	B	Floc	47	0.8	61.7	115.9	178.3	7.6	21.7	164.0	193.2
SAV	4S	outflow	C	Floc	48	0.7	111.5	225.8	338.0	10.1	37.2	271.1	318.3
MW-AlCl	7S	inflow	A	Floc	49	0.9	19.5	205.6	226.0	16.7	12.9	260.3	289.9
MW-AlCl	7S	inflow	B	Floc	50	7.9	40.6	200.8	249.3	23.5	22.6	286.5	332.6
MW-AlCl	7S	inflow	C	Floc	51	12.1	48.3	183.6	244.0	10.1	35.6	204.5	250.2
MW-AlCl	7S	outflow	A	Floc	52	9.8	94.7	161.3	265.9	24.3	90.2	257.3	371.8
MW-AlCl	7S	outflow	B	Floc	53	17.1	60.6	118.0	195.6	18.5	58.1	133.6	210.2
MW-AlCl	7S	outflow	C	Floc	54	18.5	57.5	135.4	211.4	24.9	94.5	197.5	316.8
Control	15S	inflow	A	Floc	55	8.5	27.5	106.6	142.6	19.1	77.2	223.3	319.6
Control	15S	inflow	B	Floc	56	5.8	22.2	64.5	92.5	14.7	64.1	171.8	250.6
Control	15S	inflow	C	Floc	57	9.6	37.8	92.9	140.4	17.1	94.3	230.0	341.4
Control	15S	outflow	A	Floc	58	6.0	68.1	94.5	168.5	17.6	58.8	272.2	348.7
Control	15S	outflow	B	Floc	59	1.3	94.4	82.2	177.8	16.3	83.5	268.3	368.2
Control	15S	outflow	C	Floc	60	4.1	8.9	13.6	26.5	0.5	2.2	38.2	41.0
PSTA-shelrock	3S	inflow	A	Floc	61	1.64	16.0	523.9	541.5	4.7	17.1	97.6	119.4
PSTA-shelrock	3S	inflow	B	Floc	62	1.47	20.6	382.5	404.6	6.9	28.2	136.8	172.0
PSTA-shelrock	3S	inflow	C	Floc	63	0.54	23.3	405.3	429.2	4.7	20.7	113.5	138.9
PSTA-shelrock	3S	outflow	A	Floc	64	1.04	15.4	577.3	593.7	3.4	15.5	109.4	128.3
PSTA-shelrock	3S	outflow	B	Floc	65	1.62	10.7	652.0	664.3	2.6	19.7	104.7	127.0
PSTA-shelrock	3S	outflow	C	Floc	66	2.18	39.9	476.1	518.2	10.5	42.6	124.0	177.0
PSTA-shelrock	8S	inflow	A	Floc	67	0.62	39.3	186.8	226.7	6.9	26.2	85.6	118.6
PSTA-shelrock	8S	inflow	B	Floc	68	1.34	17.4	407.0	425.8	9.6	37.4	88.4	135.4

Appendix 6: Inorganic phosphorus fractionation of the soil (0-10 cm) sampled from Test Cells in October 2001.

Treatments	Cell #	Location	Rep	Type	Lab #	NaHCO3 Pi	NaOH Pi	0.5M HCl Pi	SumTPi	NaHCO3 Po	NaOH Po	Residue P	SumTPo
						mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}
SAV	15N	inflow	C	Soil	117	12.89	5.9	23.9	42.6	2.5	10.8	31.1	44.4
SAV	15N	outflow	A	Soil	118	7.20	4.5	47.7	59.4	2.5	17.4	47.5	67.4
SAV	15N	outflow	B	Soil	119	7.00	5.0	31.5	43.4	2.6	20.0	50.6	73.3
SAV	15N	outflow	C	Soil	120	7.31	7.1	24.0	38.4	2.5	23.2	47.7	73.4
Control	1S	inflow	A	Soil	121	10.70	5.8	67.0	83.5	0.0	10.7	33.1	43.8
Control	1S	inflow	B	Soil	122	6.45	4.7	65.1	76.2	2.1	12.7	54.1	69.0
Control	1S	inflow	C	Soil	123	9.36	5.0	69.4	83.8	2.0	14.5	40.9	57.4
Control	1S	outflow	A	Soil	124	14.31	10.7	57.8	82.8	4.6	35.8	76.1	116.5
Control	1S	outflow	B	Soil	125	8.06	5.2	58.1	71.3	0.6	10.8	54.9	66.3
Control	1S	outflow	C	Soil	126	7.40	4.2	45.8	57.4	0	8.8	26.2	35.1
SAV	4S	inflow	A	Soil	127	5.32	3.4	35.2	44.0	0	10.1	23.3	33.5
SAV	4S	inflow	B	Soil	128	2.83	3.0	25.3	31.1	1.2	1.8	24.3	27.3
SAV	4S	inflow	C	Soil	129	5.69	4.0	38.0	47.7	0.0	13.1	38.6	51.7
SAV	4S	outflow	A	Soil	130	5.77	4.4	44.1	54.3	0.6	15.9	45.9	62.5
SAV	4S	outflow	B	Soil	131	5.48	3.3	58.1	66.8	0	11.2	34.0	45.2
SAV	4S	outflow	C	Soil	132	4.57	4.3	44.4	53.3	1.6	16.3	35.9	53.8
MW-AlCl	7S	inflow	A	Soil	133	6.57	3.9	38.2	48.6	1.5	14.6	43.0	59.1
MW-AlCl	7S	inflow	B	Soil	134	9.51	4.1	52.9	66.5	2.4	14.0	46.3	62.7
MW-AlCl	7S	inflow	C	Soil	135	8.71	4.1	54.0	66.8	0.3	13.9	42.4	56.7
MW-AlCl	7S	outflow	A	Soil	136	11.49	11.8	104.2	127.4	2.0	17.9	40.0	59.9
MW-AlCl	7S	outflow	B	Soil	137	8.79	3.5	69.9	82.2	2.3	12.8	38.0	53.1
MW-AlCl	7S	outflow	C	Soil	138	11.20	3.5	86.8	101.4	2.3	12.2	45.4	59.9
Control	15S	inflow	A	Soil	139	9.84	5.7	29.3	44.9	8.0	30.4	134.2	172.7
Control	15S	inflow	B	Soil	140	7.16	4.5	19.4	31.1	2.7	20.1	77.9	100.6
Control	15S	inflow	C	Soil	141	5.49	3.5	10.3	19.4	1.3	16.6	31.1	49.0
Control	15S	outflow	A	Soil	142	4.41	3.2	13.1	20.6	0	10.6	21.1	31.7
Control	15S	outflow	B	Soil	143	5.03	3.2	28.3	36.5	0.3	11.1	34.1	45.6
Control	15S	outflow	C	Soil	144	5.71	3.2	26.1	35.0	3.5	13.4	49.6	66.5
PSTA-shelrock	3S	inflow	A	Soil	145	3.96	2.1	796.7	802.7	0.0	0.2	19.99	20.2
PSTA-shelrock	3S	inflow	B	Soil	146	4.19	3.3	869.7	877.2	0	0	22.0	22.0
PSTA-shelrock	3S	inflow	C	Soil	147	3.83	3.6	824.7	832.1	0	0.6	20.8	21.5
PSTA-shelrock	3S	outflow	A	Soil	148	4.19	2.9	945.1	952.1	0	0	18.1	18.1
PSTA-shelrock	3S	outflow	B	Soil	149	4.64	2.3	1022.3	1029.2	0	0	17.0	17.0

Appendix 6: Inorganic phosphorus fractionation of the soil (0-10 cm) sampled from Test Cells in October 2001.

Treatments	Cell #	Location	Rep	Type	Lab #	NaHCO3 Pi	NaOH Pi	0.5M HCl Pi	SumTPi	NaHCO3 Po	NaOH Po	Residue P	SumTPo
						mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}
PSTA-shelrock	3S	outflow	C	Soil	150	4.29	4.0	1006.6	1014.8	0	1.3	20.7	22.0
PSTA-shelrock	8S	inflow	A	Soil	151	3.54	4.7	910.4	918.7	0	0.0	19.1	19.1
PSTA-shelrock	8S	inflow	B	Soil	152	3.74	3.7	891.2	898.6	0	0	16.3	16.3
PSTA-shelrock	8S	inflow	C	Soil	153	3.90	3.6	816.7	824.2	0	0	20.6	20.6
PSTA-shelrock	8S	outflow	A	Soil	154	3.27	5.3	803.0	811.6	0	2.1	28.2	30.3
PSTA-shelrock	8S	outflow	B	Soil	155	4.04	4.7	975.1	983.9	0	0	22.2	22.2
PSTA-shelrock	8S	outflow	C	Soil	156	3.77	3.5	852.2	859.5	0	0	18.7	18.7
SAV	9S	inflow	A	Soil	157	3.77	3.2	34.4	41.4	0.7	4.3	48.8	53.8
SAV	9S	inflow	B	Soil	158	4.06	3.1	34.9	42.0	1.1	5.9	46.3	53.2
SAV	9S	inflow	C	Soil	159	4.55	4.2	41.5	50.3	0.4	8.0	56.6	65.0
SAV	9S	outflow	A	Soil	160	5.34	5.3	63.0	73.6	0	8.0	44.6	52.6
SAV	9S	outflow	B	Soil	161	4.53	4.6	55.2	64.4	0	8.8	39.6	48.4
SAV	9S	outflow	C	Soil	162	4.63	4.2	73.9	82.7	0.2	11.1	47.5	58.9
PSTA - peat	13S	inflow	A	Soil	163	9.80	5.2	151.9	167.0	0	8.2	36.1	44.3
PSTA - peat	13S	inflow	B	Soil	164	6.43	5.1	122.9	134.5	0.2	9.2	48.7	58.2
PSTA - peat	13S	inflow	C	Soil	165	16.06	6.2	163.3	185.6	0.0	1.8	27.1	28.9
PSTA - peat	13S	outflow	A	Soil	166	10.58	7.7	165.5	183.8	0.5	4.6	32.0	37.1
PSTA - peat	13S	outflow	B	Soil	167	10.12	9.4	170.2	189.7	0.0	3.4	38.0	41.3
PSTA - peat	13S	outflow	C	Soil	168	19.70	11.6	187.8	219.2	0.1	2.6	37.7	40.3

Appendix 7: Organic phosphorus fractionation of the floc sampled from Test Cells in October 2001.

Treatments	Cell #	Location	Rep	Type	Lab #	NaHCO3 Pi	HCl Pi	SumTPi	NaHCO3 Po	MBP	FAP	HAP	Residue P	SumTPo
						mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}
SAV	1N	inflow	A	Floc	1	103.2	198.3	301.5	13.1	88.4	47.9	28.0	186.7	364.0
SAV	1N	inflow	B	Floc	2	62.5	172.3	234.8	16.9	51.1	48.8	29.0	181.9	327.7
SAV	1N	inflow	C	Floc	3	117.7	216.7	334.4	19.3	82.90	46.59	26.97	188.8	364.6
SAV	1N	outflow	A	Floc	4	19.6	112.6	132.2	17.6	69.2	44.2	26.0	153.6	310.6
SAV	1N	outflow	B	Floc	5	65.6	94.5	160.2	17.7	129.9	26.2	11.6	147.6	332.9
SAV	1N	outflow	C	Floc	6	75.8	120.8	196.5	22.4	108.5	34.5	22.9	99.1	287.4
MW-FeCl	2N	inflow	A	Floc	7	28.8	611.6	640.4	37.8	43.5	113.4	136.0	125.4	456.2
MW-FeCl	2N	inflow	B	Floc	8	30.7	381.7	412.4	41.6	81.2	130.0	71.6	107.1	431.4
MW-FeCl	2N	inflow	C	Floc	9	27.3	491.5	518.7	39.3	54.3	119.0	109.9	146.0	468.4
MW-FeCl	2N	outflow	A	Floc	10	23.6	117.9	141.6	9.8	30.7	39.0	17.3	59.3	156.1
MW-FeCl	2N	outflow	B	Floc	11	39.5	197.7	237.2	16.5	79.9	63.2	47.7	97.4	304.7
MW-FeCl	2N	outflow	C	Floc	12	83.8	424.1	500.4	22.31	115.8	134.47	60.68	161.9	495.2
MW-AlCl	4N	inflow	A	Floc	13	15.6	762.5	778.1	22.8	21.9	102.5	69.7	71.9	288.7
MW-AlCl	4N	inflow	B	Floc	14	14.0	695.7	709.7	23.2	30.2	126.1	74.0	61.0	314.6
MW-AlCl	4N	inflow	C	Floc	15	17.4	647.8	665.3	22.1	25.1	112.1	57.3	47.9	264.5
MW-AlCl	4N	outflow	A	Floc	16	24.6	119.9	144.5	10.8	49.4	71.9	57.6	154.3	344.0
MW-AlCl	4N	outflow	B	Floc	17	27.7	144.5	172.1	6.7	55.1	57.7	26.4	173.3	319.1
MW-AlCl	4N	outflow	C	Floc	18	33.0	148.6	181.6	8.4	62.3	81.1	38.5	159.4	349.7
Control	5N	inflow	A	Floc	19	40.0	131.1	171.0	9.4	74.8	61.8	39.9	131.5	317.4
Control	5N	inflow	B	Floc	20	46.8	141.0	187.7	21.8	147.8	54.4	26.2	265.1	515.4
Control	5N	inflow	C	Floc	21	47.8	121.0	168.8	24.2	156.7	59.6	32.0	251.7	524.3
Control	5N	outflow	A	Floc	22	21.8	145.4	167.2	17.7	97.8	34.1	31.9	204.1	385.5
Control	5N	outflow	B	Floc	23	2.5	91.5	94.0	23.8	125.8	53.1	53.4	113.1	369.2
Control	5N	outflow	C	Floc	24	11.7	136.6	148.2	38.9	252.6	54.3	50.4	217.7	613.9
Control	10N	inflow	A	Floc	25	31.9	120.3	152.2	10.3	60.4	55.6	40.0	126.6	293.0
Control	10N	inflow	B	Floc	26	26.8	169.6	196.4	27.5	167.3	59.3	53.6	262.0	569.7
Control	10N	inflow	C	Floc	27	50.9	161.5	212.4	36.8	187.0	51.3	31.9	253.1	560.2
Control	10N	outflow	A	Floc	28	28.0	154.9	182.9	26.6	116.8	45.7	15.4	209.4	413.9
Control	10N	outflow	B	Floc	29	14.0	115.1	129.1	14.6	50.9	22.5	11.5	104.8	204.3
Control	10N	outflow	C	Floc	30	14.2	128.1	142.3	13.0	50.2	32.8	23.0	178.1	297.1
SAV	15N	inflow	A	Floc	31	233.5	251.6	485.1	15.4	135.1	24.3	9.8	249.7	434.2
SAV	15N	inflow	B	Floc	32	179.0	191.9	370.9	28.6	75.0	37.4	22.1	183.5	346.5

Appendix 7: Organic phosphorus fractionation of the floc sampled from Test Cells in October 2001.

Treatments	Cell #	Location	Rep	Type	Lab #	NaHCO3 Pi	HCl Pi	SumTPi	NaHCO3 Po	MBP	FAP	HAP	Residue P	SumTPo
						mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}
SAV	15N	inflow	C	Floc	33	138.5	179.2	317.7	22.6	110.9	34.8	36.5	197.2	402.0
SAV	15N	outflow	A	Floc	34	33.1	177.7	210.8	20.3	190.9	21.8	30.4	187.8	451.2
SAV	15N	outflow	B	Floc	35	17.0	184.7	201.7	15.9	171.1	23.1	34.6	217.9	462.6
SAV	15N	outflow	C	Floc	36	13.6	200.4	214.0	23.5	171.8	13.1	46.5	226.1	481.0
Control	1S	inflow	A	Floc	37	32.1	130.2	162.3	26.8	139.0	132.5	151.7	483.3	933.3
Control	1S	inflow	B	Floc	38	28.4	165.3	193.7	30.4	116.6	68.9	75.5	307.3	598.6
Control	1S	inflow	C	Floc	39	41.7	193.8	235.5	33.8	244.2	105.1	112.4	343.9	839.4
Control	1S	outflow	A	Floc	40	37.8	145.4	183.2	30.7	136.8	126.7	63.4	249.7	607.3
Control	1S	outflow	B	Floc	41	26.0	123.5	149.5	25.5	93.7	94.9	61.8	226.4	502.2
Control	1S	outflow	C	Floc	42	43.7	157.7	201.4	21.1	218.9	172.3	65.7	350.6	828.6
SAV	4S	inflow	A	Floc	43	7.3	52.3	59.6	3.6	25.6	18.1	2.3	54.2	103.7
SAV	4S	inflow	B	Floc	44	8.7	89.3	98.0	10.0	74.9	22.7	10.1	178.7	296.3
SAV	4S	inflow	C	Floc	45	1.2	66.0	67.1	8.9	89.4	13.6	8.9	68.5	189.4
SAV	4S	outflow	A	Floc	46	0.9	129.4	130.3	10.4	138.8	23.4	26.4	261.5	460.5
SAV	4S	outflow	B	Floc	47	0.8	97.9	98.7	7.6	105.0	19.7	34.7	158.1	325.0
SAV	4S	outflow	C	Floc	48	0.7	119.8	120.5	10.1	247.4	23.8	21.9	290.2	593.3
MW-AlCl	7S	inflow	A	Floc	49	0.9	307.4	308.3	16.7	22.2	9.7	63.7	143.1	255.4
MW-AlCl	7S	inflow	B	Floc	50	7.9	285.4	293.3	23.5	12.0	8.1	41.9	191.6	277.1
MW-AlCl	7S	inflow	C	Floc	51	12.1	272.9	285.0	10.1	24.2	9.8	44.4	169.4	257.9
MW-AlCl	7S	outflow	A	Floc	52	9.8	167.8	177.6	24.3	192.0	29.6	29.9	273.9	549.7
MW-AlCl	7S	outflow	B	Floc	53	17.1	111.2	128.3	18.5	82.5	37.3	24.2	141.8	304.2
MW-AlCl	7S	outflow	C	Floc	54	18.5	146.2	164.7	24.9	93.2	44.0	19.4	189.4	370.8
Control	15S	inflow	A	Floc	55	8.5	102.3	110.8	19.1	106.4	47.8	0	256.5	429.8
Control	15S	inflow	B	Floc	56	5.8	79.2	84.9	14.7	51.2	50.9	15.9	179.6	312.3
Control	15S	inflow	C	Floc	57	9.6	105.0	114.6	17.1	107.9	80.5	38.3	218.9	462.7
Control	15S	outflow	A	Floc	58	6.0	103.9	109.9	17.6	97.6	83.3	35.6	258.4	492.5
Control	15S	outflow	B	Floc	59	1.3	109.2	110.4	16.3	132.8	111.5	45.8	296.0	602.5
Control	15S	outflow	C	Floc	60	4.1	17.4	21.4	0.5	12.4	9.5	7.0	34.8	64.3
PSTA-shelrock	3S	inflow	A	Floc	61	1.64	422.9	424.6	4.7	62.0	1.0	16.8	116.4	200.9
PSTA-shelrock	3S	inflow	B	Floc	62	1.47	384.7	386.2	6.9	62.7	2.7	21.4	150.3	244.1
PSTA-shelrock	3S	inflow	C	Floc	63	0.54	379.4	379.9	4.7	67.0	4.5	15.8	132.6	224.6
PSTA-shelrock	3S	outflow	A	Floc	64	1.04	617.9	619.0	3.4	32.1	0	10.7	153.1	192.2
PSTA-shelrock	3S	outflow	B	Floc	65	1.62	674.3	675.9	2.6	39.8	0	7.2	109.8	149.9

Appendix 7: Organic phosphorus fractionation of the floc sampled from Test Cells in October 2001.

Treatments	Cell #	Location	Rep	Type	Lab #	NaHCO3 Pi	HCl Pi	SumTPi	NaHCO3 Po	MBP	FAP	HAP	Residue P	SumTPo
						mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}
PSTA-shelrock	3S	outflow	C	Floc	66	2.18	566.8	568.9	10.5	93.0	0	14.5	138.3	242.9
PSTA-shelrock	8S	inflow	A	Floc	67	0.62	98.2	98.8	6.9	135.4	16.7	3.8	75.1	237.8
PSTA-shelrock	8S	inflow	B	Floc	68	1.34	315.0	316.4	9.6	108.1	0	0	98.3	210.6
PSTA-shelrock	8S	inflow	C	Floc	69	0.56	110.8	111.3	2.3	141.9	14.4	0	77.6	228.7
PSTA-shelrock	8S	outflow	A	Floc	70	0.48	185.5	186.0	3.6	117.8	5.6	0	92.7	215.0
PSTA-shelrock	8S	outflow	B	Floc	71	1.23	458.3	459.6	10.8	109.0	0	0	122.1	223.0
PSTA-shelrock	8S	outflow	C	Floc	72	1.35	311.6	312.9	9.2	86.9	0	0	99.6	191.3
SAV	9S	inflow	A	Floc	73	12.44	80.6	93.1	11.8	119.0	35.3	14.7	161.8	342.7
SAV	9S	inflow	B	Floc	74	14.31	63.5	77.8	19.2	96.8	38.0	13.1	138.7	305.8
SAV	9S	inflow	C	Floc	75	13.66	76.1	89.8	10.5	150.1	26.5	35.5	141.9	364.7
SAV	9S	outflow	A	Floc	76	3.87	109.2	113.1	14.4	109.9	35.1	35.4	167.9	362.7
SAV	9S	outflow	B	Floc	77	11.80	136.4	148.2	8.5	237.5	54.3	41.7	255.6	597.6
SAV	9S	outflow	C	Floc	78	4.30	115.0	119.3	15.7	196.8	42.7	24.9	192.1	472.2
PSTA - peat	13S	inflow	A	Floc	79	24.44	158.2	182.6	8.1	70.5	23.2	8.9	104.2	214.8
PSTA - peat	13S	inflow	B	Floc	80	18.26	156.6	174.8	0.0	44.4	12.6	3.1	96.0	156.1
PSTA - peat	13S	inflow	C	Floc	81	29.86	103.2	133.1	18.0	154.1	32.7	0	126.5	329.2
PSTA - peat	13S	outflow	A	Floc	82	16.74	169.4	186.1	8.6	52.9	18.2	0	106.1	184.4
PSTA - peat	13S	outflow	B	Floc	83	36.29	144.2	180.5	14.3	82.0	28.8	0	127.5	249.1
PSTA - peat	13S	outflow	C	Floc	84	39.60	146.7	186.3	11.8	139.2	42.9	0	142.2	330.1

Appendix 8: Organic phosphorus fractionation of the soil (0-10 cm) sampled from Test Cells in October 2001.

Treatments	Cell #	Location	Rep	Type	Lab #	NaHCO3 Pi	HCl Pi	SumTPi	NaHCO3 Po	MBP	FAP	HAP	Residue P	SumTPo
						mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}
SAV	1N	inflow	A	Soil	85	13.79	50.0	63.8	4.0	7.5	22.3	20.7	50.4	104.9
SAV	1N	inflow	B	Soil	86	20.87	134.3	155.2	3.7	20.9	13.1	12.8	58.2	108.8
SAV	1N	inflow	C	Soil	87	13.24	128.4	141.6	5.1	14.6	24.0	24.5	64.1	132.3
SAV	1N	outflow	A	Soil	88	9.26	46.9	56.2	5.3	14.2	26.0	50.5	56.4	152.5
SAV	1N	outflow	B	Soil	89	15.71	58.3	74.0	9.9	14.4	30.3	34.0	75.3	163.9
SAV	1N	outflow	C	Soil	90	9.99	39.1	49.1	5.6	9.3	20.3	25.5	50.4	111.1
MW-FeCl	2N	inflow	A	Soil	91	23.21	103.0	126.2	10.3	26.4	15.9	17.1	76.0	145.7
MW-FeCl	2N	inflow	B	Soil	92	30.13	157.4	187.5	19.8	42.6	62.6	38.3	93.0	256.2
MW-FeCl	2N	inflow	C	Soil	93	34.26	196.1	230.4	19.4	45.7	72.7	39.8	90.0	267.6
MW-FeCl	2N	outflow	A	Soil	94	15.59	64.2	79.8	5.5	7.9	7.7	18.0	51.3	90.5
MW-FeCl	2N	outflow	B	Soil	95	12.69	78.6	91.3	5.6	14.3	27.1	20.7	51.9	119.5
MW-FeCl	2N	outflow	C	Soil	96	15.51	131.2	146.7	6.4	16.4	26.4	25.8	49.0	123.9
MW-AlCl	4N	inflow	A	Soil	97	13.68	74.0	87.7	3.9	11.8	8.1	15.5	61.8	101.1
MW-AlCl	4N	inflow	B	Soil	98	16.70	77.5	94.2	7.4	28.0	40.8	39.3	75.4	190.9
MW-AlCl	4N	inflow	C	Soil	99	17.87	89.1	107.0	6.5	20.5	33.9	36.3	54.3	151.4
MW-AlCl	4N	outflow	A	Soil	100	16.92	54.0	70.9	7.4	23.4	47.0	50.0	85.5	213.4
MW-AlCl	4N	outflow	B	Soil	101	15.23	89.1	104.4	3.3	22.9	50.1	46.0	95.6	217.8
MW-AlCl	4N	outflow	C	Soil	102	9.04	45.8	54.9	4.3	12.1	34.9	34.6	70.0	156.0
Control	5N	inflow	A	Soil	103	28.50	55.6	84.1	12.2	38.9	48.7	43.4	85.8	229.0
Control	5N	inflow	B	Soil	104	12.65	57.7	70.3	7.6	4.2	37.0	39.9	92.8	181.5
Control	5N	inflow	C	Soil	105	11.75	54.7	66.4	8.8	14.9	36.7	33.7	96.0	190.1
Control	5N	outflow	A	Soil	106	12.56	70.3	82.8	8.2	17.1	31.2	30.2	62.1	148.8
Control	5N	outflow	B	Soil	107	9.62	53.5	63.1	6.1	17.4	29.6	20.3	54.0	127.5
Control	5N	outflow	C	Soil	108	9.27	52.7	62.0	9.1	12.0	25.6	29.8	90.7	167.1
Control	10N	inflow	A	Soil	109	11.26	63.5	74.7	6.2	13.3	24.5	30.4	67.1	141.5
Control	10N	inflow	B	Soil	110	11.26	69.2	80.5	4.0	16.8	23.6	24.1	74.9	143.4
Control	10N	inflow	C	Soil	111	13.30	109.4	122.7	1.6	16.4	14.3	11.9	64.6	108.7
Control	10N	outflow	A	Soil	112	10.04	118.1	128.2	0.6	9.9	11.7	13.7	46.8	82.6
Control	10N	outflow	B	Soil	113	8.92	99.2	108.1	0.6	8.6	12.6	13.2	43.6	78.6
Control	10N	outflow	C	Soil	114	8.21	125.3	133.5	1.5	8.4	6.8	14.6	45.7	77.1

Appendix 8: Organic phosphorus fractionation of the soil (0-10 cm) sampled from Test Cells in October 2001.

Treatments	Cell #	Location	Rep	Type	Lab #	NaHCO3 Pi	HCl Pi	SumTPi	NaHCO3 Po	MBP	FAP	HAP	Residue P	SumTPo
						mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}
SAV	15N	inflow	A	Soil	115	11.51	32.2	43.7	0.3	9.7	12.3	14.6	27.4	64.4
SAV	15N	inflow	B	Soil	116	16.06	46.3	62.3	0.4	9.0	11.0	14.6	26.6	61.6
SAV	15N	inflow	C	Soil	117	12.89	53.2	66.1	2.5	10.4	13.1	12.3	26.8	65.3
SAV	15N	outflow	A	Soil	118	7.20	28.2	35.4	2.5	11.0	20.2	15.5	35.5	84.7
SAV	15N	outflow	B	Soil	119	7.00	23.5	30.5	2.6	8.6	24.4	23.2	43.1	102.0
SAV	15N	outflow	C	Soil	120	7.31	30.3	37.6	2.5	13.3	21.8	21.6	49.3	108.5
Control	1S	inflow	A	Soil	121	10.70	67.6	78.3	0.0	5.1	5.6	7.4	37.1	55.2
Control	1S	inflow	B	Soil	122	6.45	81.9	88.4	2.1	5.3	8.4	13.1	55.8	84.7
Control	1S	inflow	C	Soil	123	9.36	78.9	88.2	2.0	9.7	9.8	14.1	52.5	88.1
Control	1S	outflow	A	Soil	124	14.31	68.8	83.1	4.6	10.5	24.4	22.0	87.8	149.4
Control	1S	outflow	B	Soil	125	8.06	70.9	79.0	0.6	4.1	14.3	11.6	52.1	82.7
Control	1S	outflow	C	Soil	126	7.40	40.1	47.5	0	2.8	8.3	10.6	30.7	51.4
SAV	4S	inflow	A	Soil	127	5.32	42.0	47.4	0	4.7	6.0	6.6	23.3	39.6
SAV	4S	inflow	B	Soil	128	2.83	29.2	32.0	1.2	3.9	5.4	11.6	31.8	53.8
SAV	4S	inflow	C	Soil	129	5.69	37.7	43.4	0.0	8.8	11.3	10.4	35.5	65.9
SAV	4S	outflow	A	Soil	130	5.77	47.3	53.1	0.6	9.7	14.9	11.5	48.9	85.6
SAV	4S	outflow	B	Soil	131	5.48	68.9	74.4	0	6.0	6.7	9.0	27.3	47.9
SAV	4S	outflow	C	Soil	132	4.57	51.8	56.4	1.6	3.3	10.5	12.1	37.8	65.2
MW-AlCl	7S	inflow	A	Soil	133	6.57	54.7	61.3	1.5	3.8	11.1	4.9	40.1	61.3
MW-AlCl	7S	inflow	B	Soil	134	9.51	75.1	84.6	2.4	6.8	8.1	7.3	51.2	75.7
MW-AlCl	7S	inflow	C	Soil	135	8.71	76.9	85.6	0.3	5.0	0.5	3.3	43.3	52.5
MW-AlCl	7S	outflow	A	Soil	136	11.49	78.9	90.4	2.0	5.2	4.5	4.5	46.7	63.0
MW-AlCl	7S	outflow	B	Soil	137	8.79	72.6	81.4	2.3	2.2	7.5	3.8	40.1	55.9
MW-AlCl	7S	outflow	C	Soil	138	11.20	82.8	94.0	2.3	5.0	9.8	4.6	49.2	70.9
Control	15S	inflow	A	Soil	139	9.84	33.5	43.4	8.0	14.9	49.4	29.1	103.3	204.7
Control	15S	inflow	B	Soil	140	7.16	22.4	29.5	2.7	11.9	27.8	11.1	55.4	109.0
Control	15S	inflow	C	Soil	141	5.49	15.3	20.8	1.3	5.1	15.6	5.8	30.1	57.9
Control	15S	outflow	A	Soil	142	4.41	17.7	22.1	0	2.3	7.3	1.5	40.0	50.9
Control	15S	outflow	B	Soil	143	5.03	31.4	36.4	0.3	4.8	11.5	3.6	33.3	53.6
Control	15S	outflow	C	Soil	144	5.71	26.3	32.0	3.5	4.4	15.8	11.5	31.6	66.7
PSTA-shelrock	3S	inflow	A	Soil	145	3.96	751.3	755.3	0.0	2.2	0.0	0.0	31.1	32.9
PSTA-shelrock	3S	inflow	B	Soil	146	4.19	861.1	865.3	0	3.3	0	0	36.7	38.9

Appendix 8: Organic phosphorus fractionation of the soil (0-10 cm) sampled from Test Cells in October 2001.

Treatments	Cell #	Location	Rep	Type	Lab #	NaHCO3 Pi	HCl Pi	SumTPi	NaHCO3 Po	MBP	FAP	HAP	Residue P	SumTPo
						mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}
PSTA-shelrock	3S	inflow	C	Soil	147	3.83	848.7	852.5	0	1.9	0	0	44.6	47.8
PSTA-shelrock	3S	outflow	A	Soil	148	4.19	991.1	995.3	0	1.1	0	0	37.6	39.5
PSTA-shelrock	3S	outflow	B	Soil	149	4.64	888.0	892.6	0	4.0	0	0	30.7	31.8
PSTA-shelrock	3S	outflow	C	Soil	150	4.29	940.1	944.3	0	2.1	0	0	50.2	54.2
PSTA-shelrock	8S	inflow	A	Soil	151	3.54	849.7	853.3	0	2.7	0	0	42.6	44.7
PSTA-shelrock	8S	inflow	B	Soil	152	3.74	940.9	944.6	0	1.7	0	0	37.3	40.0
PSTA-shelrock	8S	inflow	C	Soil	153	3.90	764.8	768.7	0	5.0	0	0	38.3	40.1
PSTA-shelrock	8S	outflow	A	Soil	154	3.27	684.4	687.7	0	1.9	0	0	47.4	52.4
PSTA-shelrock	8S	outflow	B	Soil	155	4.04	911.3	915.3	0	2.1	0	0	46.7	48.7
PSTA-shelrock	8S	outflow	C	Soil	156	3.77	939.9	943.6	0	4.0	0	0	41.0	43.1
SAV	9S	inflow	A	Soil	157	3.77	39.9	43.6	0.7	5.1	11.3	3.4	44.3	63.7
SAV	9S	inflow	B	Soil	158	4.06	37.8	41.9	1.1	9.3	12.8	3.5	42.8	65.4
SAV	9S	inflow	C	Soil	159	4.55	51.5	56.0	0.4	10.4	11.8	0	49.4	68.7
SAV	9S	outflow	A	Soil	160	5.34	73.5	78.9	0	8.0	9.4	0	46.6	61.7
SAV	9S	outflow	B	Soil	161	4.53	77.6	82.1	0	8.7	4.0	0	46.8	56.0
SAV	9S	outflow	C	Soil	162	4.63	89.6	94.3	0.2	6.6	5.9	0	51.8	64.1
PSTA - peat	13S	inflow	A	Soil	163	9.80	157.7	167.5	0	7.2	1.0	1.6	41.3	49.6
PSTA - peat	13S	inflow	B	Soil	164	6.43	152.4	158.8	0.2	3.2	4.9	5.6	51.4	69.4
PSTA - peat	13S	inflow	C	Soil	165	16.06	187.1	203.1	0.0	2.2	0.0	0.0	31.7	34.6
PSTA - peat	13S	outflow	A	Soil	166	10.58	171.7	182.3	0.5	3.6	0.7	1.2	38.2	44.0
PSTA - peat	13S	outflow	B	Soil	167	10.12	179.2	189.4	0.0	1.7	0.2	0.5	34.7	37.6
PSTA - peat	13S	outflow	C	Soil	168	19.70	200.9	220.6	0.1	2.7	1.2	0.5	38.8	44.1

Appendix 9: Inorganic phosphorus fractionation of the floc sampled from Test Cells in October 2001 at air dry condition.

Treatments	Cell #	Location	Rep	Type	Lab #	NaHCO3 Pi	NaOH Pi	0.5M HCl Pi	SumTPi	NaHCO3 Po	NaOH Po	Residue P	SumTPo
						mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}
SAV	1N	inflow	A	Floc	169	123.8	14.5	200.7	339.0	7.8	91.1	186.3	285.1
SAV	1N	inflow	B	Floc	170	60.8	17.8	173.2	251.8	10.3	61.1	151.2	222.6
SAV	1N	inflow	C	Floc	171	133.1	9.1	211.1	353.3	5.7	81.4	151.1	238.1
SAV	1N	outflow	A	Floc	172	36.4	19.5	124.8	180.8	16.3	69.8	171.4	257.5
SAV	1N	outflow	B	Floc	173	108.2	9.4	125.0	242.6	12.2	65.9	113.1	191.2
SAV	1N	outflow	C	Floc	174	113.3	10.7	139.1	263.1	13.6	76.8	111.1	201.6
MW-FeCl	2N	inflow	A	Floc	175								
MW-FeCl	2N	inflow	B	Floc	176								
MW-FeCl	2N	inflow	C	Floc	177	41.3	174.6	278.4	494.3	27.1	164.6	181.0	372.8
MW-FeCl	2N	outflow	A	Floc	178	21.9	9.8	83.8	115.5	5.3	35.9	66.4	107.5
MW-FeCl	2N	outflow	B	Floc	179	47.1	33.6	115.8	196.5	11.0	74.3	131.5	216.7
MW-FeCl	2N	outflow	C	Floc	180								
MW-AlCl	4N	inflow	A	Floc	181	21.0	26.6	578.8	626.3	12.9	103.6	100.7	217.2
MW-AlCl	4N	inflow	B	Floc	182	24.0	22.1	614.7	660.7	19.7	101.7	136.4	257.9
MW-AlCl	4N	inflow	C	Floc	183	23.0	22.4	519.8	565.2	14.4	108.4	117.7	240.5
MW-AlCl	4N	outflow	A	Floc	184	36.4	20.7	158.1	215.2	9.9	27.4	178.0	215.3
MW-AlCl	4N	outflow	B	Floc	185	38.9	36.2	143.7	218.8	12.7	67.7	185.2	265.6
MW-AlCl	4N	outflow	C	Floc	186	47.2	51.0	128.8	227.0	12.6	64.3	203.4	280.3
Control	5N	inflow	A	Floc	187	51.7	17.1	101.4	170.2	12.0	53.6	143.3	208.9
Control	5N	inflow	B	Floc	188	80.8	26.8	133.4	241.0	24.6	98.5	162.7	285.8
Control	5N	inflow	C	Floc	189	87.0	46.0	144.9	278.0	36.6	129.2	268.8	434.7
Control	5N	outflow	A	Floc	190	43.0	28.1	115.7	186.9	13.2	43.9	100.8	157.8
Control	5N	outflow	B	Floc	191	44.7	32.3	79.3	156.3	30.4	73.9	138.1	242.3
Control	5N	outflow	C	Floc	192	92.4	70.9	116.7	280.1	52.1	123.8	233.0	409.0
Control	10N	inflow	A	Floc	193	39.4	20.9	136.6	196.9	20.2	55.8	83.1	159.1
Control	10N	inflow	B	Floc	194	64.1	36.5	195.4	296.1	33.3	115.8	275.9	425.0
Control	10N	inflow	C	Floc	195	116.9	55.7	190.7	363.4	36.2	119.2	237.3	392.7
Control	10N	outflow	A	Floc	196	45.8	21.1	153.4	220.3	17.0	40.6	170.2	227.9
Control	10N	outflow	B	Floc	197	27.4	16.3	108.1	151.8	8.6	44.6	96.1	149.3
Control	10N	outflow	C	Floc	198								
SAV	15N	inflow	A	Floc	199	211.7	3.9	179.3	395.0	10.3	84.0	109.8	204.0
SAV	15N	inflow	B	Floc	200	180.4	4.5	170.3	355.1	14.9	80.7	121.5	217.2
SAV	15N	inflow	C	Floc	201	171.1	13.9	172.5	357.5	27.2	98.5	109.4	235.2

Appendix 9: Inorganic phosphorus fractionation of the floc sampled from Test Cells in October 2001 at air dry condition.

Treatments	Cell #	Location	Rep	Type	Lab #	NaHCO3 Pi	NaOH Pi	0.5M HCl Pi	SumTPi	NaHCO3 Po	NaOH Po	Residue P	SumTPo
						mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}
SAV	15N	outflow	A	Floc	202	121.2	35.2	183.7	340.1	26.6	82.0	167.0	275.6
SAV	15N	outflow	B	Floc	203	82.5	25.0	191.3	298.8	24.1	82.1	178.0	284.1
SAV	15N	outflow	C	Floc	204	59.2	24.7	146.5	230.4	23.9	61.2	95.4	180.5
Control	1S	inflow	A	Floc	205	71.7	30.8	127.9	230.3	45.3	134.1	393.7	573.2
Control	1S	inflow	B	Floc	206								
Control	1S	inflow	C	Floc	207	58.8	45.2	147.6	251.6	59.3	185.3	434.2	678.7
Control	1S	outflow	A	Floc	208	51.3	43.6	132.2	227.1	32.4	146.7	279.6	458.8
Control	1S	outflow	B	Floc	209	45.8	28.6	108.3	182.7	20.1	90.7	249.2	359.9
Control	1S	outflow	C	Floc	210								
SAV	4S	inflow	A	Floc	211	16.7	9.5	73.1	99.2	3.6	29.8	72.6	106.0
SAV	4S	inflow	B	Floc	212	16.8	9.7	82.1	108.6	11.7	62.7	159.1	233.6
SAV	4S	inflow	C	Floc	213								
SAV	4S	outflow	A	Floc	214	6.6	62.0	137.3	206.0	24.0	78.6	243.7	346.3
SAV	4S	outflow	B	Floc	215	14.5	46.0	99.7	160.2	17.5	56.5	155.3	229.3
SAV	4S	outflow	C	Floc	216	25.4	103.6	181.1	310.1	39.2	89.4	217.9	346.4
MW-AlCl	7S	inflow	A	Floc	217	5.0	18.4	147.1	170.5	16.9	45.0	124.6	186.5
MW-AlCl	7S	inflow	B	Floc	218	13.5	21.1	159.9	194.5	13.1	50.2	149.2	212.5
MW-AlCl	7S	inflow	C	Floc	219	17.2	20.0	128.5	165.7	7.4	25.3	107.8	140.5
MW-AlCl	7S	outflow	A	Floc	220	62.4	51.9	150.9	265.2	36.5	104.5	253.3	394.3
MW-AlCl	7S	outflow	B	Floc	221	48.0	32.5	99.8	180.3	15.6	44.1	141.5	201.2
MW-AlCl	7S	outflow	C	Floc	222	49.4	31.1	126.3	206.8	21.4	66.2	206.0	293.7
Control	15S	inflow	A	Floc	223	35.4	16.2	107.5	159.1	25.3	63.5	226.1	314.8
Control	15S	inflow	B	Floc	224								
Control	15S	inflow	C	Floc	225								
Control	15S	outflow	A	Floc	226	29.0	34.1	89.4	152.5	29.3	48.3	249.2	326.8
Control	15S	outflow	B	Floc	227	38.5	46.0	88.6	173.2	28.3	80.5	263.1	372.0
Control	15S	outflow	C	Floc	228	10.5	5.5	14.8	30.8	0.6	10.5	39.1	50.2
PSTA-shelrock	3S	inflow	A	Floc	229	6.3	14.5	501.5	522.3	9.4	31.8	132.3	173.5
PSTA-shelrock	3S	inflow	B	Floc	230								
PSTA-shelrock	3S	inflow	C	Floc	231	1.4	16.1	417.4	434.9	8.7	33.5	125.7	167.9
PSTA-shelrock	3S	outflow	A	Floc	232								
PSTA-shelrock	3S	outflow	B	Floc	233								
PSTA-shelrock	3S	outflow	C	Floc	234	15.9	30.6	525.1	571.7	13.3	47.0	151.5	211.9
PSTA-shelrock	8S	inflow	A	Floc	235	48.1	15.0	176.6	239.7	20.6	34.7	94.7	150.0

Appendix 9: Inorganic phosphorus fractionation of the floc sampled from Test Cells in October 2001 at air dry condition.

Treatments	Cell #	Location	Rep	Type	Lab #	NaHCO3 Pi	NaOH Pi	0.5M HCl Pi	SumTPi	NaHCO3 Po	NaOH Po	Residue P	SumTPo
						mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}
PSTA-shelrock	8S	inflow	B	Floc	236	48.1	6.3	387.7	442.1	10.3	29.7	79.4	119.3
PSTA-shelrock	8S	inflow	C	Floc	237	39.5	12.0	174.3	225.7	22.3	41.9	87.9	152.2
PSTA-shelrock	8S	outflow	A	Floc	238	38.3	13.2	243.5	295.0	18.4	30.7	98.9	148.0
PSTA-shelrock	8S	outflow	B	Floc	239	50.8	11.6	391.0	453.4	11.9	36.3	109.5	157.7
PSTA-shelrock	8S	outflow	C	Floc	240	33.2	8.0	351.8	393.1	13.0	43.0	99.0	154.9
SAV	9S	inflow	A	Floc	241	29.3	8.3	107.0	144.5	19.2	97.4	173.8	290.5
SAV	9S	inflow	B	Floc	242	25.2	9.2	84.5	118.9	22.1	98.9	163.0	283.9
SAV	9S	inflow	C	Floc	243	59.9	7.8	86.9	154.6	13.9	87.6	162.9	264.4
SAV	9S	outflow	A	Floc	244	26.8	29.7	126.6	183.1	14.4	67.8	234.6	316.8
SAV	9S	outflow	B	Floc	245	52.5	64.3	163.0	279.9	39.3	123.2	301.2	463.6
SAV	9S	outflow	C	Floc	246	63.0	47.6	144.8	255.5	29.4	75.9	222.1	327.4
PSTA - peat	13S	inflow	A	Floc	247	49.2	6.7	140.1	196.1	13.5	28.7	117.6	159.8
PSTA - peat	13S	inflow	B	Floc	248	29.1	6.9	161.5	197.5	9.9	28.2	112.5	150.6
PSTA - peat	13S	inflow	C	Floc	249	89.8	5.4	116.5	211.7	17.8	63.4	146.5	227.7
PSTA - peat	13S	outflow	A	Floc	250	33.5	6.3	153.9	193.7	12.8	35.0	121.4	169.2
PSTA - peat	13S	outflow	B	Floc	251	63.1	8.5	163.4	235.0	16.4	58.4	163.2	238.0
PSTA - peat	13S	outflow	C	Floc	252	98.1	11.7	158.8	268.5	18.9	95.3	176.9	291.2

Appendix 10: Inorganic phosphorus fractionation of the soil (0-10 cm) sampled from Test Cells in October 2001 at air dry condition.

Treatments	Cell #	Location	Rep	Type	Lab #	NaHCO3 Pi	NaOH Pi	0.5M HCl Pi	SumTPi	NaHCO3 Po	NaOH Po	Residue P	SumTPo
						mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}
SAV	1N	inflow	A	Soil	253	12.51	5.4	50.7	68.6	1.9	22.2	85.0	109.1
SAV	1N	inflow	B	Soil	254	20.92	7.1	149.7	177.8	2.0	21.7	86.7	110.4
SAV	1N	inflow	C	Soil	255	12.01	6.4	95.0	113.4	3.3	24.9	117.1	145.3
SAV	1N	outflow	A	Soil	256	8.75	6.2	44.3	59.3	2.3	29.6	116.9	148.8
SAV	1N	outflow	B	Soil	257	13.29	9.4	56.9	79.6	4.1	18.4	139.5	161.9
SAV	1N	outflow	C	Soil	258	9.07	6.3	44.4	59.8	1.9	11.3	108.2	121.5
MW-FeCl	2N	inflow	A	Soil	259	22.15	11.6	99.4	133.2	6.3	29.0	110.4	145.7
MW-FeCl	2N	inflow	B	Soil	260	28.11	54.1	72.1	154.3	11.9	53.2	184.2	249.3
MW-FeCl	2N	inflow	C	Soil	261	30.76	33.4	129.4	193.5	10.9	82.7	213.8	307.4
MW-FeCl	2N	outflow	A	Soil	262	11.99	8.0	53.6	73.6	1.1	14.8	68.9	84.8
MW-FeCl	2N	outflow	B	Soil	263	11.94	8.5	64.9	85.3	4.1	24.9	95.1	124.1
MW-FeCl	2N	outflow	C	Soil	264	13.72	7.3	62.5	83.5	3.8	23.0	98.3	125.1
MW-AlCl	4N	inflow	A	Soil	265	15.78	14.6	62.2	92.5	1.9	18.0	86.5	106.4
MW-AlCl	4N	inflow	B	Soil	266	19.22	23.8	53.1	96.1	3.4	33.8	126.0	163.1
MW-AlCl	4N	inflow	C	Soil	267	19.93	25.9	54.6	100.5	4.0	33.0	111.4	148.3
MW-AlCl	4N	outflow	A	Soil	268	16.68	10.1	51.3	78.1	5.0	27.8	147.1	180.0
MW-AlCl	4N	outflow	B	Soil	269	15.48	10.5	99.9	125.8	8.1	41.5	196.5	246.1
MW-AlCl	4N	outflow	C	Soil	270	9.47	6.1	39.8	55.4	3.3	22.6	138.2	164.0
Control	5N	inflow	A	Soil	271	99.11	20.7	75.6	195.5	0.0	34.6	168.8	203.4
Control	5N	inflow	B	Soil	272	12.97	9.3	42.2	64.5	4.3	34.5	130.0	168.7
Control	5N	inflow	C	Soil	273	16.25	17.1	102.0	135.3	5.3	29.1	147.1	181.5
Control	5N	outflow	A	Soil	274	14.05	14.7	57.9	86.7	4.3	40.1	141.5	185.9
Control	5N	outflow	B	Soil	275	11.60	7.7	45.9	65.2	3.4	22.8	109.8	136.0
Control	5N	outflow	C	Soil	276	10.87	7.7	46.8	65.4	2.5	22.8	130.7	155.9
Control	10N	inflow	A	Soil	277	9.23	6.6	56.9	72.7	4.1	26.3	108.9	139.2
Control	10N	inflow	B	Soil	278	9.94	6.5	59.4	75.9	4.2	26.8	111.8	142.8
Control	10N	inflow	C	Soil	279	12.29	8.5	94.4	115.3	3.4	25.7	80.1	109.1
Control	10N	outflow	A	Soil	280	10.23	7.2	102.4	119.8	1.7	18.7	62.7	83.2
Control	10N	outflow	B	Soil	281	9.16	5.5	92.9	107.6	2.3	17.4	65.5	85.2
Control	10N	outflow	C	Soil	282	8.10	4.0	95.5	107.6	1.9	13.9	53.1	69.0
SAV	15N	inflow	A	Soil	283	11.63	6.5	28.2	46.3	0.6	9.6	45.9	56.2
SAV	15N	inflow	B	Soil	284	16.07	9.1	35.7	60.8	0.3	12.4	52.2	65.0
SAV	15N	inflow	C	Soil	285	13.88	7.8	30.4	52.1	0.3	13.9	44.7	58.9

Appendix 10: Inorganic phosphorus fractionation of the soil (0-10 cm) sampled from Test Cells in October 2001 at air dry condition.

Treatments	Cell #	Location	Rep	Type	Lab #	NaHCO3 Pi	NaOH Pi	0.5M HCl Pi	SumTPi	NaHCO3 Po	NaOH Po	Residue P	SumTPo
						mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}
SAV	15N	outflow	A	Soil	286	7.51	3.9	38.6	50.0	1.1	17.5	58.4	77.0
SAV	15N	outflow	B	Soil	287	6.26	3.7	28.0	38.0	2.3	18.4	64.7	85.4
SAV	15N	outflow	C	Soil	288	9.51	4.4	35.9	49.7	2.8	19.8	75.9	98.5
Control	1S	inflow	A	Soil	289	12.12	4.3	75.6	92.0	2.1	7.8	33.3	43.2
Control	1S	inflow	B	Soil	290	6.85	4.1	77.1	88.1	3.5	9.0	57.7	70.2
Control	1S	inflow	C	Soil	291	10.04	4.1	82.3	96.4	3.7	11.3	46.2	61.3
Control	1S	outflow	A	Soil	292	15.67	9.5	55.0	80.2	6.5	16.6	92.2	115.3
Control	1S	outflow	B	Soil	293	7.59	4.1	76.3	88.1	3.6	8.0	55.2	66.9
Control	1S	outflow	C	Soil	294	6.94	3.9	43.0	53.9	1	6.1	32.7	39.9
SAV	4S	inflow	A	Soil	295	5.46	1.9	66.9	74.3	3	4.3	31.3	38.2
SAV	4S	inflow	B	Soil	296	4.63	2.6	28.0	35.2	2.3	6.9	32.9	42.1
SAV	4S	inflow	C	Soil	297	6.52	2.5	57.8	66.9	4.2	8.5	46.1	58.9
SAV	4S	outflow	A	Soil	298	5.42	3.9	50.3	59.6	4.3	12.0	55.1	71.3
SAV	4S	outflow	B	Soil	299	4.35	2.7	53.3	60.3	2	6.8	35.6	44.8
SAV	4S	outflow	C	Soil	300	4.33	3.0	56.4	63.8	3.0	9.1	44.3	56.3
MW-AlCl	7S	inflow	A	Soil	301	5.12	3.5	45.5	54.1	2.9	9.7	51.8	64.4
MW-AlCl	7S	inflow	B	Soil	302	7.74	4.9	68.2	80.9	3.4	8.9	57.7	70.0
MW-AlCl	7S	inflow	C	Soil	303	7.43	4.9	68.7	81.0	3.0	11.3	51.4	65.7
MW-AlCl	7S	outflow	A	Soil	304	9.48	3.9	68.8	82.2	3.6	10.6	50.4	64.6
MW-AlCl	7S	outflow	B	Soil	305	7.64	2.9	81.5	92.0	2.4	11.6	44.0	58.0
MW-AlCl	7S	outflow	C	Soil	306	11.80	4.0	92.8	108.6	2.1	11.2	58.1	71.3
Control	15S	inflow	A	Soil	307	8.67	4.8	27.9	41.4	5.7	28.4	137.2	171.3
Control	15S	inflow	B	Soil	308	7.18	3.4	22.2	32.8	4.4	21.2	84.5	110.0
Control	15S	inflow	C	Soil	309	5.38	3.0	29.6	38.0	3.8	11.1	42.3	57.2
Control	15S	outflow	A	Soil	310	3.05	2.0	17.7	22.8	4	4.1	32.3	40.0
Control	15S	outflow	B	Soil	311	4.47	3.2	40.5	48.2	0.0	11.1	54.2	65.3
Control	15S	outflow	C	Soil	312	6.15	2.8	28.8	37.8	3.9	9.7	60.1	73.7
PSTA-shelrock	3S	inflow	A	Soil	313	5.09	1.8	670.1	676.9	1.5	2.4	23.11	27.0
PSTA-shelrock	3S	inflow	B	Soil	314	6.38	2.7	679.0	688.0	1	0	18.7	19.8
PSTA-shelrock	3S	inflow	C	Soil	315	6.49	1.4	777.0	784.9	1	0.7	20.3	22.0
PSTA-shelrock	3S	outflow	A	Soil	316	5.97	1.0	829.7	836.6	1	2	17.9	20.6
PSTA-shelrock	3S	outflow	B	Soil	317	5.65	0.8	789.5	796.0	1	0	17.4	18.6
PSTA-shelrock	3S	outflow	C	Soil	318	6.57	0.9	841.4	848.8	2	1.2	15.4	18.5
PSTA-shelrock	8S	inflow	A	Soil	319	5.52	1.6	694.5	701.6	1	0.8	15.8	17.3

Appendix 10: Inorganic phosphorus fractionation of the soil (0-10 cm) sampled from Test Cells in October 2001 at air dry condition.

Treatments	Cell #	Location	Rep	Type	Lab #	NaHCO3 Pi	NaOH Pi	0.5M HCl Pi	SumTPi	NaHCO3 Po	NaOH Po	Residue P	SumTPo
						mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}
PSTA-shelrock	8S	inflow	B	Soil	320	5.76	0.8	755.6	762.2	0	0	14.2	14.8
PSTA-shelrock	8S	inflow	C	Soil	321	5.85	1.1	683.9	690.8	1	0	15.0	16.0
PSTA-shelrock	8S	outflow	A	Soil	322	5.94	1.4	626.1	633.4	1	2.1	18.7	21.3
PSTA-shelrock	8S	outflow	B	Soil	323	5.80	0.9	659.4	666.0	1	1	16.9	18.1
PSTA-shelrock	8S	outflow	C	Soil	324	6.10	2.4	790.3	798.8	2	3	14.6	19.1
SAV	9S	inflow	A	Soil	325	4.41	2.0	50.1	56.6	3.8	10.5	42.5	56.8
SAV	9S	inflow	B	Soil	326	4.51	2.0	42.2	48.7	3.6	11.5	42.9	58.1
SAV	9S	inflow	C	Soil	327	7.49	4.2	54.9	66.6	5.8	14.7	46.6	67.2
SAV	9S	outflow	A	Soil	328	6.39	3.1	85.5	95.0	7	10.7	47.0	64.9
SAV	9S	outflow	B	Soil	329	6.54	2.9	71.9	81.4	4	9.9	41.0	54.6
SAV	9S	outflow	C	Soil	330	5.78	3.4	73.7	82.9	3.8	14.4	45.8	64.0
PSTA - peat	13S	inflow	A	Soil	331	13.27	5.0	149.1	167.3	1	7.6	30.9	39.3
PSTA - peat	13S	inflow	B	Soil	332	7.75	6.8	149.8	164.3	2.8	10.7	46.9	60.4
PSTA - peat	13S	inflow	C	Soil	333	19.25	3.6	157.6	180.5	0.4	3.3	22.2	25.8
PSTA - peat	13S	outflow	A	Soil	334	13.36	3.5	148.4	165.2	1.3	3.6	30.5	35.5
PSTA - peat	13S	outflow	B	Soil	335	12.83	6.7	174.6	194.1	1.3	3.8	27.0	32.1
PSTA - peat	13S	outflow	C	Soil	336	22.60	5.6	188.6	216.8	0.2	4.2	30.4	34.7

Appendix 11: Organic phosphorus fractionation of the floc sampled from Test Cells in October 2001 at air dry condition.

Treatments	Cell #	Location	Rep	Type	Lab #	NaHCO3 Pi	HCl Pi	SumTPi	NaHCO3 Po	MBP	FAP	HAP	Residue P	SumTPo
						mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}
SAV	1N	inflow	A	Floc	169	123.8	173.1	296.9	7.8	20.3	76.8	48.9	178.4	332.2
SAV	1N	inflow	B	Floc	170	60.8	144.6	205.4	10.3	14.1	54.7	51.2	143.1	273.3
SAV	1N	inflow	C	Floc	171	133.1	195.4	328.5	5.7	12.8	61.4	64.9	171.7	316.5
SAV	1N	outflow	A	Floc	172	36.4	116.8	153.3	16.3	2.9	68.6	56.9	144.8	289.6
SAV	1N	outflow	B	Floc	173	108.2	86.3	194.6	12.2	10.6	62.1	35.8	150.8	271.5
SAV	1N	outflow	C	Floc	174	113.3	110.0	223.3	13.6	7.2	64.3	37.8	145.2	268.1
MW-FeCl	2N	inflow	A	Floc	175									
MW-FeCl	2N	inflow	B	Floc	176									
MW-FeCl	2N	inflow	C	Floc	177	41.3	438.2	479.5	27.1	25.9	158.4	145.1	109.7	466.2
MW-FeCl	2N	outflow	A	Floc	178	21.9	95.6	117.6	5.3	4.6	28.5	34.2	55.0	127.6
MW-FeCl	2N	outflow	B	Floc	179	47.1	131.7	178.8	11.0	16.4	88.0	55.6	100.3	271.3
MW-FeCl	2N	outflow	C	Floc	180									
MW-AlCl	4N	inflow	A	Floc	181	21.0	574.9	595.9	12.9	3.3	123.3	84.9	56.8	281.2
MW-AlCl	4N	inflow	B	Floc	182	24.0	572.7	596.7	19.7	5.9	129.0	117.1	57.9	329.7
MW-AlCl	4N	inflow	C	Floc	183	23.0	489.3	512.3	14.4	8.3	104.0	126.0	41.7	294.3
MW-AlCl	4N	outflow	A	Floc	184	36.4	127.5	163.9	9.9	5.7	68.2	72.2	160.0	315.9
MW-AlCl	4N	outflow	B	Floc	185	38.9	140.0	179.0	12.7	13.8	75.7	63.3	156.6	322.0
MW-AlCl	4N	outflow	C	Floc	186	47.2	147.0	194.2	12.6	17.1	88.0	94.9	149.9	362.5
Control	5N	inflow	A	Floc	187	51.7	93.4	145.0	12.0	13.1	86.5	62.0	131.1	304.7
Control	5N	inflow	B	Floc	188	80.8	100.8	181.6	24.6	24.8	112.6	41.8	246.1	449.9
Control	5N	inflow	C	Floc	189	87.0	104.2	191.3	36.6	39.6	148.8	66.6	264.9	556.5
Control	5N	outflow	A	Floc	190	43.0	132.5	175.5	13.2	16.1	81.4	38.1	131.1	279.8
Control	5N	outflow	B	Floc	191	44.7	74.9	119.6	30.4	9.8	115.4	73.0	114.9	343.4
Control	5N	outflow	C	Floc	192	92.4	79.2	171.6	52.1	28.6	124.7	104.7	246.2	556.3
Control	10N	inflow	A	Floc	193	39.4	110.9	150.3	20.2	9.4	69.2	86.4	138.0	323.2
Control	10N	inflow	B	Floc	194	64.1	175.1	239.3	33.3	18.8	119.8	107.8	222.7	502.5
Control	10N	inflow	C	Floc	195	116.9	145.4	262.4	36.2	34.9	134.1	110.8	241.6	557.5
Control	10N	outflow	A	Floc	196	45.8	122.4	168.2	17.0	12.2	57.8	65.5	159.4	311.9
Control	10N	outflow	B	Floc	197	27.4	103.7	131.1	8.6	4.7	32.8	19.7	104.7	170.5
Control	10N	outflow	C	Floc	198									
SAV	15N	inflow	A	Floc	199	211.7	158.1	369.8	10.3	11.9	89.5	29.5	185.6	326.8
SAV	15N	inflow	B	Floc	200	180.4	145.3	325.7	14.9	7.8	86.9	29.0	159.7	298.3
SAV	15N	inflow	C	Floc	201	171.1	167.5	338.6	27.2	12.1	108.8	37.7	194.6	380.4

Appendix 11: Organic phosphorus fractionation of the floc sampled from Test Cells in October 2001 at air dry condition.

Treatments	Cell #	Location	Rep	Type	Lab #	NaHCO3 Pi	HCl Pi	SumTPi	NaHCO3 Po	MBP	FAP	HAP	Residue P	SumTPo
						mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}
SAV	15N	outflow	A	Floc	202	121.2	150.1	271.3	26.6	15.9	80.5	48.7	173.1	344.8
SAV	15N	outflow	B	Floc	203	82.5	152.7	235.2	24.1	22.4	84.5	45.0	197.0	373.0
SAV	15N	outflow	C	Floc	204	59.2	131.2	190.4	23.9	13.2	86.8	56.9	123.4	304.2
Control	1S	inflow	A	Floc	205	71.7	125.5	197.2	45.3	10.8	238.7	125.2	308.8	728.8
Control	1S	inflow	B	Floc	206									
Control	1S	inflow	C	Floc	207	58.8	136.4	195.2	59.3	66.1	228.7	160.2	262.1	776.3
Control	1S	outflow	A	Floc	208	51.3	136.0	187.3	32.4	38.1	165.5	129.5	232.3	597.8
Control	1S	outflow	B	Floc	209	45.8	115.2	161.0	20.1	21.2	118.3	86.9	199.3	445.8
Control	1S	outflow	C	Floc	210									
SAV	4S	inflow	A	Floc	211	16.7	52.5	69.2	3.6	8.3	26.4	36.1	56.6	131.0
SAV	4S	inflow	B	Floc	212	16.8	56.2	72.9	11.7	23.5	53.1	46.1	144.2	278.7
SAV	4S	inflow	C	Floc	213									
SAV	4S	outflow	A	Floc	214	6.6	90.8	97.4	24.0	67.3	96.2	51.4	210.5	449.4
SAV	4S	outflow	B	Floc	215	14.5	69.0	83.5	17.5	49.1	70.4	33.6	132.8	303.4
SAV	4S	outflow	C	Floc	216	25.4	93.7	119.1	39.2	126.0	119.8	39.1	199.1	523.3
MW-AlCl	7S	inflow	A	Floc	217	5.0	150.9	155.9	16.9	4.8	81.1	51.9	60.6	215.3
MW-AlCl	7S	inflow	B	Floc	218	13.5	174.1	187.7	13.1	4.6	85.4	44.7	76.4	224.3
MW-AlCl	7S	inflow	C	Floc	219	17.2	133.2	150.4	7.4	0.6	56.8	37.0	62.1	163.9
MW-AlCl	7S	outflow	A	Floc	220	62.4	139.8	202.2	36.5	24.9	126.3	62.4	239.3	489.4
MW-AlCl	7S	outflow	B	Floc	221	48.0	112.9	160.9	15.6	9.3	81.8	42.0	141.6	290.3
MW-AlCl	7S	outflow	C	Floc	222	49.4	121.4	170.9	21.4	2.2	97.0	53.1	171.8	345.5
Control	15S	inflow	A	Floc	223	35.4	87.4	122.8	25.3	21.4	89.3	43.9	251.1	430.9
Control	15S	inflow	B	Floc	224									
Control	15S	inflow	C	Floc	225									
Control	15S	outflow	A	Floc	226	29.0	94.5	123.5	29.3	14.0	125.8	53.4	233.4	456.0
Control	15S	outflow	B	Floc	227	38.5	92.2	130.7	28.3	29.2	165.9	81.7	270.7	575.9
Control	15S	outflow	C	Floc	228	10.5	17.1	27.6	0.6	1.9	23.0	4.4	33.6	63.5
PSTA-shelrock	3S	inflow	A	Floc	229	6.3	531.3	537.6	9.4	31.0	19.6	5.9	135.8	201.8
PSTA-shelrock	3S	inflow	B	Floc	230									
PSTA-shelrock	3S	inflow	C	Floc	231	1.4	428.2	429.6	8.7	34.1	24.1	12.0	134.8	213.7
PSTA-shelrock	3S	outflow	A	Floc	232									
PSTA-shelrock	3S	outflow	B	Floc	233									
PSTA-shelrock	3S	outflow	C	Floc	234	15.9	602.2	618.1	13.3	49.1	20.0	19.3	154.2	255.9
PSTA-shelrock	8S	inflow	A	Floc	235	48.1	149.1	197.2	20.6	18.9	28.8	6.6	117.0	191.9

Appendix 11: Organic phosphorus fractionation of the floc sampled from Test Cells in October 2001 at air dry condition.

Treatments	Cell #	Location	Rep	Type	Lab #	NaHCO3 Pi	HCl Pi	SumTPi	NaHCO3 Po	MBP	FAP	HAP	Residue P	SumTPo
						mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}
PSTA-shelrock	8S	inflow	B	Floc	236	48.1	326.4	374.5	10.3	9.3	0.0	11.6	116.4	147.5
PSTA-shelrock	8S	inflow	C	Floc	237	39.5	117.5	157.0	22.3	31.8	38.5	23.8	71.8	188.2
PSTA-shelrock	8S	outflow	A	Floc	238	38.3	202.0	240.3	18.4	27.8	19.8	26.4	100.6	193.0
PSTA-shelrock	8S	outflow	B	Floc	239	50.8	334.5	385.3	11.9	19.5	19.3	8.1	119.1	177.8
PSTA-shelrock	8S	outflow	C	Floc	240	33.2	359.4	392.6	13.0	34.7	9.4	23.1	99.8	179.9
SAV	9S	inflow	A	Floc	241	29.3	63.9	93.2	19.2	54.3	64.4	34.8	143.8	316.5
SAV	9S	inflow	B	Floc	242	25.2	69.1	94.3	22.1	48.9	53.5	36.8	150.6	311.9
SAV	9S	inflow	C	Floc	243	59.9	54.4	114.4	13.9	41.3	78.3	22.5	156.1	312.0
SAV	9S	outflow	A	Floc	244	26.8	100.9	127.6	14.4	49.7	73.5	36.3	173.2	347.1
SAV	9S	outflow	B	Floc	245	52.5	115.4	167.9	39.3	82.4	138.7	55.9	252.5	568.7
SAV	9S	outflow	C	Floc	246	63.0	100.5	163.5	29.4	33.6	102.5	42.9	171.6	379.9
PSTA - peat	13S	inflow	A	Floc	247	49.2	147.2	196.4	13.5	0	46.0	22.4	100.8	182.6
PSTA - peat	13S	inflow	B	Floc	248	29.1	153.8	182.9	9.9	0	29.8	16.7	96.3	152.7
PSTA - peat	13S	inflow	C	Floc	249	89.8	134.8	224.6	17.8	0	64.0	31.8	135.8	249.4
PSTA - peat	13S	outflow	A	Floc	250	33.5	147.8	181.2	12.8	0	25.8	25.6	113.9	178.2
PSTA - peat	13S	outflow	B	Floc	251	63.1	145.0	208.1	16.4	13.2	50.8	31.6	149.3	261.3
PSTA - peat	13S	outflow	C	Floc	252	98.1	139.9	238.0	18.9	14.3	85.9	28.3	166.5	313.9

Appendix 12: Organic phosphorus fractionation of the soil (0-10 cm) sampled from Test Cells in October 2001 at air dry condition.

Treatments	Cell #	Location	Rep	Type	Lab #	NaHCO3 Pi	HCl Pi	SumTPi	NaHCO3 Po	MBP	FAP	HAP	Residue P	SumTPo
						mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}
SAV	1N	inflow	A	Soil	253	12.5	58.3	70.8	1.9	2.2	30.5	17.4	61.1	113.1
SAV	1N	inflow	B	Soil	254	20.9	136.3	157.2	2.0	5.1	22.6	13.4	61.5	104.6
SAV	1N	inflow	C	Soil	255	12.0	102.7	114.7	3.3	4.3	27.8	31.0	73.9	140.3
SAV	1N	outflow	A	Soil	256	8.7	56.7	65.5	2.3	5.9	39.6	23.2	68.9	139.9
SAV	1N	outflow	B	Soil	257	13.3	70.0	83.3	4.1	8.8	47.2	28.0	68.3	156.3
SAV	1N	outflow	C	Soil	258	9.1	53.2	62.3	1.9	5.2	37.0	17.5	48.7	110.4
MW-FeCl	2N	inflow	A	Soil	259	22.2	99.5	121.7	6.3	0.6	38.7	24.0	75.9	145.5
MW-FeCl	2N	inflow	B	Soil	260	28.1	155.8	183.9	11.9	4.2	91.1	47.4	54.2	208.8
MW-FeCl	2N	inflow	C	Soil	261	30.8	183.3	214.1	10.9	3.5	89.6	55.5	103.6	263.1
MW-FeCl	2N	outflow	A	Soil	262	12.0	66.7	78.7	1.1	2.3	19.4	11.7	48.5	82.9
MW-FeCl	2N	outflow	B	Soil	263	11.9	82.7	94.7	4.1	0.1	30.5	19.3	64.0	118.1
MW-FeCl	2N	outflow	C	Soil	264	13.7	77.1	90.8	3.8	0.2	36.5	24.8	67.2	132.5
MW-AlCl	4N	inflow	A	Soil	265	15.8	85.5	101.3	1.9	0	27.0	12.9	52.2	94.0
MW-AlCl	4N	inflow	B	Soil	266	19.2	82.9	102.1	3.4	3.3	50.1	26.9	85.3	168.9
MW-AlCl	4N	inflow	C	Soil	267	19.9	89.8	109.7	4.0	1.6	42.0	28.5	63.9	140.0
MW-AlCl	4N	outflow	A	Soil	268	16.7	56.5	73.1	5.0	2.3	52.7	33.6	93.2	186.8
MW-AlCl	4N	outflow	B	Soil	269	15.5	126.1	141.5	8.1	8.7	68.6	41.2	129.8	256.4
MW-AlCl	4N	outflow	C	Soil	270	9.5	59.3	68.7	3.3	4.3	43.8	20.8	93.1	165.4
Control	5N	inflow	A	Soil	271	99.1	96.1	195.2	0	15.0	66.5	36.4	92.1	210.0
Control	5N	inflow	B	Soil	272	13.0	50.3	63.2	4.3	1.0	47.7	31.1	95.8	179.8
Control	5N	inflow	C	Soil	273	16.2	52.3	68.6	5.3	0	50.0	24.1	110.8	190.1
Control	5N	outflow	A	Soil	274	14.1	74.9	88.9	4.3	0.8	48.6	27.6	91.8	173.0
Control	5N	outflow	B	Soil	275	11.6	55.7	67.3	3.4	0	39.0	23.4	69.0	134.8
Control	5N	outflow	C	Soil	276	10.9	56.4	67.3	2.5	0	38.9	16.3	104.0	161.7
Control	10N	inflow	A	Soil	277	9.2	71.1	80.3	4.1	0	32.1	16.3	71.1	123.7
Control	10N	inflow	B	Soil	278	9.9	79.0	88.9	4.2	1.5	33.8	21.1	79.3	140.0
Control	10N	inflow	C	Soil	279	12.3	179.2	191.5	3.4	1.3	18.9	14.4	59.8	97.7
Control	10N	outflow	A	Soil	280	10.2	125.8	136.1	1.7	0	16.8	4.4	59.2	82.1
Control	10N	outflow	B	Soil	281	9.2	110.6	119.7	2.3	0.7	19.3	9.8	65.2	97.3
Control	10N	outflow	C	Soil	282	8.1	118.7	126.8	1.9	0.8	11.3	4.5	64.4	82.9
SAV	15N	inflow	A	Soil	283	11.6	36.0	47.7	0.6	0.4	17.8	2.1	37.5	58.5
SAV	15N	inflow	B	Soil	284	16.1	44.4	60.4	0.3	0.3	19.4	6.5	41.6	68.1
SAV	15N	inflow	C	Soil	285	13.9	43.8	57.7	0.3	0	19.8	5.9	35.4	61.3

Appendix 12: Organic phosphorus fractionation of the soil (0-10 cm) sampled from Test Cells in October 2001 at air dry condition.

Treatments	Cell #	Location	Rep	Type	Lab #	NaHCO3 Pi	HCl Pi	SumTPi	NaHCO3 Po	MBP	FAP	HAP	Residue P	SumTPo
						mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}
SAV	15N	outflow	A	Soil	286	7.5	36.4	43.9	1.1	0.4	27.6	11.5	43.1	83.7
SAV	15N	outflow	B	Soil	287	6.3	30.7	37.0	2.3	0	30.7	13.3	44.1	90.3
SAV	15N	outflow	C	Soil	288	9.5	26.6	36.1	2.8	0	37.5	12.2	45.5	97.9
Control	1S	inflow	A	Soil	289	12.1	74.0	86.2	2.1	0	6.0	2.5	47.4	58.0
Control	1S	inflow	B	Soil	290	6.9	76.4	83.3	3.5	0	8.2	2.8	66.2	80.7
Control	1S	inflow	C	Soil	291	10.0	86.2	96.3	3.7	0	9.5	3.7	52.5	69.4
Control	1S	outflow	A	Soil	292	15.7	76.8	92.5	6.5	0	35.5	6.1	100.1	148.1
Control	1S	outflow	B	Soil	293	7.6	64.5	72.1	3.6	0	14.0	2.2	58.4	78.3
Control	1S	outflow	C	Soil	294	6.9	53.5	60.5	1.0	0	7.3	0.4	43.6	52.3
SAV	4S	inflow	A	Soil	295	5.5	70.8	76.3	2.6	0	4.7	0.0	34.3	41.6
SAV	4S	inflow	B	Soil	296	4.6	30.0	34.6	2.3	0	7.8	3.5	34.9	48.5
SAV	4S	inflow	C	Soil	297	6.5	36.5	43.0	4.2	0	17.3	1.7	41.8	64.9
SAV	4S	outflow	A	Soil	298	5.4	65.6	71.0	4.3	0	18.4	3.8	57.3	83.9
SAV	4S	outflow	B	Soil	299	4.4	64.9	69.3	2.4	0	11.0	5.1	38.8	57.3
SAV	4S	outflow	C	Soil	300	4.3	64.6	68.9	3.0	0	13.9	4.5	49.1	70.6
MW-AlCl	7S	inflow	A	Soil	301	5.1	55.9	61.1	2.9	0.1	16.3	5.2	42.8	67.4
MW-AlCl	7S	inflow	B	Soil	302	7.7	81.9	89.7	3.4	0	16.5	6.7	52.0	78.6
MW-AlCl	7S	inflow	C	Soil	303	7.4	73.2	80.7	3.0	0	12.2	7.1	46.8	69.1
MW-AlCl	7S	outflow	A	Soil	304	9.5	66.9	76.4	3.6	0	9.8	3.5	52.6	69.4
MW-AlCl	7S	outflow	B	Soil	305	7.6	84.8	92.4	2.4	0	4.7	3.0	50.2	60.3
MW-AlCl	7S	outflow	C	Soil	306	11.8	93.4	105.2	2.1	0	11.5	3.2	51.7	68.5
Control	15S	inflow	A	Soil	307	8.7	30.2	38.9	5.7	0.4	60.5	23.6	100.3	190.6
Control	15S	inflow	B	Soil	308	7.2	31.2	38.3	4.4	0	39.5	13.2	52.7	109.8
Control	15S	inflow	C	Soil	309	5.4	10.6	16.0	3.8	0	24.5	8.0	43.4	79.8
Control	15S	outflow	A	Soil	310	3.1	15.8	18.8	3.6	0.5	11.6	1.5	30.8	48.1
Control	15S	outflow	B	Soil	311	4.5	40.1	44.6	0	5.2	15.8	3.2	42.4	66.5
Control	15S	outflow	C	Soil	312	6.1	31.9	38.0	3.9	0.1	27.1	9.7	51.5	92.3
PSTA-shelrock	3S	inflow	A	Soil	313	5.1	664.3	669.4	1.5	0	0	0	29.6	31.1
PSTA-shelrock	3S	inflow	B	Soil	314	6.4	675.4	681.8	1.1	0	0	0	30.6	31.6
PSTA-shelrock	3S	inflow	C	Soil	315	6.5	741.9	748.4	1.0	0	0	0	34.9	35.9
PSTA-shelrock	3S	outflow	A	Soil	316	6.0	1009.2	1015.1	0.6	0	0	0	32.1	32.7
PSTA-shelrock	3S	outflow	B	Soil	317	5.6	945.1	950.8	1.2	0	0	0	31.6	32.7
PSTA-shelrock	3S	outflow	C	Soil	318	6.6	909.3	915.9	2.0	0	0	0	28.9	30.9
PSTA-shelrock	8S	inflow	A	Soil	319	5.5	892.8	898.3	0.7	0	0	0	28.5	29.1

Appendix 12: Organic phosphorus fractionation of the soil (0-10 cm) sampled from Test Cells in October 2001 at air dry condition.

Treatments	Cell #	Location	Rep	Type	Lab #	NaHCO3 Pi	HCl Pi	SumTPi	NaHCO3 Po	MBP	FAP	HAP	Residue P	SumTPo
						mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}
PSTA-shelrock	8S	inflow	B	Soil	320	5.8	1000.3	1006.1	0.5	0	0	0	28.4	28.9
PSTA-shelrock	8S	inflow	C	Soil	321	5.9	839.3	845.2	1.1	0	0	0	41.3	42.4
PSTA-shelrock	8S	outflow	A	Soil	322	5.9	639.4	645.3	0.5	0	0	0	32.3	32.8
PSTA-shelrock	8S	outflow	B	Soil	323	5.8	659.8	665.6	0.5	0	0	0	37.5	38.0
PSTA-shelrock	8S	outflow	C	Soil	324	6.1	871.8	877.9	1.7	0	0	0	42.2	43.9
SAV	9S	inflow	A	Soil	325	4.4	122.8	127.3	3.8	0	12.9	4.9	48.7	70.2
SAV	9S	inflow	B	Soil	326	4.5	88.9	93.4	3.6	0	16.4	4.9	38.4	63.3
SAV	9S	inflow	C	Soil	327	7.5	59.8	67.3	5.8	0	22.5	7.2	41.8	77.4
SAV	9S	outflow	A	Soil	328	6.4	87.6	94.0	7.2	0	13.6	4.0	51.6	76.4
SAV	9S	outflow	B	Soil	329	6.5	80.1	86.6	3.7	0	16.3	3.6	46.5	70.2
SAV	9S	outflow	C	Soil	330	5.8	81.3	87.1	3.8	0	16.0	5.1	48.1	73.0
PSTA - peat	13S	inflow	A	Soil	331	13.3	177.8	191.1	0.8	0	0	0.3	48.9	50.0
PSTA - peat	13S	inflow	B	Soil	332	7.7	151.7	159.4	2.8	0	11.4	3.4	54.1	71.7
PSTA - peat	13S	inflow	C	Soil	333	19.3	181.6	200.9	0.4	0	0	0	41.6	42.0
PSTA - peat	13S	outflow	A	Soil	334	13.4	205.1	218.4	1.3	0	0	0	43.0	44.3
PSTA - peat	13S	outflow	B	Soil	335	12.8	174.4	187.3	1.3	0	0	0.4	47.9	49.6
PSTA - peat	13S	outflow	C	Soil	336	22.6	271.8	294.4	0.2	0	0.02	0	44.6	44.8

Appendix 13: Extractable metals of the floc sampled from Test Cells in October 2001.

Treatments	Cell #	Location	Rep	Type	Lab #	HCl-Ca	HCl-Mg	HCl-Fe	HCl-Al	Oxalate Fe (pH=3)	Oxalate Al (pH=3)
						mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}
SAV	1N	inflow	A	Floc	1	230276	59073	181	843	200.0	558.6
SAV	1N	inflow	B	Floc	2	185285	5507	217	1056	232.1	684.4
SAV	1N	inflow	C	Floc	3	242638	6280	175	743	178.8	437.7
SAV	1N	outflow	A	Floc	4	180147	5059	202	833	221.2	560.0
SAV	1N	outflow	B	Floc	5	293824	7225	128	321	99.0	161.3
SAV	1N	outflow	C	Floc	6	247123	6310	157	462	159.2	279.2
MW-FeCl	2N	inflow	A	Floc	7	107819	3720	13536	34661	12851	28708
MW-FeCl	2N	inflow	B	Floc	8	98902	3453	18907	13982	17151	12119
MW-FeCl	2N	inflow	C	Floc	9	102219	3383	16055	18669	15434	14092
MW-FeCl	2N	outflow	A	Floc	10	89450	4035	392	960	343	808
MW-FeCl	2N	outflow	B	Floc	11	102055	3914	744	2166	836	1966
MW-FeCl	2N	outflow	C	Floc	12	114951	3814	2050	4887	2505	4549
MW-AlCl	4N	inflow	A	Floc	13	58824	2134	324	171912	238	73713
MW-AlCl	4N	inflow	B	Floc	14	55868	2258	428	186736	399	121801
MW-AlCl	4N	inflow	C	Floc	15	57353	2163	343	179265	292	101071
MW-AlCl	4N	outflow	A	Floc	16	74612	3280	328	4394	299	3533
MW-AlCl	4N	outflow	B	Floc	17	139686	3757	395	2780	408	2711
MW-AlCl	4N	outflow	C	Floc	18	96302	3126	354	5069	340	4266
Control	5N	inflow	A	Floc	19	129315	4653	222	929	242	726
Control	5N	inflow	B	Floc	20	241699	6201	321	947	376	577
Control	5N	inflow	C	Floc	21	178229	5357	334	1352	362	847
Control	5N	outflow	A	Floc	22	115789	3899	429	1688	433	1127
Control	5N	outflow	B	Floc	23	104675	3834	242	849	265	695
Control	5N	outflow	C	Floc	24	170710	4931	248	644	274	444
Control	10N	inflow	A	Floc	25	127495	4062	266	961	299	693
Control	10N	inflow	B	Floc	26	133563	4267	406	1136	441	754
Control	10N	inflow	C	Floc	27	174553	4518	352	1037	391	640
Control	10N	outflow	A	Floc	28	160968	5203	330	1135	328	804
Control	10N	outflow	B	Floc	29	177485	4473	379	857	341	641
Control	10N	outflow	C	Floc	30	124111	4160	375	1652	372	1141
SAV	15N	inflow	A	Floc	31	290905	7545	197	420	176	193

Appendix 13: Extractable metals of the floc sampled from Test Cells in October 2001.

Treatments	Cell #	Location	Rep	Type	Lab #	HCl-Ca	HCl-Mg	HCl-Fe	HCl-Al	Oxalate Fe (pH=3)	Oxalate Al (pH=3)
						mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}
SAV	15N	inflow	B	Floc	32	272465	7256	160	319	145	173
SAV	15N	inflow	C	Floc	33	244643	6462	177	405	185	212
SAV	15N	outflow	A	Floc	34	188600	5125	190	439	214	305
SAV	15N	outflow	B	Floc	35	214721	6008	209	610	219	358
SAV	15N	outflow	C	Floc	36	158333	4887	198	627	225	448
Control	1S	inflow	A	Floc	37	74951	2530	515	2126	514	1317
Control	1S	inflow	B	Floc	38	93689	3444	956	2242	1039	1338
Control	1S	inflow	C	Floc	39	79734	3176	413	1395	414	847
Control	1S	outflow	A	Floc	40	64752	2569	607	2058	649	1276
Control	1S	outflow	B	Floc	41	70950	2800	903	2255	928	1394
Control	1S	outflow	C	Floc	42	64066	2639	794	2699	764	1602
SAV	4S	inflow	A	Floc	43	88519	2364	183	497	153	311
SAV	4S	inflow	B	Floc	44	227133	5952	207	735	166	314
SAV	4S	inflow	C	Floc	45	154208	5163	213	361	224	219
SAV	4S	outflow	A	Floc	46	191535	9419	307	1156	283	644
SAV	4S	outflow	B	Floc	47	140644	7545	232	602	231	367
SAV	4S	outflow	C	Floc	48	241865	16240	222	477	198	183
MW-AlCl	7S	inflow	A	Floc	49	95169	3302	196	97311	150	63936
MW-AlCl	7S	inflow	B	Floc	50	114691	3486	174	55428	148	48964
MW-AlCl	7S	inflow	C	Floc	51	143762	4003	154	43566	128	39522
MW-AlCl	7S	outflow	A	Floc	52	180610	5148	192	2884	184	3022
MW-AlCl	7S	outflow	B	Floc	53	143688	3323	323	1247	253	1110
MW-AlCl	7S	outflow	C	Floc	54	149708	3872	278	1867	260	1741
Control	15S	inflow	A	Floc	55	171324	5461	325	1570	313	779
Control	15S	inflow	B	Floc	56	91275	3333	664	3554	649	2223
Control	15S	inflow	C	Floc	57	110178	3888	778	3760	913	838
Control	15S	outflow	A	Floc	58	94831	2468	633	2659	613	1761
Control	15S	outflow	B	Floc	59	78536	2598	856	4042	838	2504
Control	15S	outflow	C	Floc	60	23430	506	207	1071	157	637
PSTA-shelrock	3S	inflow	A	Floc	61	181853	2387	1456	890	1579	474
PSTA-shelrock	3S	inflow	B	Floc	62	175593	2732	2574	1468	2943	798

Appendix 13: Extractable metals of the floc sampled from Test Cells in October 2001.

Treatments	Cell #	Location	Rep	Type	Lab #	HCl-Ca	HCl-Mg	HCl-Fe	HCl-Al	Oxalate Fe (pH=3)	Oxalate Al (pH=3)
						mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}
PSTA-shelrock	3S	inflow	C	Floc	63	175455	2854	2535	834	2811	401
PSTA-shelrock	3S	outflow	A	Floc	64	163953	2234	1706	1128	1903	660
PSTA-shelrock	3S	outflow	B	Floc	65	148713	2162	1562	934	1596	498
PSTA-shelrock	3S	outflow	C	Floc	66	147554	2515	2573	755	3010	399
PSTA-shelrock	8S	inflow	A	Floc	67	254317	5497	300	197	227	57
PSTA-shelrock	8S	inflow	B	Floc	68	250956	5473	398	197	336	63
PSTA-shelrock	8S	inflow	C	Floc	69	269246	6176	259	126	198	47
PSTA-shelrock	8S	outflow	A	Floc	70	235878	4596	610	382	506	119
PSTA-shelrock	8S	outflow	B	Floc	71	230550	3885	675	381	620	126
PSTA-shelrock	8S	outflow	C	Floc	72	232784	4721	599	437	501	131
SAV	9S	inflow	A	Floc	73	250051	7363	180	436	119	138
SAV	9S	inflow	B	Floc	74	241121	6820	182	462	112	163
SAV	9S	inflow	C	Floc	75	241602	7765	193	413	125	152
SAV	9S	outflow	A	Floc	76	146105	5533	277	549	267	374
SAV	9S	outflow	B	Floc	77	178443	6562	255	513	270	271
SAV	9S	outflow	C	Floc	78	184912	6968	304	450	293	243
PSTA - peat	13S	inflow	A	Floc	79	229980	6040	329	651	224	393
PSTA - peat	13S	inflow	B	Floc	80	230885	5775	362	696	218	393
PSTA - peat	13S	inflow	C	Floc	81	281175	8700	146	240	63	87
PSTA - peat	13S	outflow	A	Floc	82	225496	5149	421	551	301	290
PSTA - peat	13S	outflow	B	Floc	83	233952	6000	341	542	205	254
PSTA - peat	13S	outflow	C	Floc	84	245717	6843	295	432	169	182

Appendix 14: Extractable metals of the soil (0-10 cm) sampled from Test Cells in October 2001.

Treatments	Cell #	Location	Rep	Type	Lab #	HCl-Ca mg kg^{-1}	HCl-Mg mg kg^{-1}	HCl-Fe mg kg^{-1}	HCl-Al mg kg^{-1}	Oxalate Fe (pH=3) mg kg^{-1}	Oxalate Al (pH=3) mg kg^{-1}
SAV	1N	inflow	A	Soil	85	84930	3189	161	545	178	515
SAV	1N	inflow	B	Soil	86	166075	4877	473	589	586	534
SAV	1N	inflow	C	Soil	87	80974	3278	184	815	207	717
SAV	1N	outflow	A	Soil	88	77810	3396	191	767	216	753
SAV	1N	outflow	B	Soil	89	103443	3757	246	897	249	758
SAV	1N	outflow	C	Soil	90	101854	3667	204	640	221	610
MW-FeCl	2N	inflow	A	Soil	91	146421	4884	1585	1587	2139	1661
MW-FeCl	2N	inflow	B	Soil	92	64307	3545	4149	4673	4787	4059
MW-FeCl	2N	inflow	C	Soil	93	97796	2936	2660	2288	3504	2349
MW-FeCl	2N	outflow	A	Soil	94	126804	5401	265	507	277	477
MW-FeCl	2N	outflow	B	Soil	95	113330	3742	342	746	392	742
MW-FeCl	2N	outflow	C	Soil	96	104712	3100	278	658	327	656
MW-AlCl	4N	inflow	A	Soil	97	118489	3842	217	3643	257	3772
MW-AlCl	4N	inflow	B	Soil	98	67134	2761	253	5832	306	5659
MW-AlCl	4N	inflow	C	Soil	99	95291	2695	221	7495	253	7762
MW-AlCl	4N	outflow	A	Soil	100	74704	3009	240	1621	315	1535
MW-AlCl	4N	outflow	B	Soil	101	120272	6811	388	1108	433	1034
MW-AlCl	4N	outflow	C	Soil	102	75854	2979	221	1099	267	1002
Control	5N	inflow	A	Soil	103	98998	3151	224	1067	305	1035
Control	5N	inflow	B	Soil	104	98650	3100	241	1016	311	948
Control	5N	inflow	C	Soil	105	76400	2980	271	1153	354	1032
Control	5N	outflow	A	Soil	106	97044	2926	220	721	285	716
Control	5N	outflow	B	Soil	107	100302	2807	206	626	265	650
Control	5N	outflow	C	Soil	108	84722	2693	268	1314	362	1250
Control	10N	inflow	A	Soil	109	104541	3528	228	654	302	650
Control	10N	inflow	B	Soil	110	108943	3295	417	833	619	833
Control	10N	inflow	C	Soil	111	160100	3920	374	705	438	659
Control	10N	outflow	A	Soil	112	197982	5034	461	692	482	631
Control	10N	outflow	B	Soil	113	193936	4801	445	733	507	707
Control	10N	outflow	C	Soil	114	210800	5100	427	657	446	586

Appendix 14: Extractable metals of the soil (0-10 cm) sampled from Test Cells in October 2001.

Treatments	Cell #	Location	Rep	Type	Lab #	HCl-Ca mg kg^{-1}	HCl-Mg mg kg^{-1}	HCl-Fe mg kg^{-1}	HCl-Al mg kg^{-1}	Oxalate Fe (pH=3) mg kg^{-1}	Oxalate Al (pH=3) mg kg^{-1}
SAV	15N	inflow	A	Soil	115	61546	1187	220	734	237	623
SAV	15N	inflow	B	Soil	116	59823	1291	193	631	213	525
SAV	15N	inflow	C	Soil	117	54383	1337	236	614	267	528
SAV	15N	outflow	A	Soil	118	47852	1559	184	560	185	481
SAV	15N	outflow	B	Soil	119	45374	1671	193	738	198	569
SAV	15N	outflow	C	Soil	120	49345	1690	175	662	185	513
Control	1S	inflow	A	Soil	121	95760	1669	654	946	665	751
Control	1S	inflow	B	Soil	122	96553	1872	918	1045	1048	799
Control	1S	inflow	C	Soil	123	120383	2082	656	894	631	707
Control	1S	outflow	A	Soil	124	63446	1652	1046	1628	1127	1171
Control	1S	outflow	B	Soil	125	67535	1472	1026	1168	1160	896
Control	1S	outflow	C	Soil	126	60322	991	559	1040	547	779
SAV	4S	inflow	A	Soil	127	82692	1283	385	523	357	441
SAV	4S	inflow	B	Soil	128	47892	832	439	1089	442	827
SAV	4S	inflow	C	Soil	129	60089	1221	259	723	269	565
SAV	4S	outflow	A	Soil	130	55040	1347	396	1000	414	772
SAV	4S	outflow	B	Soil	131	78000	1635	349	567	338	450
SAV	4S	outflow	C	Soil	132	64207	1351	497	909	554	707
MW-AlCl	7S	inflow	A	Soil	133	111631	2002	611	686	733	617
MW-AlCl	7S	inflow	B	Soil	134	98008	2659	551	1249	683	1199
MW-AlCl	7S	inflow	C	Soil	135	116884	2444	627	719	752	664
MW-AlCl	7S	outflow	A	Soil	136	116600	2419	564	684	590	594
MW-AlCl	7S	outflow	B	Soil	137	164020	2163	608	492	625	426
MW-AlCl	7S	outflow	C	Soil	138	155792	2584	824	636	829	552
Control	15S	inflow	A	Soil	139	60657	2918	716	1195	927	969
Control	15S	inflow	B	Soil	140	48843	2049	437	794	482	581
Control	15S	inflow	C	Soil	141	20534	1185	265	963	302	764
Control	15S	outflow	A	Soil	142	65316	921	341	905	341	758
Control	15S	outflow	B	Soil	143	111597	1441	345	692	376	623
Control	15S	outflow	C	Soil	144	51248	1248	429	783	566	682
PSTA-shelrock	3S	inflow	A	Soil	145	194397	1198	1311	327	1509	229

Appendix 14: Extractable metals of the soil (0-10 cm) sampled from Test Cells in October 2001.

Treatments	Cell #	Location	Rep	Type	Lab #	HCl-Ca mg kg^{-1}	HCl-Mg mg kg^{-1}	HCl-Fe mg kg^{-1}	HCl-Al mg kg^{-1}	Oxalate Fe (pH=3) mg kg^{-1}	Oxalate Al (pH=3) mg kg^{-1}
PSTA-shelrock	3S	inflow	B	Soil	146	194716	1094	1608	367	1849	249
PSTA-shelrock	3S	inflow	C	Soil	147	202701	1405	1021	366	1007	231
PSTA-shelrock	3S	outflow	A	Soil	148	173868	1057	1154	382	1262	263
PSTA-shelrock	3S	outflow	B	Soil	149	182198	1086	855	382	842	245
PSTA-shelrock	3S	outflow	C	Soil	150	188273	1076	981	424	1075	287
PSTA-shelrock	8S	inflow	A	Soil	151	201212	1381	731	364	773	233
PSTA-shelrock	8S	inflow	B	Soil	152	212331	1568	848	373	892	232
PSTA-shelrock	8S	inflow	C	Soil	153	201303	1561	867	363	831	222
PSTA-shelrock	8S	outflow	A	Soil	154	217490	1241	878	680	859	417
PSTA-shelrock	8S	outflow	B	Soil	155	186673	1465	880	633	838	428
PSTA-shelrock	8S	outflow	C	Soil	156	212426	1335	723	340	785	222
SAV	9S	inflow	A	Soil	157	66896	1585	396	829	393	652
SAV	9S	inflow	B	Soil	158	94822	1856	588	531	707	430
SAV	9S	inflow	C	Soil	159	75886	2018	490	507	646	440
SAV	9S	outflow	A	Soil	160	158002	2666	374	446	353	442
SAV	9S	outflow	B	Soil	161	169378	2520	541	470	423	455
SAV	9S	outflow	C	Soil	162	157692	2448	359	477	411	468
PSTA - peat	13S	inflow	A	Soil	163	224048	2896	664	518	731	455
PSTA - peat	13S	inflow	B	Soil	164	160159	3053	546	619	647	545
PSTA - peat	13S	inflow	C	Soil	165	277806	3803	710	459	633	367
PSTA - peat	13S	outflow	A	Soil	166	242238	3024	670	561	627	464
PSTA - peat	13S	outflow	B	Soil	167	245409	3249	782	522	747	433
PSTA - peat	13S	outflow	C	Soil	168	243960	3183	699	607	669	499