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Supplement of

Forms of organic phosphorus in wetland soils

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Supplementary Table 1. Twenty eight wetland sites sampled for characterization of phosphorus composition.

Wetland		Location	Wetland Type [†]	Climate [‡]		Vegetation Type [§]	Dominant species	Potential impacts [#]
				Temp (°C)	Precip. (m)			
1	8 mile	Al, USA	Bog	0.1	0.63	Persistent emergent (Moss)	<i>Sphagnum, Carex sp.</i>	
2	Laguna Papallacta,	Ecuador	Cushion forming, Paramo	19.2	0.97	Persistent emergent (Herbaceous)	Self-emergent succulent species <i>Distichia muscoides, Spagnum</i>	Cattle Grazing
3	Wicken Fen	UK	Fen	9.6	0.54	Persistent emergent (Herbaceous)	<i>Cladium mariscus</i>	Sedge Harvesting since 1419
4	Houghton lake (CT350)	MI, USA	Treatment wetland	6.1	0.75	Persistent emergent (Herbaceous)	<i>Typha sp.</i>	Intermediate P loading
5	Houghton lake (550C)	MI, USA	Treatment wetland	6.1	0.75	Persistent emergent (Herbaceous)	Cyperaceae sp. <i>Typha</i>	Low P loading
6	Houghton lake (P)	MI, USA	Treatment wetland	6.1	0.75	Persistent emergent (Herbaceous)	<i>Typha.</i>	High P loading
7	Francis Marion National Forest (FMNF) Bay 1	SC,USA	Carolina Bay	17.9	1.29	Persistent emergent (Forested)	<i>Acer rubrum (var. trilobum), Nyssa biflora and Nyssa aquatica, Lyonia lucida, Ilex myrtifolia</i>	
8	Francis Marion National Forest (FMNF) Bay 2	SC,USA	Carolina Bay	17.9	1.29	Persistent emergent (Forested)	<i>Taxodium ascendans, Nyssa biflora, Lyonia lucida, Carex striata, Woodwardia virginica</i>	
9	Francis Marion National Forest (FMNF) Bay 3	SC,USA	Carolina Bay	17.9	1.29	Persistent emergent (Herbaceous)	<i>Ilex glabra, Iris tridentata, Amphicarpum muhlenbergianum, Eleocharis spp., Melanocarpa, tricostrata, and Lachnanthes caroliniana</i>	Periodic burning
10	Francis Marion National Forest (FMNF) Bay 4	SC,USA	Carolina Bay	17.9	1.29	Persistent emergent (Forested)	<i>Nyssa biflora, Taxodium ascendans, Acer rubrum, Lyonia lucida, Cyrilla racemiflora, Pinus taeda</i>	
11	Savannah River Site (SRS) Bay 1	SC,USA	Carolina Bay	16.8	1.23	Persistent emergent (forested/herbaceous)	<i>Panicum hemitomon, Nyssa biflora, Cephalanthus occidentalis, Utricularia spp., Sphagnum spp., Pontederia cordata var. lancifolia</i>	

12	Savannah River Site (SRS) Bay 2	SC,USA	Carolina Bay	16.8	1.23	Persistent emergent (Herbaceous)	<i>Panicum hemitomon</i> , <i>Sphagnum</i> spp., <i>Pontederia cordata</i> var. <i>lanceifolia</i> , <i>Juncus canadensis</i> , <i>Cephalanthus occidentalis</i> , <i>Acer rubrum</i> (var. <i>trilobum</i>)	
13	Savannah River Site (SRS) Bay 3	SC,USA	Carolina Bay	16.8	1.23	Open water /herbaceous	<i>Nymphaea odorata</i> , <i>Panicum hemitomon</i> , <i>Utricularia</i> spp., <i>Leersia hexandra</i> , <i>Eleocharis melanocarpa</i>	
14	Savannah River Site (SRS) Bay 4	SC,USA	Carolina Bay	16.8	1.23	Persistent emergent (Forested)	<i>Liquidambar styraciflua</i> , <i>Acer rubrum</i> (var. <i>trilobum</i>), <i>Nyssa biflora</i> , <i>Taxodium ascendans</i> , <i>Smilax rotundifolia</i>	
15	Larry Fen	NY, USA	Rich Fen	7.7	1.00	Persistent emergent (Herbaceous)	<i>Carex</i> sp. <i>Campyllum stellatum</i>	
16	Fish Fen	NY, USA	Rich Fen	7.7	1.00	Persistent emergent (Herbaceous)	<i>Typha angustifolia</i> . <i>Carex</i> sp. <i>Campyllum stellatum</i> , <i>Sphagnum</i> spp. <i>Calliergonella cuspidata</i>	
17	Hidden	Belize	Oligotrophic Sumpland	25.0	1.59	Persistent emergent (Herbaceous/ Cyanobacteria)	<i>Eleocharis cellulosa</i> , <i>Cyanobacteria</i> spp.	salt intrusion
18	Quiet	Belize	Sumpland	25.0	1.59	Persistent emergent (Herbaceous/ Cyanobacteria)	<i>Eleocharis cellulosa</i> , <i>Cyanobacteria</i> spp.	salt intrusion
19	Doubloon	Belize	Sumpland	25.0	1.59	Persistent emergent (Herbaceous/ Cyanobacteria)	<i>Eleocharis cellulosa</i> , <i>Cyanobacteria</i> spp.	salt intrusion
20	Changuinola Site 1	Panama	Tropical peat dome	25.9	2.84	Persistent emergent (Forested)	<i>Raphia tadeiga</i>	
21	Changuinola Site 2	Panama	Tropical peat dome	25.9	2.84	Persistent emergent (Forested)	<i>Camptosperma panamensis</i> , <i>Cassipourea elliptica</i> (Sw.) Poir, <i>Drypetes standleyi</i> G.L. Webster	
22	Changuinola Site 3	Panama	Tropical peat dome	25.9	2.84	Persistent emergent (Forested)	<i>Camptosperma panamensis</i> , <i>Cyrilla racemiflora</i> , sawgrass	
23	WCA 3A	FL, USA	Calcareous Fen	23.5	1.34	Open water	<i>Nymphaea</i> sp. <i>Utricularia</i>	
24	Everglades National Park	FL, USA	Calcareous Fen	23.7	1.27	Persistent emergent	<i>Cladium jamaicense</i>	

						(Herbaceous)		
25	Ny Alesund	Spitsbergen, Norway	Wet tundra	-5.2	0.43	Persistent emergent (Moss)	<i>Calliergon richardsoni</i> , <i>Poa arctica</i> , <i>Dupotia</i> species	Geese grazing
26	Stordalen	Abisko, Sweden	Mire	-1.0	0.40	Persistent emergent (Moss)	<i>Spagnum fuscum</i> , <i>Betula nana</i> , <i>Rubus chamaemorus</i> , <i>Vaccinium vitis idaeae</i> , <i>Empetrum nigrum</i>	
27	Bog 8	Canada	Ombrotrophic Bog	-3.1	0.54	Persistent emergent (Moss)	<i>Sphagnum fuscum</i> , graminoids, Lichens	
28	Fen 1	Canada	Fen	-5.2	0.47	Persistent emergent (Herbaceous)	<i>Carex</i> sp.	

† = common wetland description

‡ = Average annual temperature and precipitation estimates, derived from WorldClim data set (1950- 2000)

§ = vegetation descriptor based upon Cowardin (1979) classification

¶ = dominant vegetation species noted in the field

= potential external impacts noted that may affect P cycling

Supplementary Table 2. Biogeochemical properties of surface (0 – 10 cm) soils in 28 palustrine wetland systems. Values represent arithmetic mean \pm 1 SD.

Site	pH	Organic matter %		Phosphorus $\mu\text{g g}^{-1}$		Total C		Total N		Total Al		Total Ca		Total Fe		Molar Ratio			
						mg g^{-1}		mg g^{-1}		mg g^{-1}		mg g^{-1}		mg g^{-1}		C:P	N:P		
Group A																			
27	3.9	97	\pm 1	356	\pm 62	436	\pm 11	7.8	\pm 0.3	0.5	\pm 0.2	3.2	\pm 0.7	0.3	\pm 0.0	3220	\pm 493	49	\pm 8
26	4.1	100	\pm na	238	\pm na	424	\pm na	6.3	\pm	0.4	\pm na	1.8	\pm na	0.2	\pm na	4596	\pm na	59	\pm na
22	3.7	84	\pm 5	579	\pm 102	424	\pm 30	21.7	\pm 3.1	1.2	\pm 0.2	1.0	\pm 0.1	1.5	\pm 0.4	1929	\pm 289	83	\pm 5
21	3.6	93	\pm 1	852	\pm 130	485	\pm 12	25.1	\pm 1.8	1.3	\pm 0.1	3.3	\pm 0.5	3.7	\pm 0.6	1498	\pm 234	66	\pm 7
20	3.8	88	\pm 1	1124	\pm 38	489	\pm 4	27.7	\pm 0.8	3.0	\pm 0.1	1.4	\pm 0.2	6.2	\pm 0.7	1125	\pm 40	55	\pm 3
1	4.6	92	\pm 1	986	\pm 72	410	\pm 9	12.4	\pm 1.5	3.0	\pm 0.5	4.7	\pm 0.5	15.0	\pm 2.5	1060	\pm 70	27	\pm 2
mean	4.0	92		689		445		16.8		1.6		2.6		4.5		2238		57	
min	3.6	84		238		410		6.3		0.4		1.0		0.2		1060		27	
max	4.6	100		1124		489		27.7		3.0		4.7		15.0		4596		83	
Group B																			
14	4.4	23	\pm 5	918	\pm 253	94	\pm 25	7.2	\pm 2.3	77.1	\pm 3.3	0.2	\pm 0.1	6.2	\pm 1.9	285	\pm 120	18	\pm 7
13	4	25	\pm 18	347	\pm 233	117	\pm 89	9.3	\pm 6.9	26.2	\pm 6.7	0.2	\pm 0.2	2.9	\pm 0.7	814	\pm 121	56	\pm 6
12	3.9	55	\pm 10	1056	\pm 120	307	\pm 67	21.4	\pm 4.5	15.7	\pm 4.0	1.2	\pm 0.6	3.7	\pm 0.5	745	\pm 97	45	\pm 6
11	4.3	24	\pm 11	918	\pm 320	105	\pm 58	8.7	\pm 4.1	72.9	\pm 8.2	0.4	\pm 0.3	5.6	\pm 0.8	283	\pm 59	21	\pm 3
10	4.4	48	\pm 18	752	\pm 422	239	\pm 115	12.7	\pm 6.0	34.7	\pm 7.6	0.3	\pm 0.3	4.7	\pm 1.1	1079	\pm 65	49	\pm 4
9	4.2	9	\pm 4	51	\pm 35	44	\pm 16	2.2	\pm 0.8	2.9	\pm 1.5	0	\pm 0.1	0.7	\pm 0.3	2551	\pm 748	111	\pm 26
8	3.5	69	\pm 21	750	\pm 165	376	\pm 131	19.0	\pm 5.3	8.2	\pm 2.6	2.0	\pm 1.3	2.1	\pm 0.5	1275	\pm 189	56	\pm 4
7	3.6	50	\pm 17	925	\pm 169	260	\pm 87	14.5	\pm 3.6	25.8	\pm 2.0	0.7	\pm 0.4	3.3	\pm 1.6	729	\pm 191	35	\pm 6
mean	4.0	38		715		193		11.9		32.9		0.6		3.6		970		49	
min	3.5	9		51		44		2.2		2.9		-0.1		0.7		283		18	
max	4.4	69		1056		376		21.4		77.1		2.0		6.2		2551		111	
Group C																			
28	6.3	89	\pm 1	679	\pm 5	406	\pm 2	26.3	\pm 5.0	1.0	\pm 0.3	18.4	\pm 4.4	0.4	\pm 0.0	1545	\pm 19	86	\pm 15
24	6.1	90	\pm 1	310	\pm 55	443	\pm 12	30.4	\pm 2.7	3.5	\pm 1.6	26.1	\pm 1.7	0.2	\pm 0.0	3800	\pm 843	225	\pm 62
23	5.9	93	\pm 1	277	\pm 16	445	\pm 14	36.1	\pm 2.0	2.3	\pm 0.5	26.0	\pm 1.2	0.2	\pm 0.0	4170	\pm 348	290	\pm 31
16	7	85	\pm 2	1184	\pm 138	421	\pm 17	28.3	\pm 1.3	3.6	\pm 1.4	31.6	\pm 1.5	4.6	\pm 1.6	929	\pm 120	53	\pm 6
15	7	56	\pm 5	1184	\pm 52	270	\pm 24	20.3	\pm 1.7	20.4	\pm 4.2	27.3	\pm 2.6	18.8	\pm 1.0	591	\pm 74	38	\pm 5
6	6.4	70	\pm 6	3516	\pm 442	353	\pm 26	35.2	\pm 2.8	15.2	\pm 3.7	23.0	\pm 5.0	18.9	\pm 5.4	261	\pm 15	22	\pm 1
5	6.1	94	\pm 0	982	\pm 67	455	\pm 6	20.1	\pm 1.2	0.9	\pm 0.1	8.6	\pm 0.8	7.2	\pm 0.8	1201	\pm 87	45	\pm 4
4	7.2	94	\pm 0	1439	\pm 59	452	\pm 1	26.2	\pm 0.6	1.0	\pm 0.2	14.0	\pm 1.1	6.0	\pm 0.2	811	\pm 31	40	\pm 1
3	7.3	78	\pm 15	937	\pm 85	353	\pm 14	26.3	\pm 2.2	3.7	\pm 0.6	96.2	\pm 25	12.2	\pm 1.5	976	\pm 60	62	\pm 1

	2	6.7	84 ± 2	875 ± 175	399 ± 14	14.8 ± 2.1	3.4 ± 0.8	20.1 ± 2.3	3.7 ± 1.2	1213 ± 230	38 ± 4
mean		6.6	83	1138	400	26.4	5.5	29.1	7.2	1550	90
min		5.9	56	277	270	14.8	0.9	8.6	0.2	261	22
max		7.3	94	3516	455	36.1	20.4	96.2	18.9	4170	290
Group D											
	25	7	29 ± 10	1513 ± 773	133 ± 57	5.8 ± 2.0	19.9 ± 2.5	15.1 ± 3.3	0.2 ± 0.0	247 ± 114	9 ± 3
	19	7.6	16 ± 3	126 ± 25	153 ± 0	5.3 ± 0.1	2.3 ± 0.7	334 ± 15	0.2 ± 0.0	3213 ± 603	96 ± 19
	18	7.5	30 ± 1	287 ± 324	70 ± 6	6.0 ± 0.5	45.8 ± 3.2	14.4 ± 0.8	0.2 ± 0.0	1338 ± 954	94 ± 65
	17	7.3	25 ± 2	192 ± 55	162 ± 12	11.4 ± 0.2	15.3 ± 7.1	232 ± 51	0.2 ± 0.0	2305 ± 654	137 ± 34
mean		7.4	25	530	129	7.1	20.8	149	0.2	1776	84
min		7.0	16	126	70	5.3	2.3	14.4	0.2	247	9
max		7.6	30	1513	162	11.4	45.8	333	0.2	3213	137

1 Supplementary Table 3: Phosphorus composition of surface soils as determined by solution ³¹P NMR spectroscopy. Values represent concentration
 2 $\mu\text{g g}^{-1}$ (% of total soil P)
 3
 4

	NaOH- TP [‡]		Phosph-P [§]		Ortho-P [¶]		Mono-P ^{††}		DNA		Phospholipids		Total inorganic Polyphosphates		Organic P		Mono:Dies ^{**}	
	$\mu\text{g g}^{-1}$ (% of total soil P)																	
Group A																		
27	138	(39)			36	(10)	31	(9)	23	(7)	9	(3)	38	(11)	64	(18)	0.9	
26	190	(80)			70	(29)	44	(18)	25	(11)	10	(4)	41	(17)	79	(33)	1.3	
22	261	(45)			54	(9)	68	(12)	57	(10)	3	(1)	79	(14)	128	(22)	1.1	
21	320	(38)	8	(1)	95	(11)	55	(6)	31	(4)	12	(1)	118	(14)	107	(13)	1.3	
20	516	(46)	20	(2)	171	(15)	162	(14)	35	(3)	6	(1)	123	(11)	222	(20)	3.9	
1	758	(77)			201	(20)	337	(34)	135	(14)	42	(4)	43	(4)	514	(52)	1.9	
mean	364	(54)	14	(2)	105	(16)	116	(16)	51	(8)	14	(2)	74	(12)	186	(26)	1.7	
max	758	(80)	20	(2)	201	(29)	337	(34)	135	(14)	42	(4)	123	(17)	514	(52)	3.7	
min	138	(38)	8	(1)	36	(9)	31	(6)	23	(3)	3	(1)	38	(4)	64	(13)	0.9	
Group B																		
14	534	(58)	12	(1)	267	(29)	189	(21)	47	(5)	10	(1)	9	(1)	258	(28)	3.3	
13	219	(63)	4	(1)	56	(16)	110	(32)	25	(7)	15	(4)	9	(3)	154	(44)	2.8	
12	722	(68)	44	(4)	179	(17)	390	(37)	65	(6)	19	(2)	25	(2)	518	(49)	4.6	
11	598	(65)	14	(2)	128	(14)	408	(44)	32	(3)	12	(1)	4	(0)	466	(51)	9.3	
10	497	(66)	18	(2)	120	(16)	252	(33)	57	(8)	24	(3)	26	(3)	351	(47)	3.1	
9 [†]	63	(125)			14	(27)	38	(76)	6	(12)			5	(10)	45	(88)	6.2	
8	476	(63)	16	(2)	138	(18)	192	(26)	67	(9)	14	(2)	50	(7)	288	(38)	2.4	
7	637	(69)	29	(3)	137	(15)	368	(40)	56	(6)	17	(2)	30	(3)	470	(51)	5	
mean	526	(65)	20	(2)	146	(18)	273	(33)	50	(6)	16	(2)	22	(3)	358	(44)	4	
max	722	(69)	44	(4)	267	(29)	408	(44)	67	(9)	24	(4)	50	(7)	518	(51)	9.3	
min	219	(58)	4	(1)	56	(14)	110	(21)	25	(3)	10	(1)	4	(1)	154	(28)	2.4	
Group C																		
28	283	(42)			54	(8)	77	(11)	57	(8)	22	(3)	74	(11)	156	(23)	1	
24	130	(42)			46	(15)	38	(12)	27	(9)	9	(3)	10	(3)	75	(24)	1.1	
23	102	(37)			38	(14)	28	(10)	18	(7)	6	(2)	11	(4)	53	(19)	1.2	
16	595	(50)			131	(11)	270	(23)	106	(9)	28	(2)	60	(5)	404	(34)	2	

15	753	(64)	118	(10)	461	(39)	88	(7)	37	(3)	50	(4)	586	(49)	3.7
6	2569	(73)	1759	(50)	407	(12)	141	(4)	64	(2)	197	(6)	612	(17)	2
5	593	(60)	225	(23)	170	(17)	96	(10)	30	(3)	72	(7)	296	(30)	1.3
4	909	(63)	295	(20)	317	(22)	142	(10)	67	(5)	88	(6)	526	(37)	1.5
3	789	(84)	167	(18)	344	(37)	144	(15)	62	(7)	73	(8)	549	(59)	1.7
2	609	(70)	244	(28)	176	(20)	76	(9)	31	(4)	81	(9)	284	(32)	1.6
mean	733	(59)	308	(20)	229	(20)	90	(9)	36	(3)	72	(6)	354	(32)	2
max	2569	(84)	1759	(50)	461	(39)	144	(15)	67	(7)	197	(11)	612	(59)	4
min	102	(37)	38	(8)	28	(10)	18	(4)	6	(2)	10	(3)	53	(17)	1
Group D															
25	534	(35)	292	(19)	221	(15)	11	(1)	10	(1)			242	(16)	10.6
19	33	(26)	33	(26)											
18	53	(46)	53	(46)											
17	47	(25)	36	(19)	8	(4)	3	(2)					11	(6)	2.3
mean	167	(33)	104	(28)	57	(5)	4	(1)	3	(0)			127	(11)	6
max	534	(46)	292	(46)	221	(15)	11	(2)	10	(1)			242	(16)	11
min	33	(25)	33	(19)	0	(0)	0	(0)	0	(0)			11	(6)	2

1

2 † suspected error associated with determination of total P composition, site removed from subsequent analysis.

3 ‡ Total P recovered by alkaline extraction

4 § Total phosphonates

5 ¶ Total orthophosphate

6 †† Total phosphomonoesters

7 ‡‡ Ratio of total phosphomonoesters: total phosphodiester

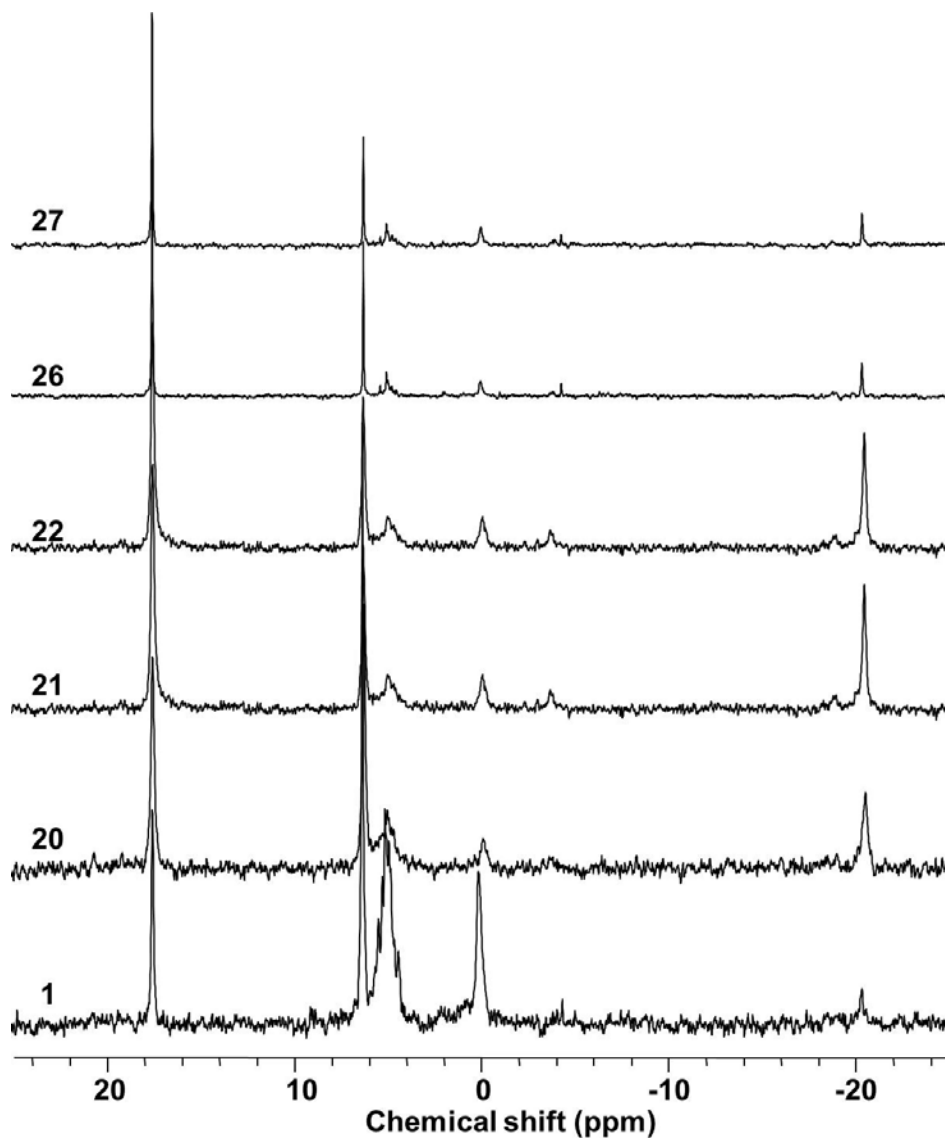
Supplementary Table 4. Inorganic polyphosphates as determined by solution ^{31}P NMR spectroscopy of wetland soils. Values represent total inorganic polyphosphates delineated into pyrophosphate, and the terminal (TR) and mid-chain (MR) of long chain ($n > 3$) polyphosphates.

	Pyrophosphate		Long chain polyphosphate		
	$\mu\text{g g}^{-1}$	% total P	$\mu\text{g g}^{-1}$		% of total P
			TR	MR	
<u>Group A</u>					
27	4.3	1.2	6.2	27.3	9.4
26	4.9	2.1	7.9	28	15.1
22	7.5	1.3	trace	71.6	12.4
21	19.5	2.3	trace	98.9	11.6
20	12.6	1.1	trace	110.1	9.8
1	7.5	0.8	trace	35.5	3.6
mean	9.4	1.5	2.4	61.9	10.3
<u>Group B</u>					
14	8.8	1	-	-	
13	9.2	2.6	-	-	
12	5.6	0.5	5.6	13.6	1.8
11	4.3	0.5	-	-	
10	9.7	1.3	6.2	9.9	2.2
9	4.9	9.8	-	-	
8	5.4	0.7	7	37.6	6
7	9.1	1	6.3	14.2	2.2
mean	7.1	2.2	3.9	9.4	1.5
<u>Group C</u>					
28	10.3	1.5	23.6	39.8	9.3
24	9.6	3.1	-	-	
23	6.6	2.4	1.7	3.1	1.7
16	46.2	3.9	6.3	7.8	1.2
15	32.3	2.7	10.6	6.8	1.5
6	136.3	3.9	30.1	31.1	1.7
5	24.6	2.5	12.1	35.2	4.8
23	6.6	2.4	1.7	3.1	1.7
24	9.6	3.1	-	-	
28	10.3	1.5	23.6	39.8	9.3
mean	37.9	3.1	14.7	19.1	3.3
<u>Group D</u>					
No inorganic polyphosphates detected					

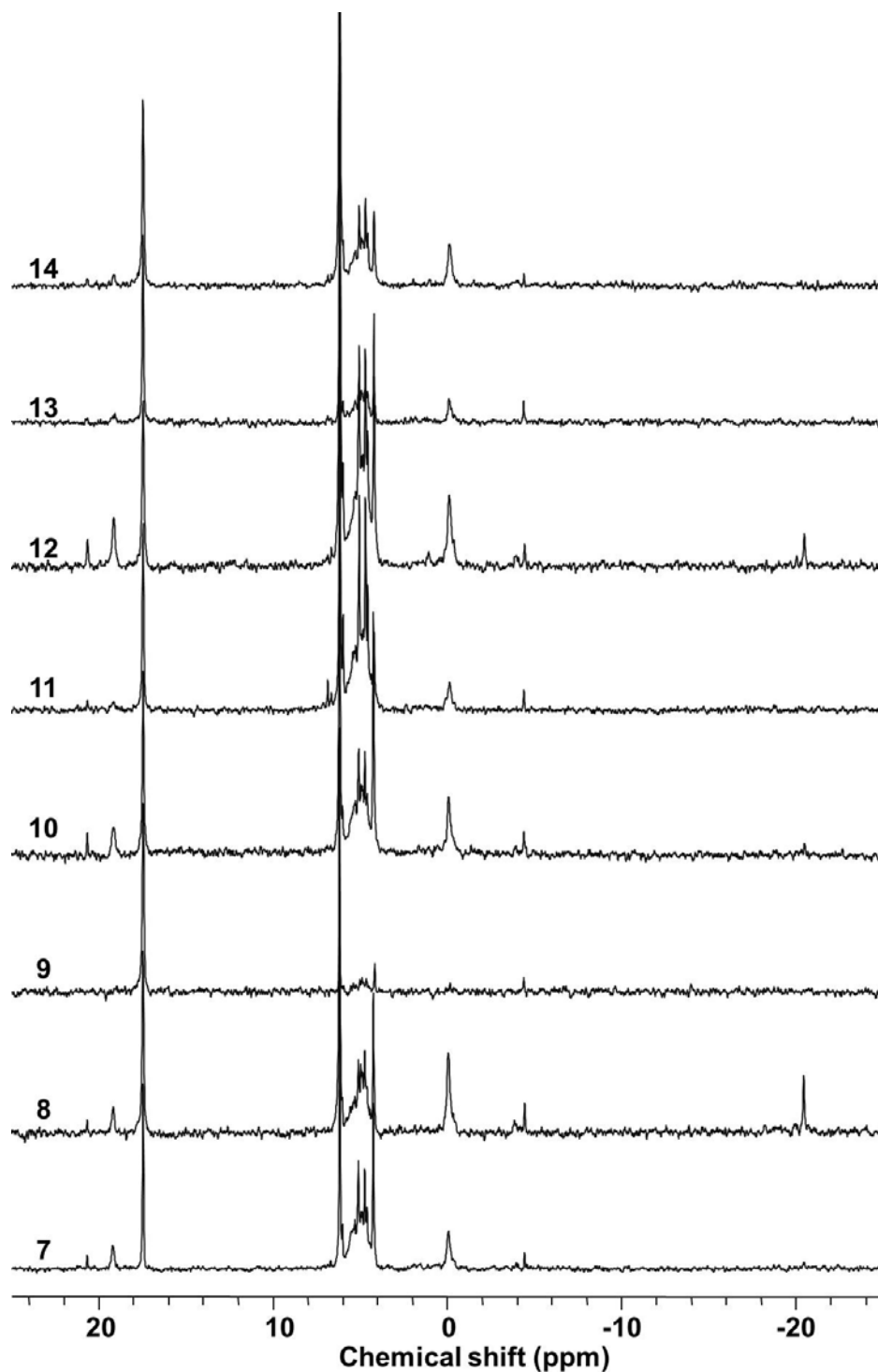
1 Supplementary Table 5. Correlation coefficients between microbial P (% of total P) and P
2 forms determined by solution ^{31}P NMR spectroscopy (% of total P).
3

Phosphorus form	Spearman rho correlation	<i>p</i>
Phosphonate	-0.21	ns
Orthophosphate	-0.38	ns
Phosphomonoesters	-0.15	ns
DNA	0.57	<0.01
Other phosphodiester	0.30	ns
Pyrophosphate	0.38	ns
Long chain Polyphosphate	0.80	<0.001
Residual	-0.05	ns

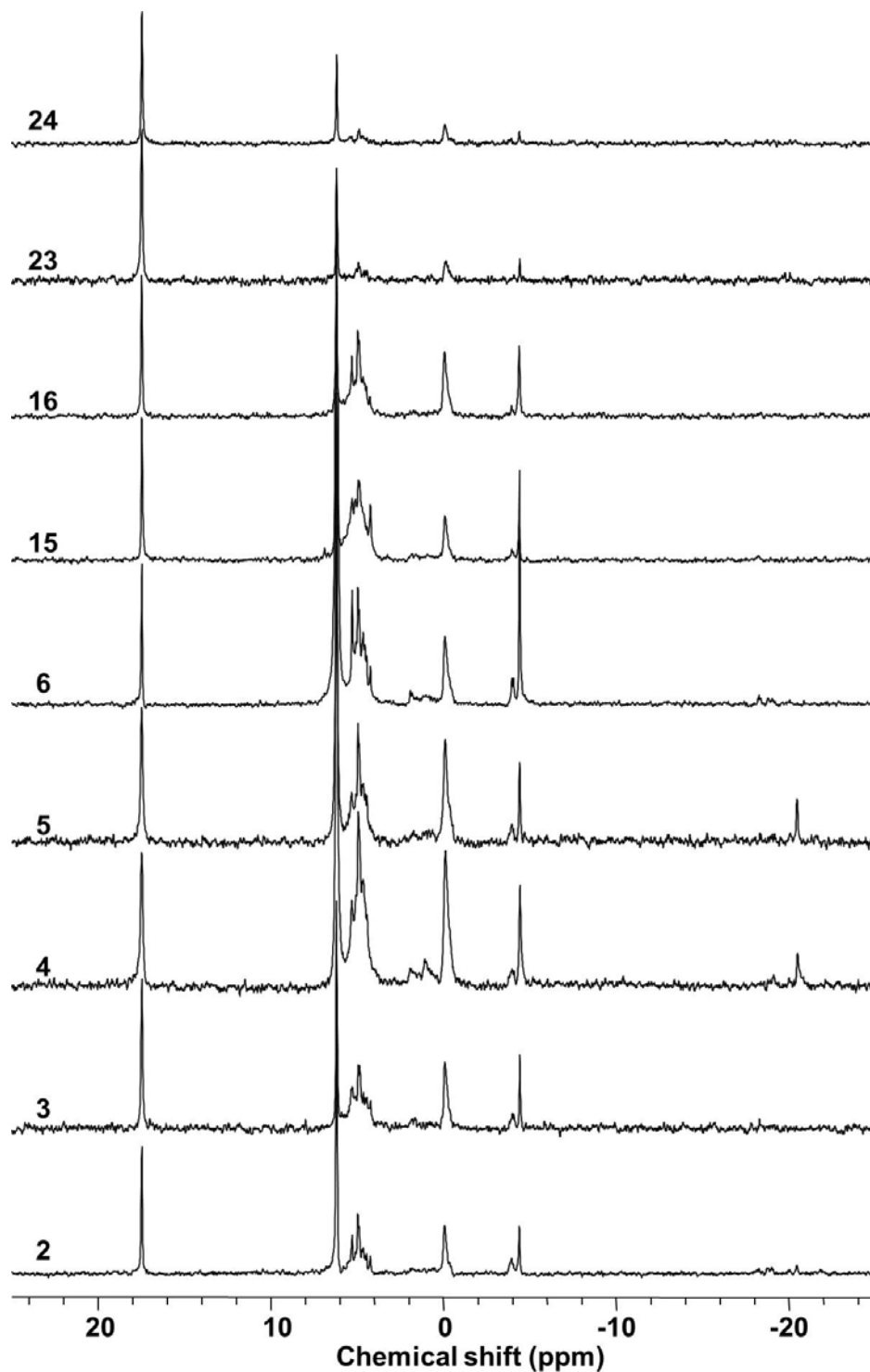
4



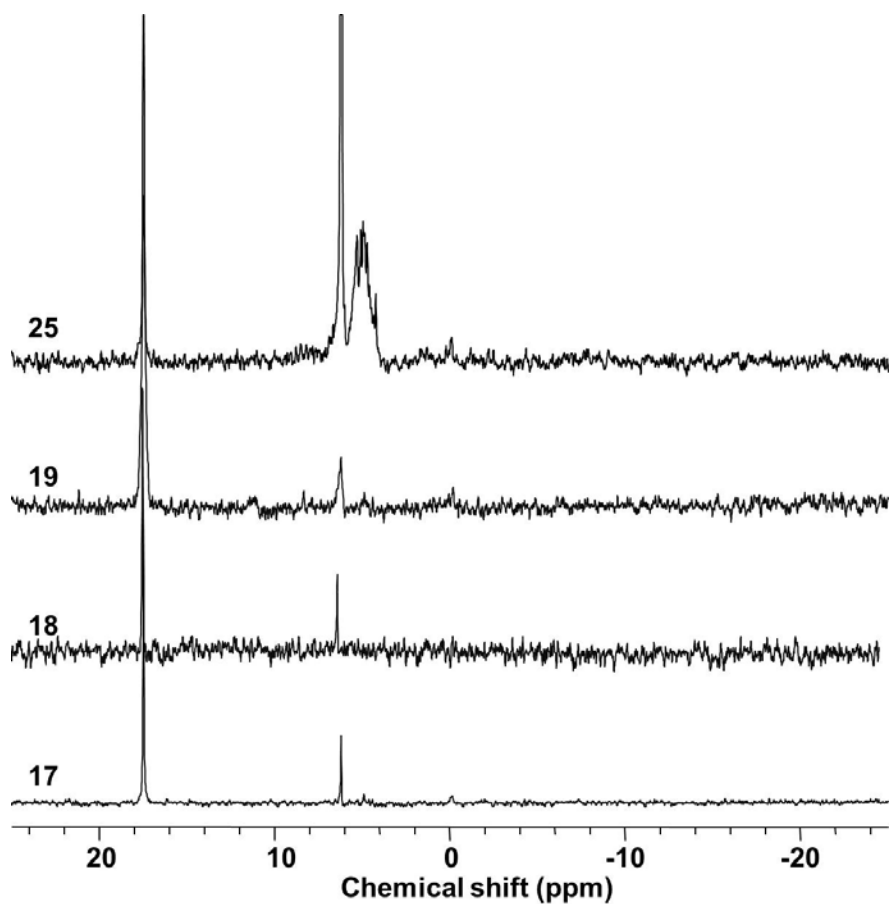
Supplementary Figure 1: Solution ³¹P NMR spectra of biogenic P composition within group A wetlands (high organic low pH). Spectra acquired using an Avance III 500, Magnex 11.8 tesla 54 mm Bore, at pH > 13 using a simple ztig pulse program and calibrated 30° pulse angle. Spectra presented here using 15 Hz line broadening scaled and referenced to internal standard methylenediphosphonic acid ($\delta = 17.46$ ppm).



Supplementary Figure 2: Solution ³¹P NMR spectra of biogenic P composition within group B wetlands (low organic low pH). Spectra acquired using an Avance III 500, Magnex 11.8 tesla 54 mm Bore, at pH > 13 using a simple zgig pulse program and calibrated 30° pulse angle. Spectra presented here using 15 Hz line broadening scaled and referenced to internal standard methylenediphosphonic acid ($\delta = 17.46$ ppm).



Supplementary Figure 3: Solution ³¹P NMR spectra of biogenic P composition within group C wetlands (high organic matter high pH). Spectra acquired using an Avance III 500, Magnex 11.8 tesla 54 mm Bore, at pH > 13 using a simple zgpg pulse program and calibrated 30° pulse angle. Spectra presented here using 15 Hz line broadening scaled and referenced to internal standard methylenediphosphonic acid ($\delta = 17.46$ ppm).



1
2

3 Supplementary Figure 4: Solution ³¹P NMR spectra of biogenic P composition within group
4 D wetlands (low organic matter high pH). Spectra acquired using an Avance III 500, Magnex
5 11.8 tesla 54 mm Bore, at pH > 13 using a simple zgig pulse program and calibrated 30° pulse
6 angle. Spectra presented here using 15 Hz line broadening scaled and referenced to internal
7 standard methylenediphosphonic acid ($\delta = 17.46$ ppm).