Supplemental Material

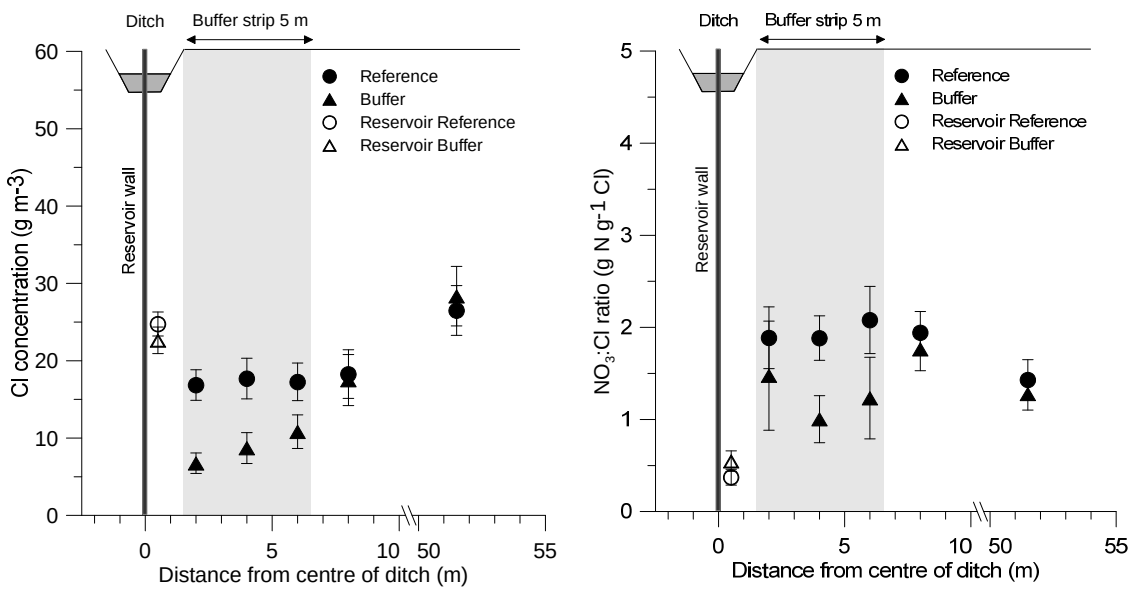
A novel method to determine buffer strip effectiveness on deep soils

Heinen, Noij, Heesmans, van Groenigen, Groenendijk and Thissen.

In the main text the focus was on N_t, P_t, NO_3-N and Cl. Here the data for N_{ts}, P_{ts}, NH_4-N, N_{org}-N (N_{org}-N = N_t – NO_3-N – NH_4-N), and DOC are given as well, without any further explanation or discussion.

Concentration in Upper Ground Water

In the main text the NO_3 concentration of the upper ground water (mostly at 1 m bss) as a function of distance to the ditch was depicted in Figure 7. Here similar graphs are given for Cl, the ratio NO_3:Cl, N_{org}, N_{ts}, and DOC (Figure SM-1).



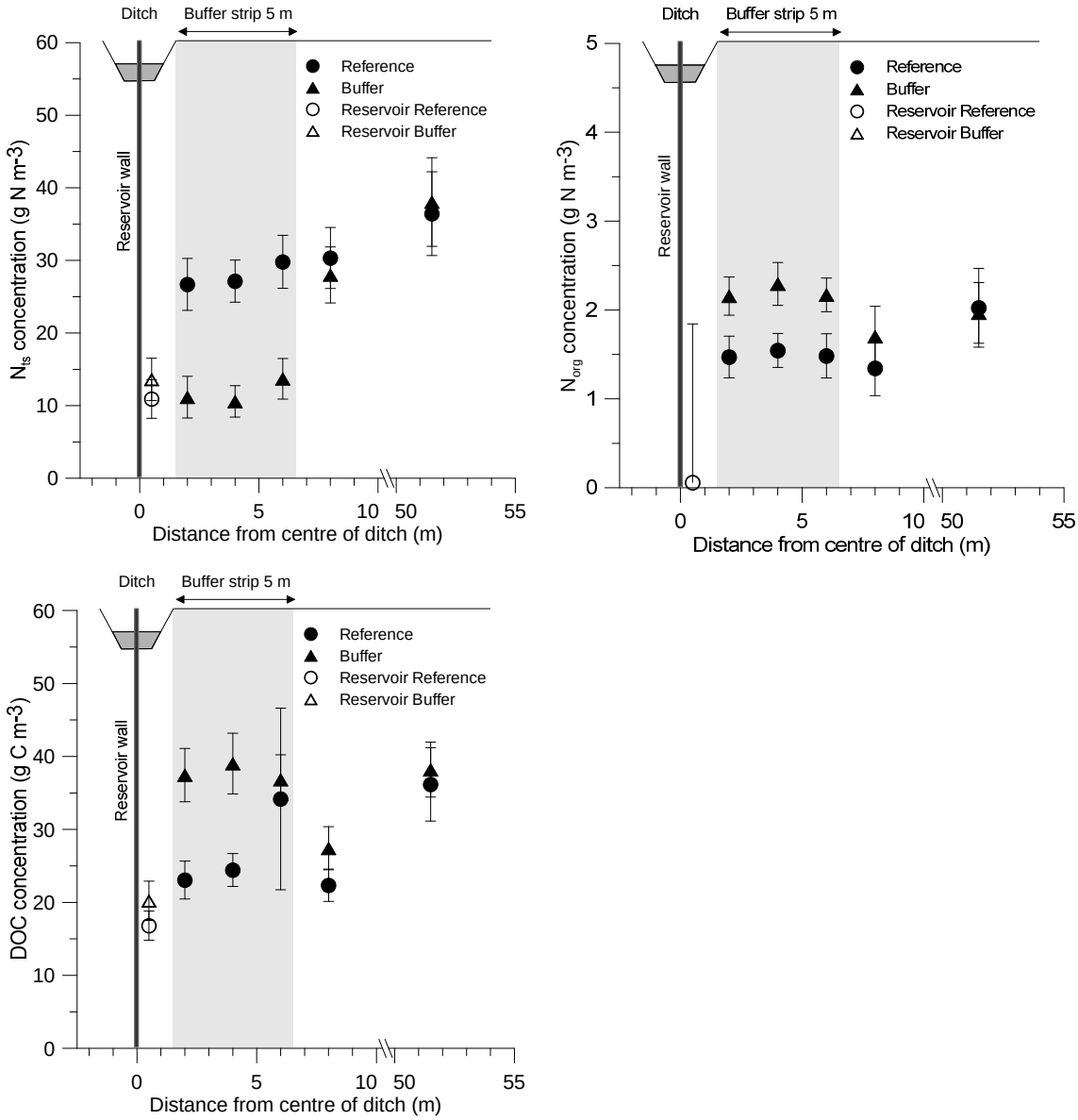


Figure SM-1. Time-averaged concentration of upper ground water (mostly at 1 m bss; closed symbols) as a function of distance from the centre of the ditch for all treatments and replicates (grey area represents the buffer strip) for Cl, the ratio NO_3:Cl, DOC, N_{org}, and N_{ts}. The measurements at distance 0.25 m (open symbols) are average concentrations in the reservoirs at the same sampling moments. The length of the error bars represent two times the standard error of the mean based on 32 (replicate A) or 22 (replicates B and C) sampling times. Note that the concentrations at shallow depths (i.e., 0.50 and 0.75 m bss) refer to unsaturated conditions.

Discharge, concentration, flow-averaged concentration, load

Tables SM-1 and SM-2 present the cumulative discharges and flow-averaged concentrations for all nutrients per reservoir for all replicates for all leaching seasons and for the sum of all leaching seasons. Table SM-1 refers to periods of equal time and Table SM-2 refers to periods of equal discharge.

Table SM-1. Total discharge of water and flow-averaged concentrations for Cl, N_t, P_t, NH_4-N, NO_3-N, N_{ts}, P_{ts}, DOC and PO_4-P for all treatments, replicates and leaching seasons based on periods of equal time.

			A				B					C			
Quantity†	**Units**	**Treatment**	**06/07**	**07/08**	**08/09**	**09/10**	**06/10**	**07/08**	**08/09**	**09/10**	**07/10**	**07/08**	**08/09**	**09/10**	**07/10**
Water	m^3	Ref	50.21	39.42	17.52	25.12	132.27	43.73	28.18	47.28	119.19	44.86	33.49	40.30	118.64
		Buf	44.91	47.45	20.50	20.24	133.10	32.00	24.33	41.22	97.54	42.13	23.56	46.35	112.04
Cl	$g\ m^{-3}$	Ref	28.00	28.02	24.52	22.95	26.59	27.92	21.81	21.74	24.02	28.03	26.05	24.16	26.16
		Buf	21.66	22.88	17.01	16.85	20.65	25.58	25.36	26.20	25.79	23.27	21.77	22.44	22.61
N_t	$g\ m^{-3}$	Ref	17.84	11.08	10.64	14.15	14.17	21.69	22.60	25.44	23.39	9.63	10.65	10.86	10.34
		Buf	17.89	13.56	15.84	16.57	15.83	16.81	19.36	22.10	19.68	19.79	18.91	20.12	19.74
P_t	$g\ m^{-3}$	Ref	0.043	0.107	0.078	0.048	0.068	0.052	0.058	0.117	0.08	0.068	0.053	0.135	0.09
		Buf	0.028	0.062	0.054	0.064	0.049	0.099	0.165	0.052	0.10	0.074	0.058	0.050	0.06
NH_4	$g\ m^{-3}$	Ref	0.10	0.15	0.15	0.14	0.13	0.14	0.11	0.18	0.15	0.15	0.10	0.15	0.14
		Buf	0.06	0.14	0.16	0.17	0.12	0.18	0.10	0.09	0.12	0.13	0.11	0.10	0.12
NO_3	$g\ m^{-3}$	Ref	16.64	9.20	9.01	12.58	12.64	20.37	20.16	23.64	21.62	8.66	9.79	9.76	9.35
		Buf	16.31	11.63	13.60	14.43	13.94	15.39	17.52	20.56	18.11	17.36	17.27	18.88	17.97
N_{ts}	$g\ m^{-3}$	Ref	17.59	10.34	10.25	13.70	13.72	21.61	21.56	24.41	22.71	9.47	10.48	10.46	10.09
		Buf	17.66	13.19	15.25	16.09	15.46	16.62	18.35	21.29	19.02	18.57	18.20	19.44	18.85
P_{ts}	$g\ m^{-3}$	Ref	0.019	0.012	0.018	0.018	0.017	0.013	0.020	0.045	0.028	0.011	0.014	0.018	0.014
		Buf	0.020	0.016	0.020	0.029	0.020	0.015	0.015	0.022	0.018	0.016	0.021	0.019	0.018
DOC	$g\ m^{-3}$	Ref	13.89	13.30	14.31	14.45	13.88	13.10	15.69	14.37	14.22	8.07	8.46	9.37	8.62
		Buf	22.10	20.43	21.81	20.81	21.27	11.78	9.75	9.85	10.46	11.24	10.09	10.02	10.49
PO_4	$g\ m^{-3}$	Ref	0.001	0.000	0.001	0.001	0.001	0.000	0.002	0.034	0.014	0.000	0.000	0.004	0.001
		Buf	0.000	0.001	0.001	0.001	0.001	0.000	0.000	0.002	0.001	0.000	0.002	0.000	0.001
N_{org}	$g\ m^{-3}$	Ref	1.10	1.74	1.47	1.43	1.40	1.18	2.33	1.61	1.62	0.82	0.76	0.96	0.85
		Buf	1.52	1.79	2.09	1.96	1.77	1.24	1.74	1.45	1.45	2.30	1.53	1.14	1.90
NO_3:Cl	$g\ g^{-1}$	Ref	0.59	0.33	0.37	0.55	0.48	0.73	0.92	1.09	0.90	0.31	0.38	0.40	0.36
		Buf	0.75	0.51	0.80	0.86	0.68	0.60	0.69	0.78	0.70	0.75	0.79	0.84	0.79

†: Loads are not presented as these can be easily calculated as discharge times flow-average concentration.

Table SM-2. Total discharge of water, and loads and flow-averaged concentrations for Cl, N_t, P_t, NH_4, NO_3, N_{ts}, P_{ts}, DOC and PO_4 for all treatments, replicates and leaching seasons based on periods of equal discharge.

			A				B				C				
Quantity†	**Units**	**Treatment**	**06/07**	**07/08**	**08/09**	**09/10**	**06/10**	**07/08**	**08/09**	**09/10**	**07/10**	**07/08**	**08/09**	**09/10**	**07/10**
Water‡	m^3	Ref	44.91	39.42	17.52	20.24	132.27	32.00	24.33	41.22	97.54	42.13	23.56	40.30	112.04
		Buf	44.91	39.42	17.52	20.24	132.27	32.00	24.33	41.22	97.54	42.13	23.56	40.30	112.04
Cl	$g\ m^{-3}$	Ref	27.70	28.02	24.52	22.20	26.59	28.04	21.18	21.51	24.16	28.08	25.04	24.16	29.86
		Buf	21.66	22.54	16.99	16.85	20.62	25.58	25.36	26.20	25.79	23.27	21.77	22.39	25.97
N_t	$g\ m^{-3}$	Ref	18.23	11.08	10.64	13.15	14.17	21.76	22.47	25.43	22.88	9.81	11.45	10.86	12.30
		Buf	17.89	12.66	15.89	16.57	15.78	16.81	19.36	22.10	19.68	19.79	18.91	19.86	22.68
P_t	$g\ m^{-3}$	Ref	0.045	0.107	0.078	0.049	0.068	0.060	0.060	0.129	0.015	0.070	0.053	0.135	0.013
		Buf	0.028	0.069	0.056	0.064	0.049	0.099	0.165	0.052	0.041	0.074	0.058	0.052	0.014
NH_4	$g\ m^{-3}$	Ref	0.10	0.15	0.15	0.17	0.13	0.15	0.12	0.21	0.18	0.15	0.10	0.15	0.16
		Buf	0.06	0.16	0.17	0.17	0.12	0.18	0.10	0.09	0.12	0.13	0.11	0.11	0.13
NO_3	$g\ m^{-3}$	Ref	17.01	9.20	9.01	11.51	12.64	20.53	20.02	23.52	20.87	8.82	10.46	9.76	11.14
		Buf	16.31	10.72	13.57	14.43	13.88	15.39	17.52	20.56	18.11	17.36	17.27	18.55	20.64
N_{ts}	$g\ m^{-3}$	Ref	17.98	10.34	10.25	12.71	13.72	21.90	21.46	24.40	22.22	9.64	11.26	10.46	12.01
		Buf	17.66	12.34	15.29	16.09	15.41	16.62	18.35	21.29	19.02	18.57	18.20	19.20	21.66
P_{ts}	$g\ m^{-3}$	Ref	0.019	0.012	0.018	0.018	0.017	0.014	0.022	0.049	0.029	0.011	0.016	0.018	0.016
		Buf	0.020	0.016	0.021	0.029	0.020	0.015	0.015	0.022	0.018	0.016	0.021	0.017	0.021
DOC	$g\ m^{-3}$	Ref	14.09	13.30	14.31	15.02	13.88	13.36	16.41	14.77	14.75	8.08	9.03	9.37	10.03
		Buf	22.10	21.11	21.98	20.81	21.29	11.78	9.75	9.85	10.46	11.24	10.09	10.09	12.05
PO_4	$g\ m^{-3}$	Ref	0.001	0.000	0.001	0.001	0.001	0.000	0.002	0.039	0.017	0.000	0.000	0.004	0.002
		Buf	0.000	0.001	0.001	0.001	0.001	0.000	0.000	0.002	0.001	0.000	0.002	0.001	0.001
N_{org}	$g\ m^{-3}$	Ref	1.12	1.74	1.47	1.47	1.40	1.07	2.33	1.70	1.83	0.83	0.89	0.96	0.87
		Buf	1.52	1.78	2.16	1.96	1.77	1.24	1.74	1.45	1.45	2.30	1.53	1.19	1.66
NO_3:Cl	$g\ g^{-1}$	Ref	0.61	0.33	0.37	0.52	0.48	0.73	0.95	1.09	0.86	0.31	0.42	0.40	0.37
		Buf	0.75	0.48	0.80	0.86	0.67	0.60	0.69	0.78	0.70	0.75	0.79	0.83	0.79

†: Loads are not presented as these can be easily calculated as discharge times flow-average concentration.

‡: For periods of equal discharge by definition the discharges for both treatments are equal. Note that the sum of the discharge for the whole period not always equals the sum of the discharges of the individual leaching seasons because data of the first three (A) or two (B and C) leaching seasons are then completely used, while only data at the end of the last leaching season has been skipped.

BSE

Upper ground water

Table SM-3 presents BSE_I and BSE_{II} for all species measured in upper ground water.

Table SM-3. Buffer strip effectiveness (BSE, %) according to Eq. [5] and Eq. [6] based on the average concentrations of NO_3-N (see Figure 7), N_{ts}, NH_4-N, Cl, DOC and N_{org} measured in upper ground water.

	NO_3-N	N_{ts}	NH_4-N	Cl	DOC	N_{org}
Eq. [5]	67.21	60.13	-20.22	61.41	-36.56	-26.82
Eq. [6]	66.37	58.19	-12.57	59.96	-62.36	-46.60

Reservoirs

Table SM-4 presents the buffer strip effectiveness (BSE) according to Eq. [6] for the three replicates at Beltrum and their averages based on L or $\overline{C}$ of all species in the reservoirs for the complete experimental period.

Table SM-4. Buffer strip effectiveness (BSE_I, %) according to Eq. [6] for the three replicates at Beltrum and their averages (± standard deviation) based on load L or flow-averaged concentration $\overline{C}$ of N_t, P_t, NO_3-N, Cl, N_{ts}, P_{ts}, NH_4-N, DOC and N_{org} in the reservoirs for the complete experimental period of either equal time (t) or equal discharge (Q).

Replicate	Period	N_t		P_t		NO_3-N		Cl		N_{ts}	
		L	$\overline{C}$	L	$\overline{C}$	L	$\overline{C}$	L	$\overline{C}$	L	$\overline{C}$
A	Q	-11.34	-11.34	27.32	27.32	-9.84	-9.84	22.46	22.46	-12.35	-12.35
	t	-12.40	-11.70	26.82	27.28	-10.95	-10.25	21.86	22.35	-13.42	-12.71
B	Q	13.97	13.97	-8.36	-8.36	13.23	13.23	-6.74	-6.74	14.39	14.39
	t	31.14	15.86	1.06	-20.90	31.46	16.24	12.16	-7.34	31.44	16.22
C	Q	-84.44	-84.44	26.19	26.19	-85.31	-85.31	13.00	13.00	-80.37	-80.37
	t	-80.35	-90.97	33.90	30.01	-81.45	-92.14	18.37	13.56	-76.40	-86.79
Average	Q	-17.21 ± 5.25	-17.21 ± 6.44	15.45 ± 3.22	15.45 ± 4.64	-17.15 ± 5.27	-17.15 ± 6.45	11.49 ± 2.34	11.49 ± 3.41	-16.56 ± 4.99	-16.56 ± 6.15
	t	-5.94 ± 2.41	-14.41 ± 6.34	20.88 ± 4.48	14.55 ± 3.97	-5.15 ± 2.16	-13.57 ± 6.14	17.79 ± 2.06	11.21 ± 2.29	-5.37 ± 2.17	-13.81 ± 6.04

Replicate	Period	P_{ts}		NH_4-N		DOC		N_{org}	
		L	$\overline{C}$	L	$\overline{C}$	L	$\overline{C}$	L	$\overline{C}$
A	Q	-18.22	-18.22	3.35	3.35	-53.43	-53.43	-26.20	-26.20
	t	-19.07	-18.32	3.10	3.71	-54.22	-53.26	-26.91	-26.11
B	Q	38.27	38.27	30.85	30.85	29.08	29.08	20.77	20.77
	t	46.76	34.95	33.20	18.37	39.80	26.44	26.77	10.52
C	Q	-27.92	-27.92	16.27	16.27	-20.18	-20.18	-90.80	-90.80
	t	-20.51	-27.61	19.15	14.39	-14.96	-21.73	-84.11	-94.95
Average	Q	3.64 ± 1.28	3.64 ± 1.50	17.01 ± 2.94	17.01 ± 4.71	-17.87 ± 11.94	-17.87 ± 12.55	87.57 ± 122.95	87.57 ± 124.40
	t	10.75 ± 4.34	3.61 ± 1.58	18.82 ± 3.27	12.33 ± 2.98	-10.41 ± 6.91	-19.24 ± 13.17	87.61 ± 122.35	86.62 ± 121.84