SOME ASPECTS OF PHOSPHORUS CYCLING IN MIDMAR DAM

VOLUME 2. FIGURES AND TABLES

by

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VOLUME 2

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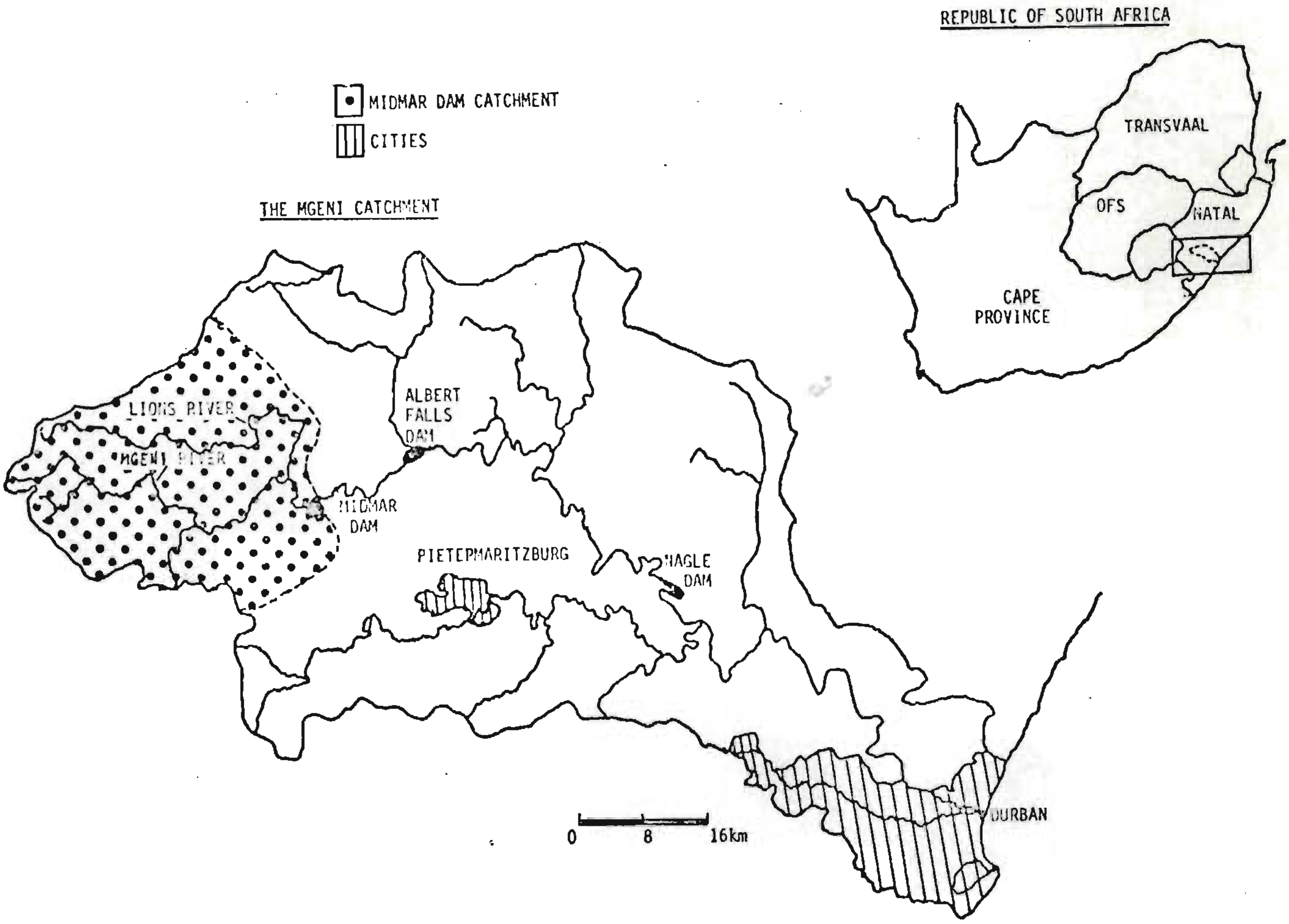


Fig. 1.1. The Mgeni catchment in relation to South Africa.

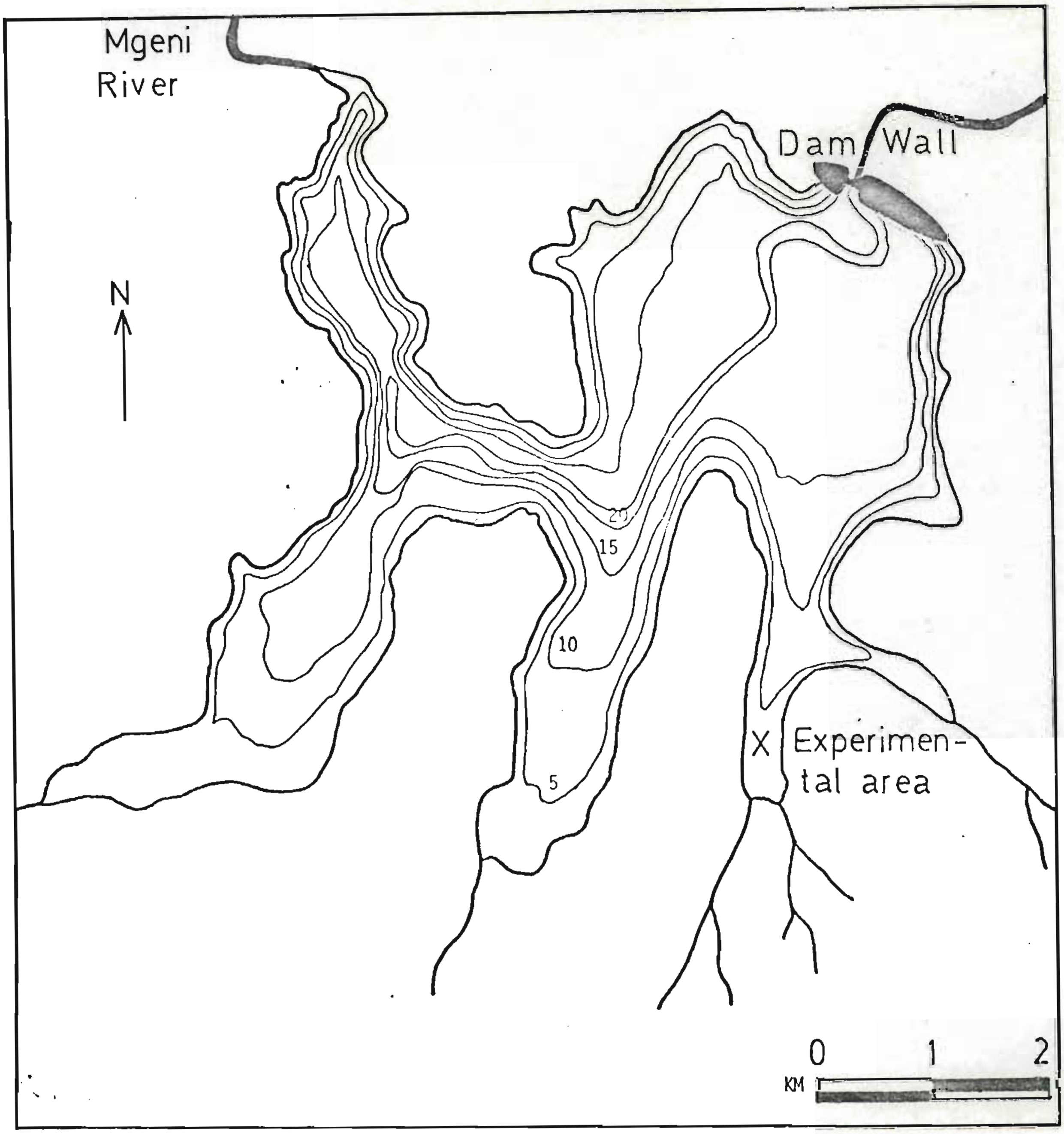


Fig. 1.2. Bathymetric map of Midmar Dam showing the experimental area. Depth contours in metres.

TABLE 1.1. Some characteristics of Midmar Dam. (After Walmsley, 1976 and Archibald *et al.*, 1979). FSL = Full supply level.

Volume (FSL)	177.2 x 10^6 m^3
Area (FSL)	15.59 km^2
Maximum Depth (FSL)	22.3 m
Mean Depth (FSL)	11.4 m
Mean Annual Inflow	198.1 x 10^6 m^3
Mean Annual Outflow	191.8 x 10^6 m^3
Mean Retention Time	0.87 years
Shoreline	41.0 km
Shoreline Development	2.9 (Hutchinson, 1957)

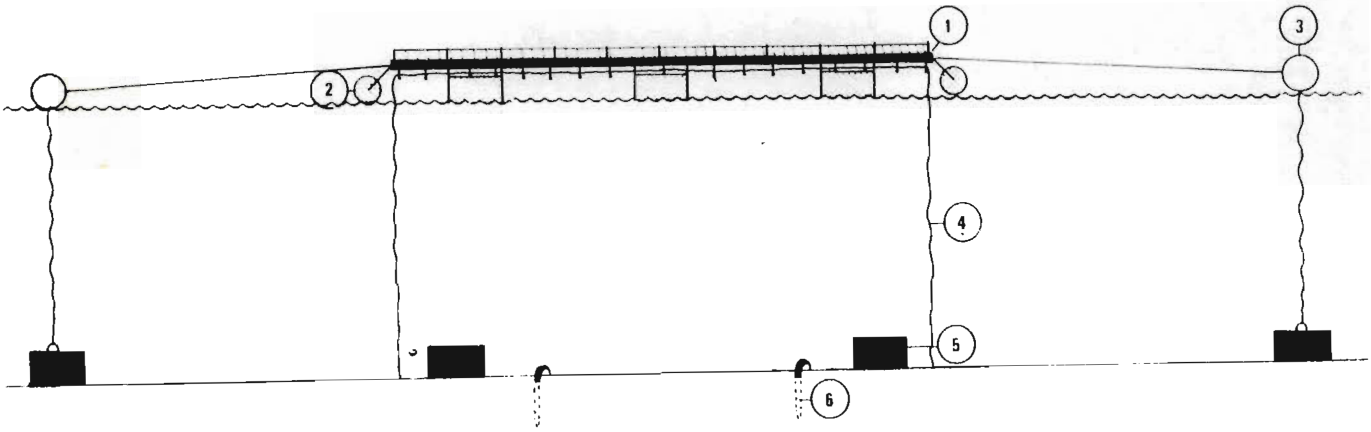


Fig. 2.1. A diagrammatic representation of an isolation column in position showing :

(1) The upper metal ring

(2) The drums providing floatation.

(3) The system of floats designed to hold the columns in position.

(4) The "sterkolite" (reinforced PVC) column.

(5) Anchors used to secure the bottom metal ring and the floats.

(6) Metal pegs used to ensure a good seal between the columns and the sediments.

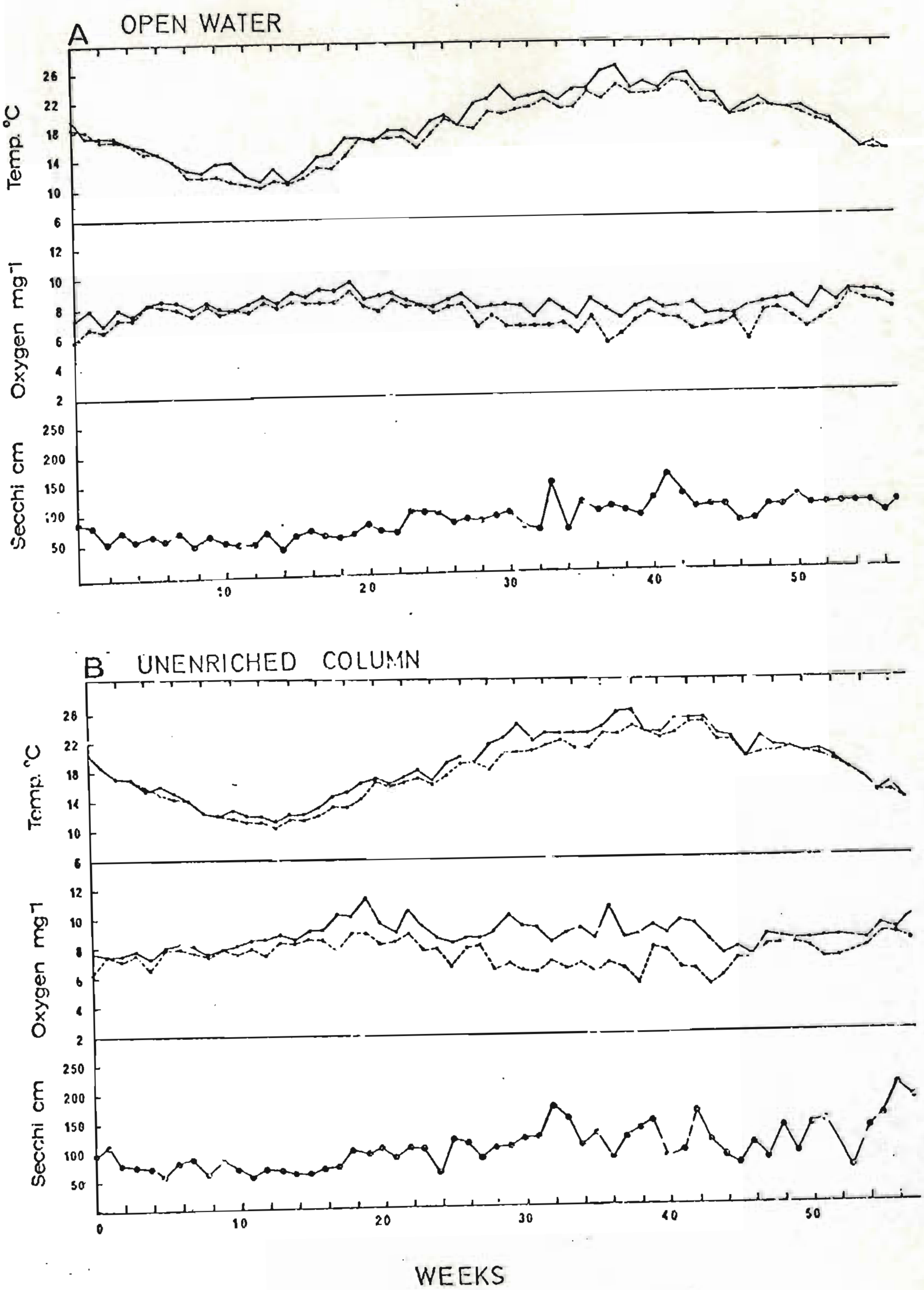


Fig. 3.1. A-B

Weekly temperature (^{O}C), oxygen concentration (mg ℓ^{-1}) and secchi disc transparency (cm) in the open water (A) and in an unenriched isolation column(B). Week 0 started on April 26, 1976. Solid lines represent surface values and broken lines bottom values.

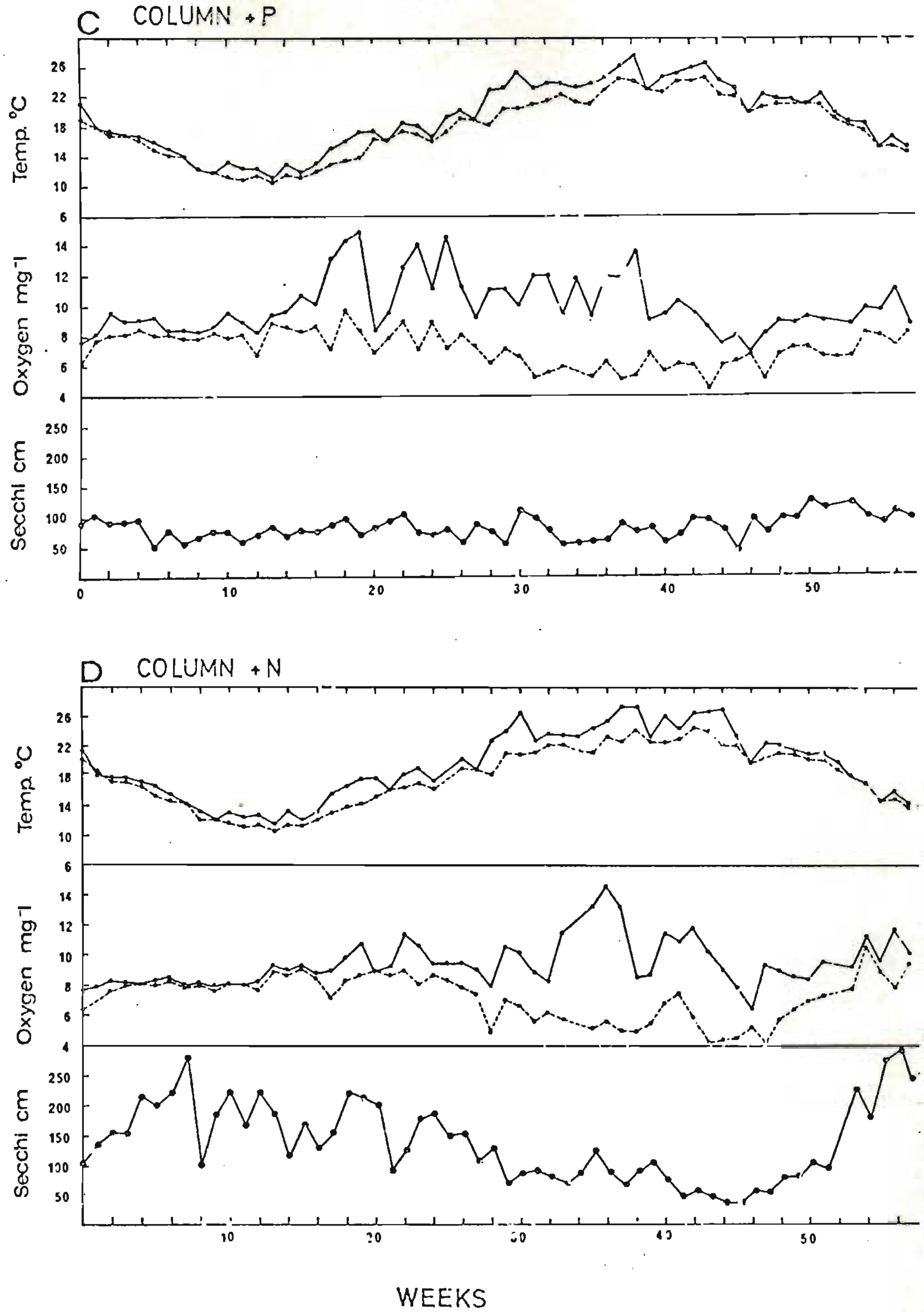


Fig. 3.1. C-D

Weekly temperature (^{o}C), oxygen concentration (mg ℓ^{-1}) and secchi disc transparency (cm) in the column +P (C) and the column +N (D). Week 0 started on April 26, 1976. Solid lines represent surface values and broken lines bottom values.

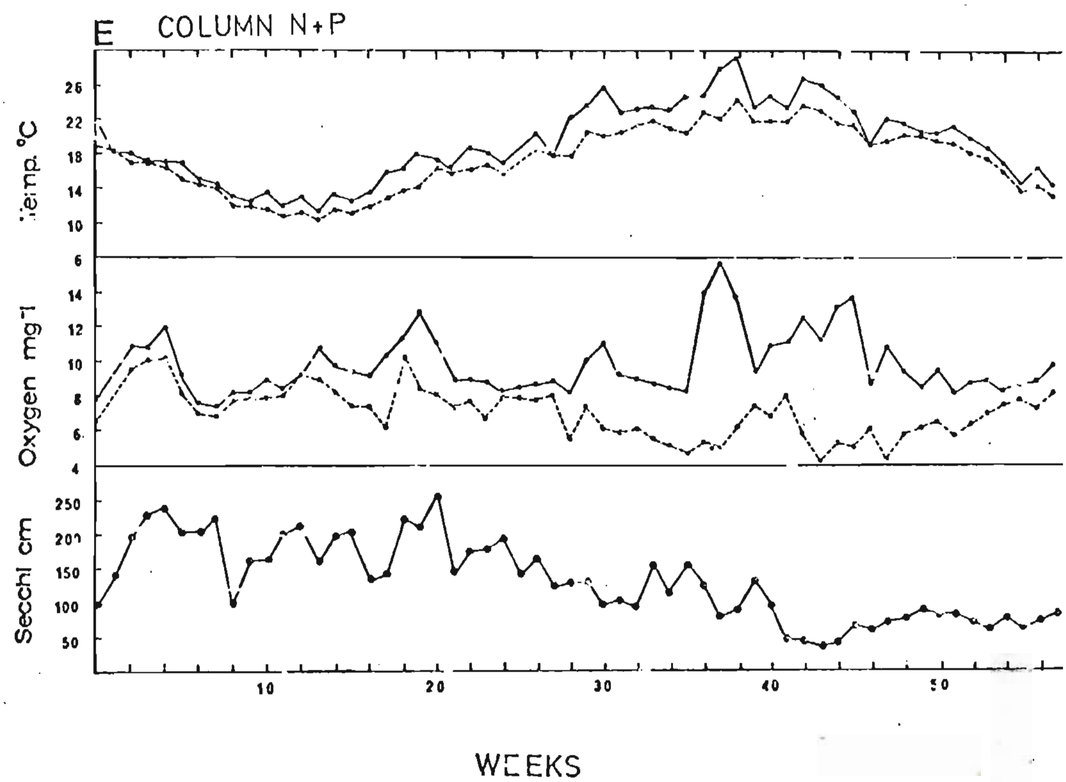


Fig. 3.1. E.

Weekly temperature (^{0}C), oxygen concentration (mg ℓ^{-1}) and secchi disc transparency (cm) in the column N+P. Week 0 started on April 26, 1976. Solid lines represent surface values and broken lines bottom values.

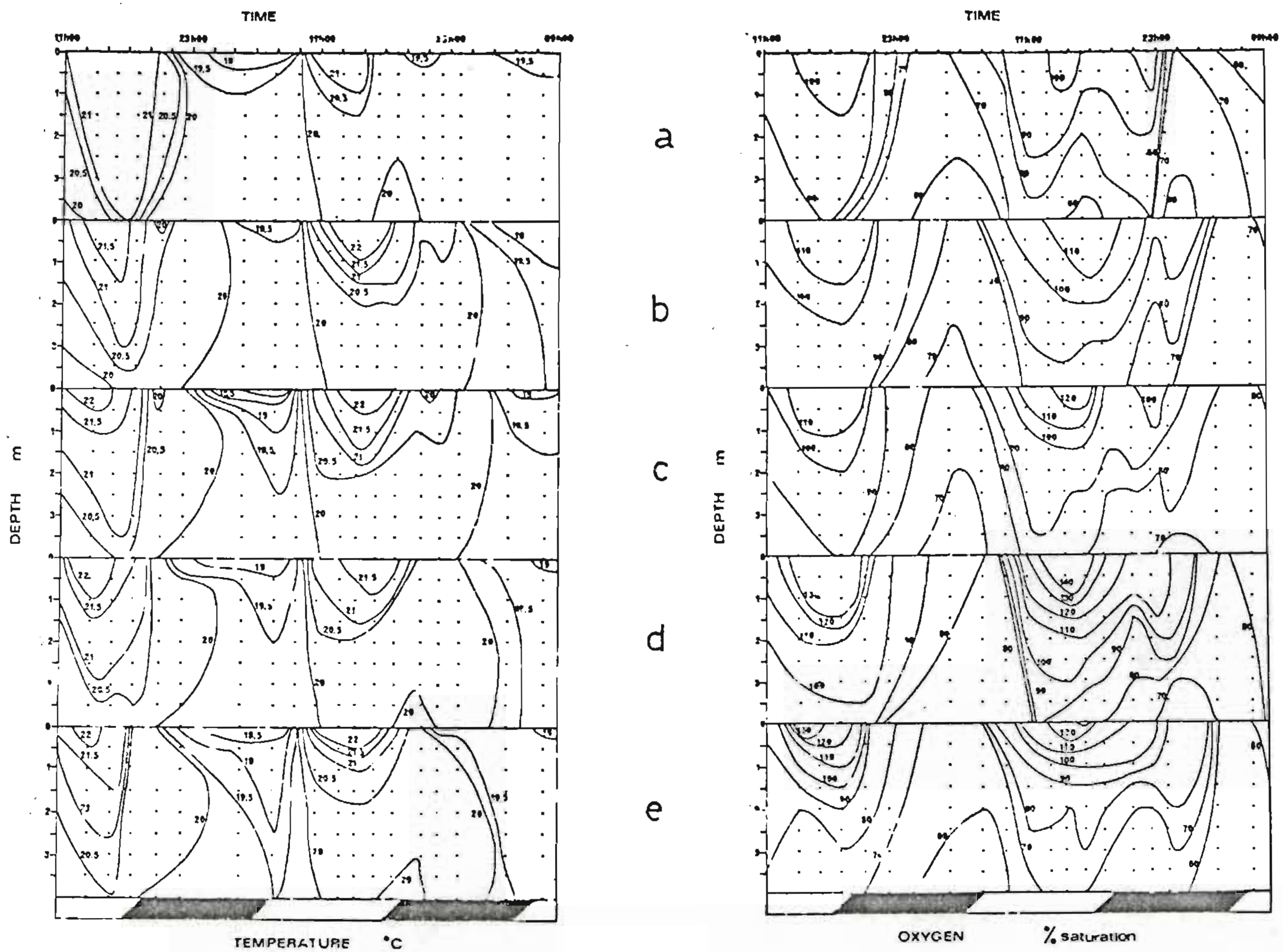


Fig. 3.2. Temperature (°C) and oxygen (% saturation) regimes over a 48 h period between weeks 52 and 53 (April 27-29, 1977) in the open water (a), unenriched column (b), column +P (c), column +N (d) and column N+P (e). Shaded and unshaded areas represent light and dark periods.

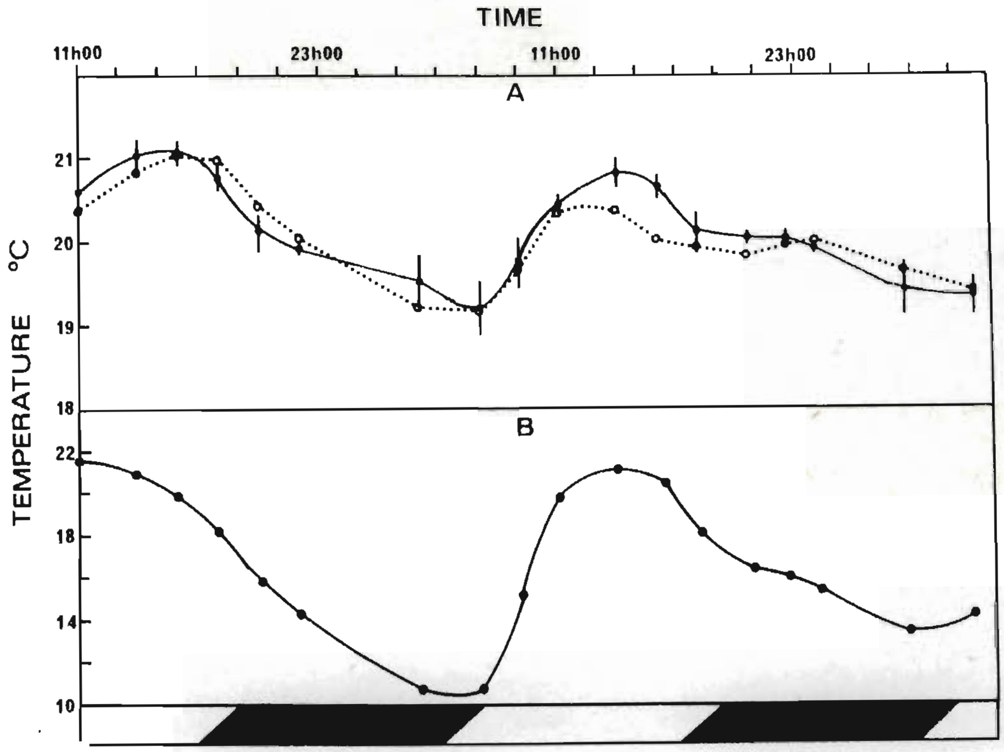


Fig. 3.3.

A. Mean water temperature between surface and bottom recorded during a 48 h period of monitoring on 27 - 29 April in the open water (dotted line) and in the four isolation columns ($\bar{x}$ ± standard deviation).

B. Air temperatures recorded during the 48 h period.

Shaded and unshaded areas represent light and dark periods.

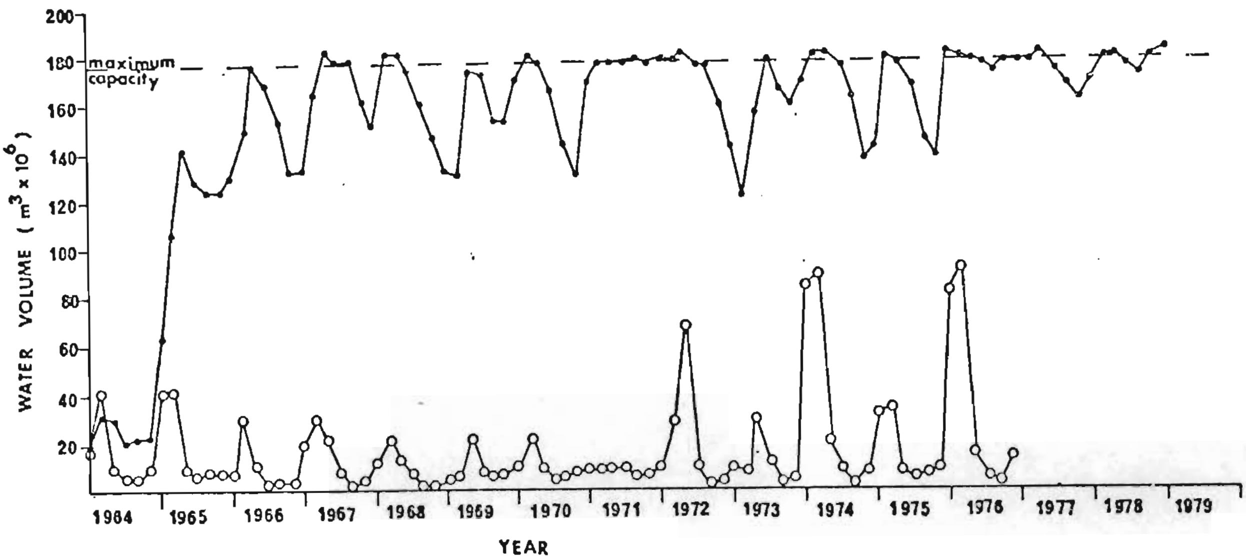


Fig. 3.4.

Water content (·) and water inflow (o) into Midmar Dam. Data for the period 1964 - 1974 from Walmsley (1976). Data for the period after 1974 from the Department of Water Affairs.

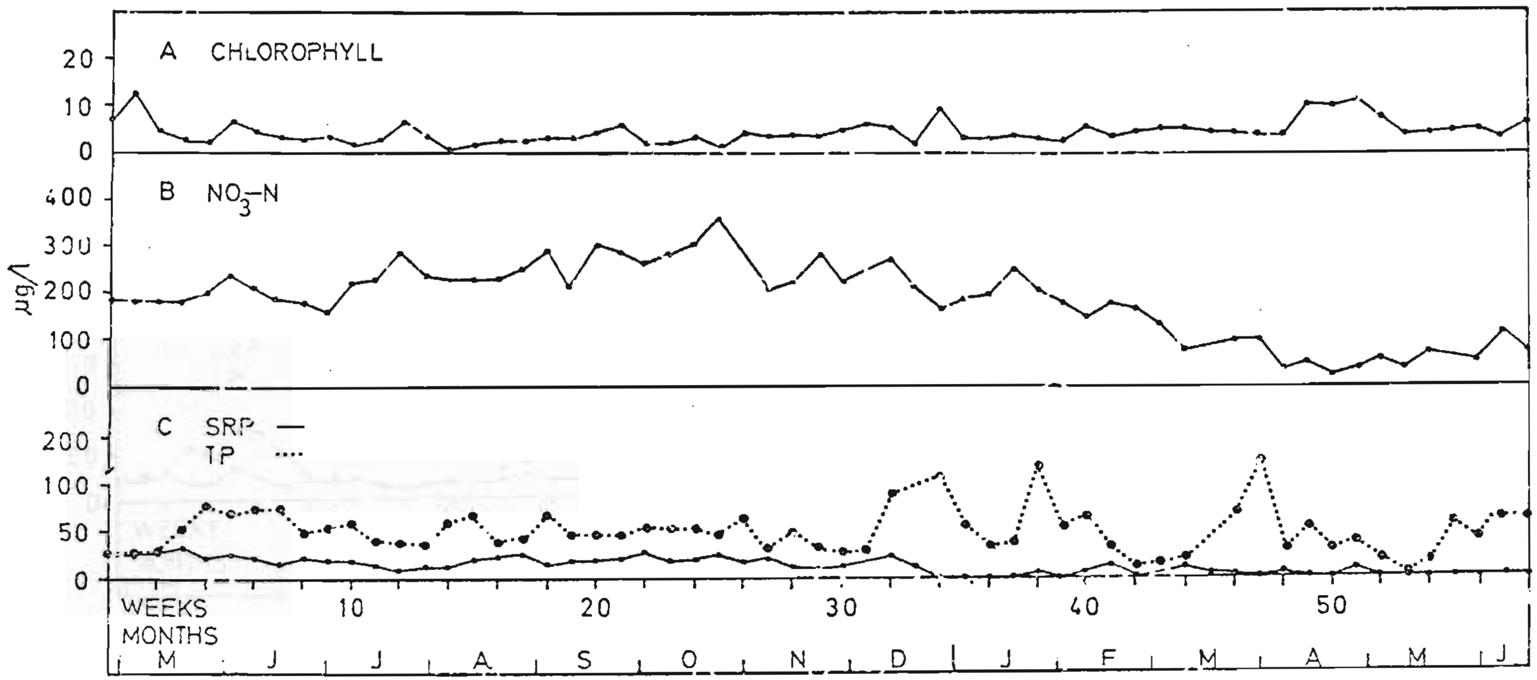


Fig. 3.5.

Changes in chlorophyll (A), NO_3-N (B), SRP and total P (C) concentrations at the open water station. A break in the vertical axis reflects a change from a linear to a doubling scale.

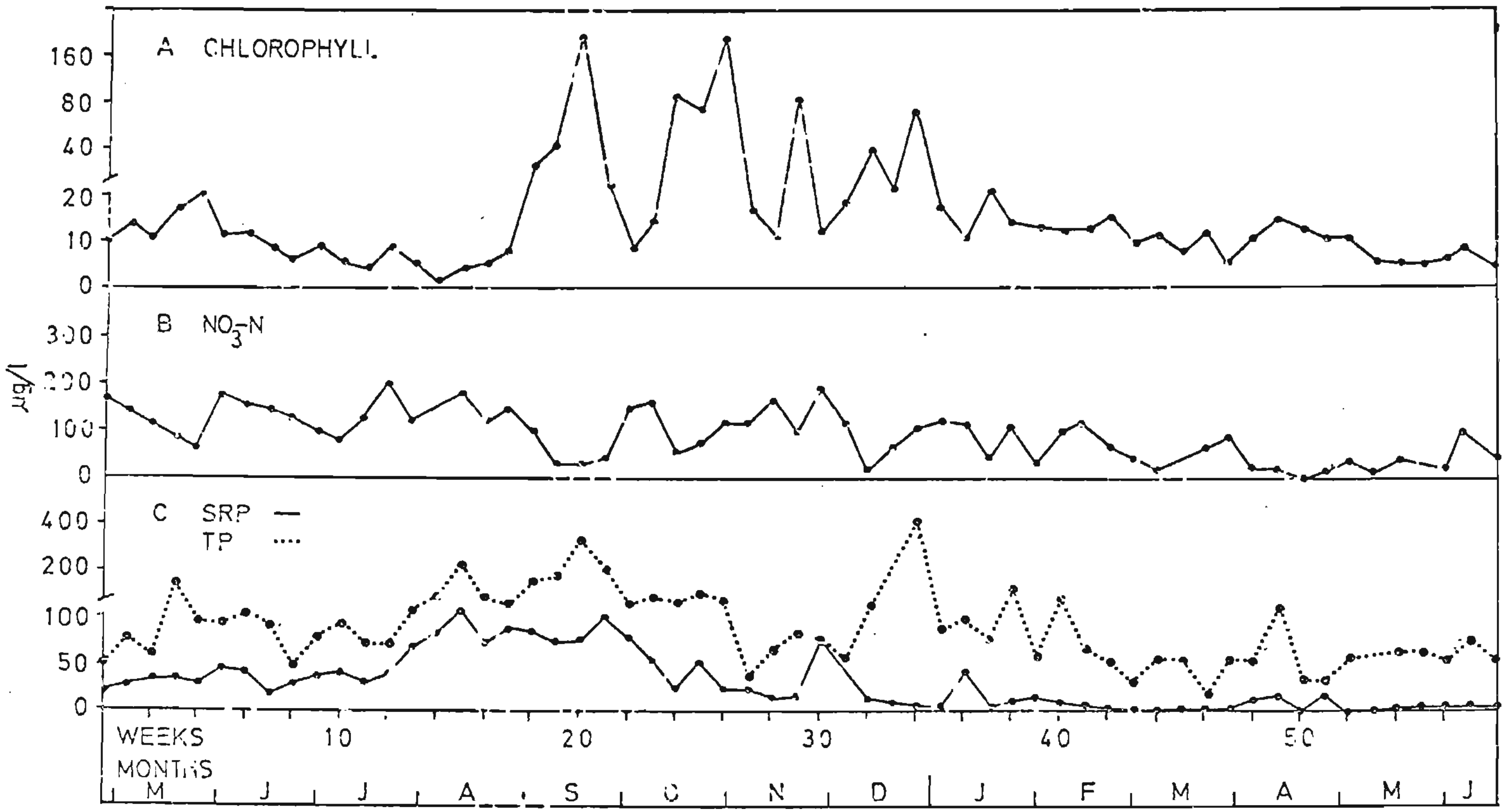


Fig. 3.7.

Changes in chlorophyll (A), NO_3-N (B), SRP and total P (C) in the column +P. A break in the vertical axis reflects a change from a linear to a doubling scale.

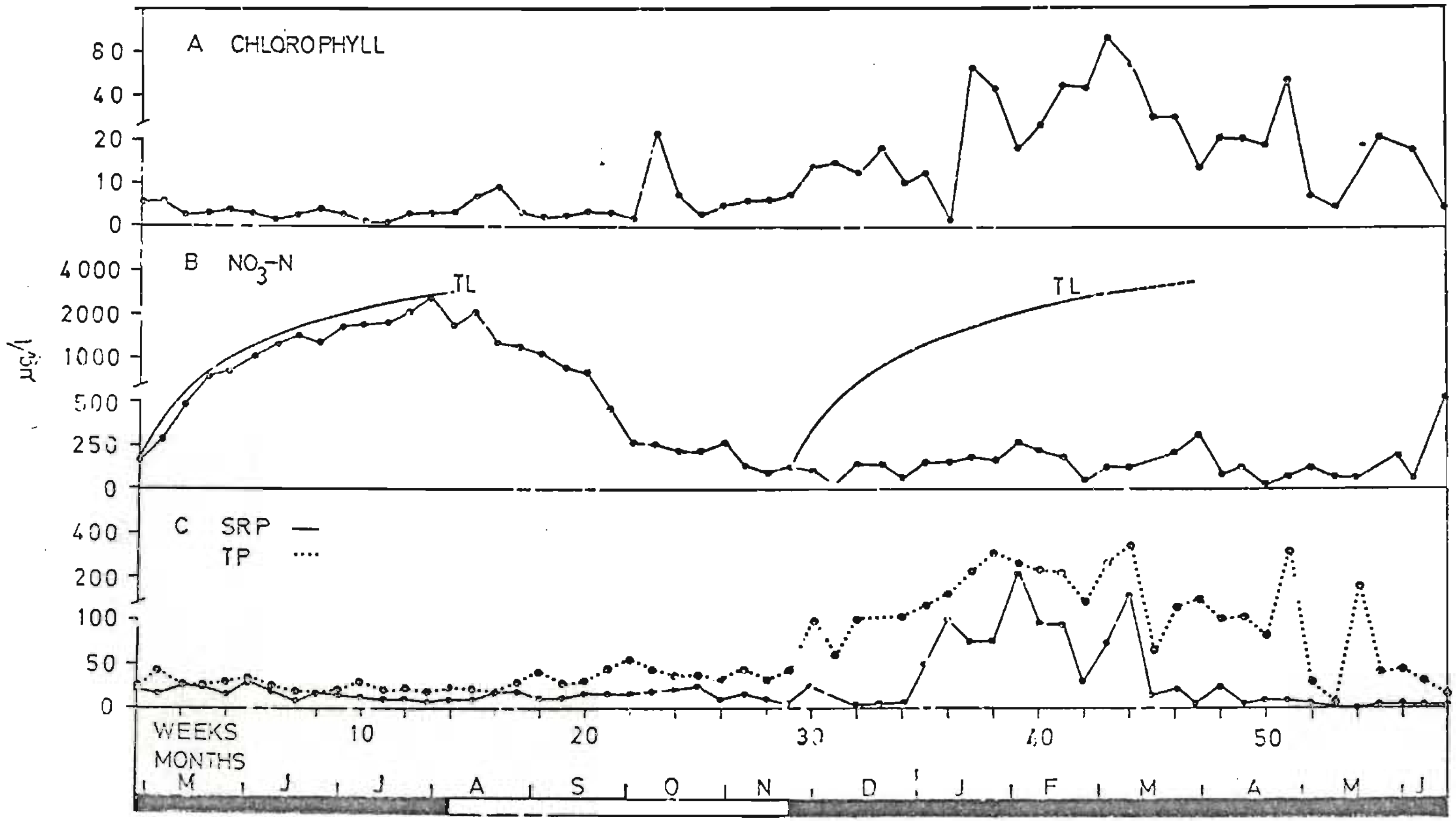


Fig. 3.8.

Changes in chlorophyll (A), NO_3-N (B), SRP and total P (C) concentrations in the column +N. Total load applied (TL) during the winter period of enrichment and during the first eighteen weeks of the summer period are indicated. Shaded areas represent periods of enrichment A break in the vertical axis represents a change from a linear to a doubling scale.

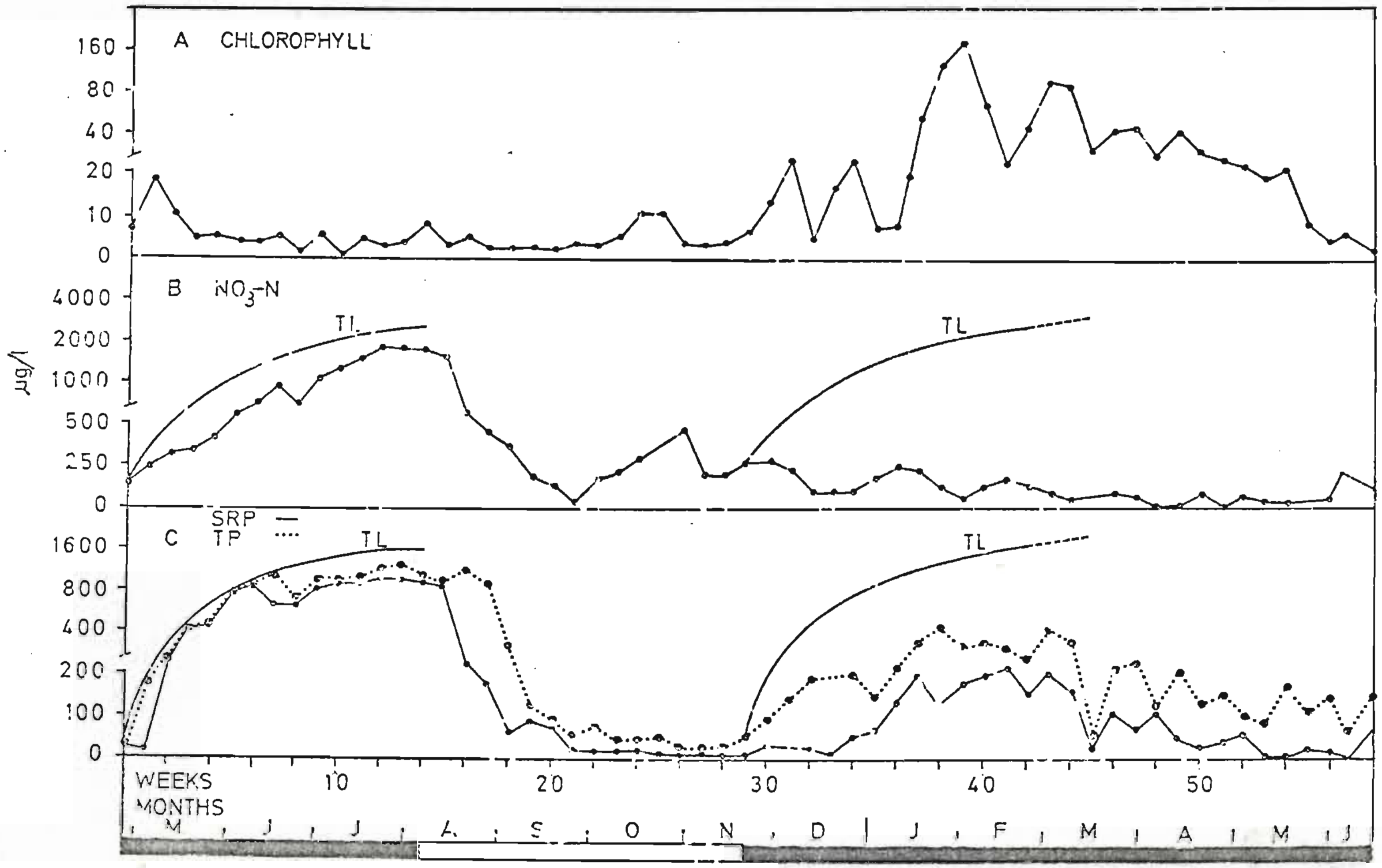


Fig. 3.9.

Changes in chlorophyll (A), NO_3-N (B), SRP and total P (C) concentrations in the column N+P. Total loads applied (TL) during the winter period of enrichment and during the first eighteen weeks of the summer period are indicated. Shaded areas represent periods of enrichment. A break in the vertical axis represents a change from a linear to a doubling scale.

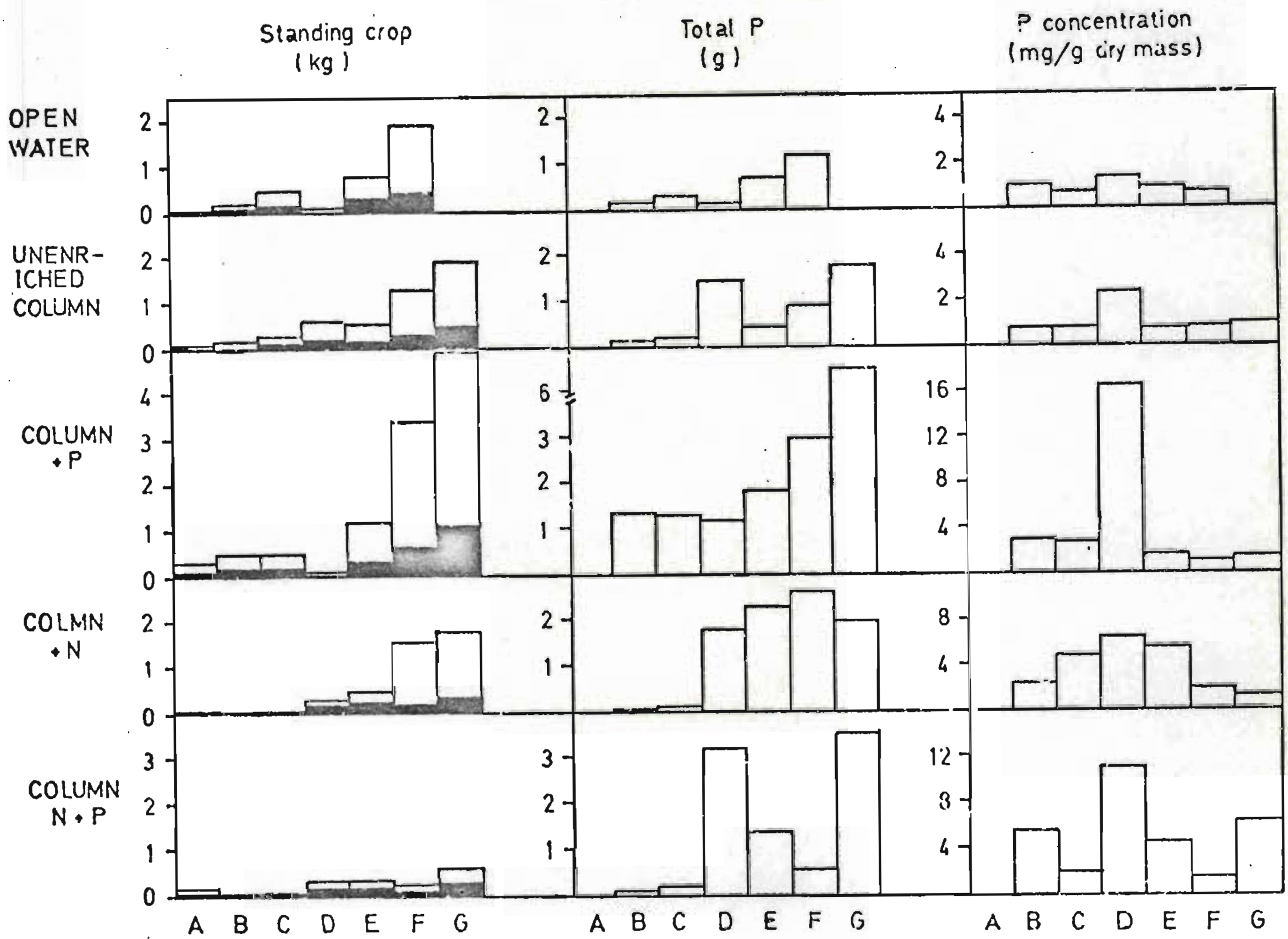


Fig. 3.10.

Standing crop as dry mass, total P bound by,and the average phosphorus concentration of the periphyton in the upper 2,5m of the columns and an equivalent area in the open water. Shaded areas represent organic content estimated by loss on ignition.

A - May 20, 1976; B - June 16; C - August 17; D - September 28; E - January 5, 1977; F - March 23; G - May 5, 1977.

No phosphorus data available for May 20, 1976.

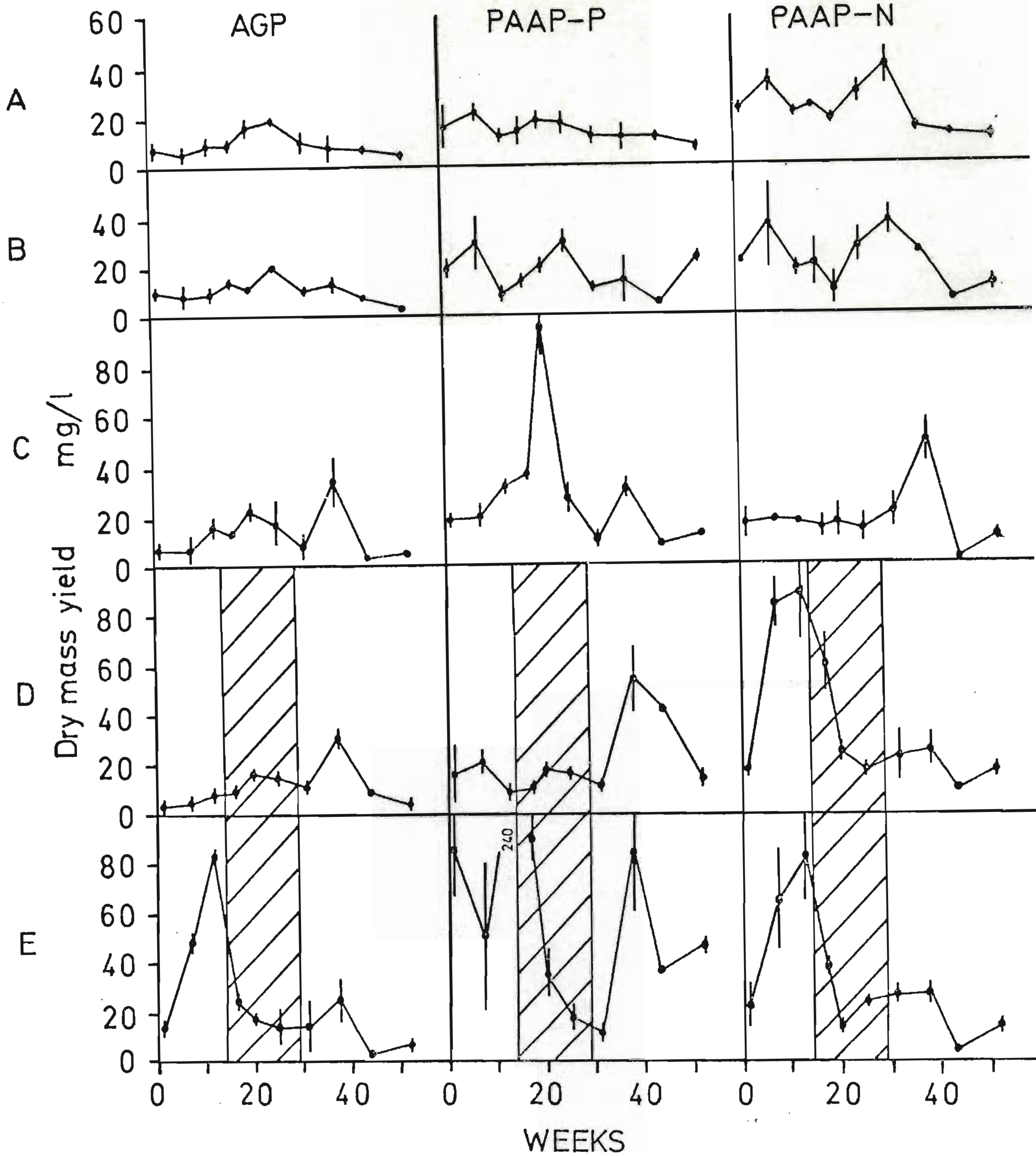


Fig. 3.11.

Algal growth potentials (AGP), PAAP-P spike yields and PAAP-N spike yields in the open water (A), unenriched column (B), the column +P (C) the column +N (D) and the column N+P (E). Vertical bars represent 95% confidence limits and shaded areas represent periods when enrichment was temporarily stopped. Yields for N+P spikes always exceeded 120 mg ℓ^{-1}.

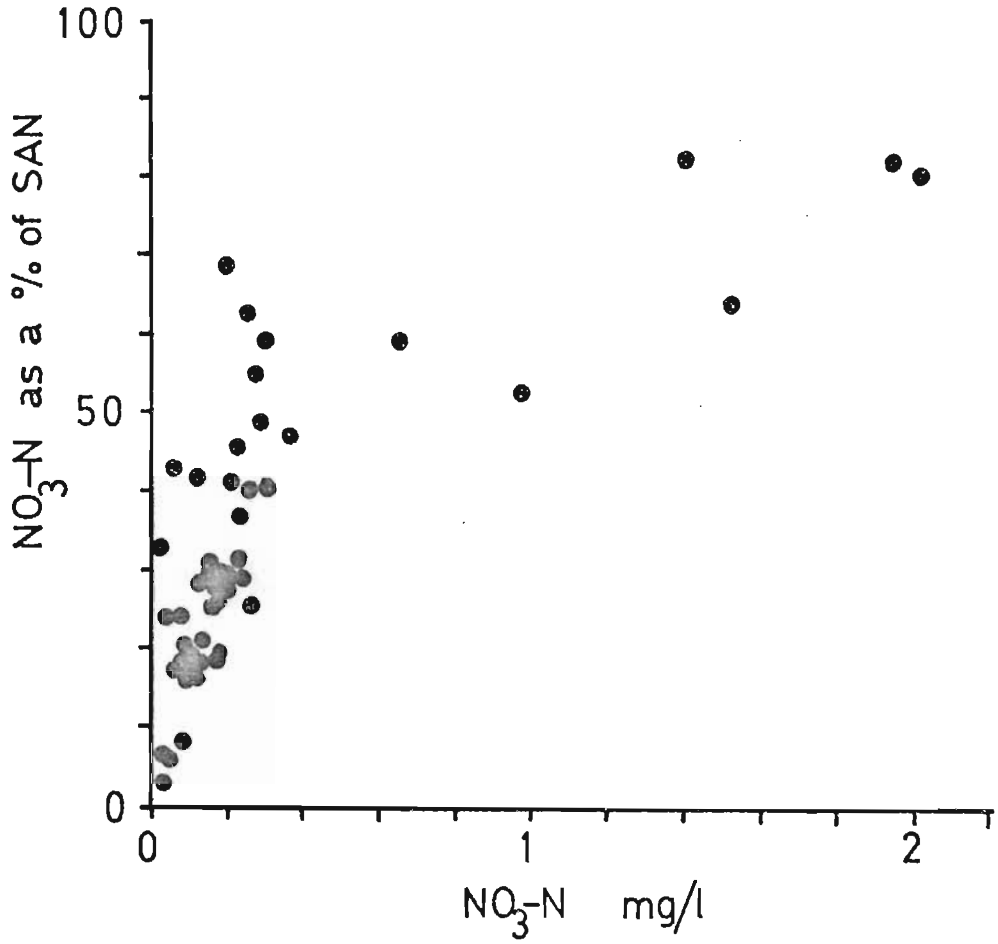


Fig. 3.12.

A scattergram showing the relationship between the analytically determined NO_3-N concentration and the relative contribution of NO_3-N to the soluble available N (SAN) calculated from bioassay yields.

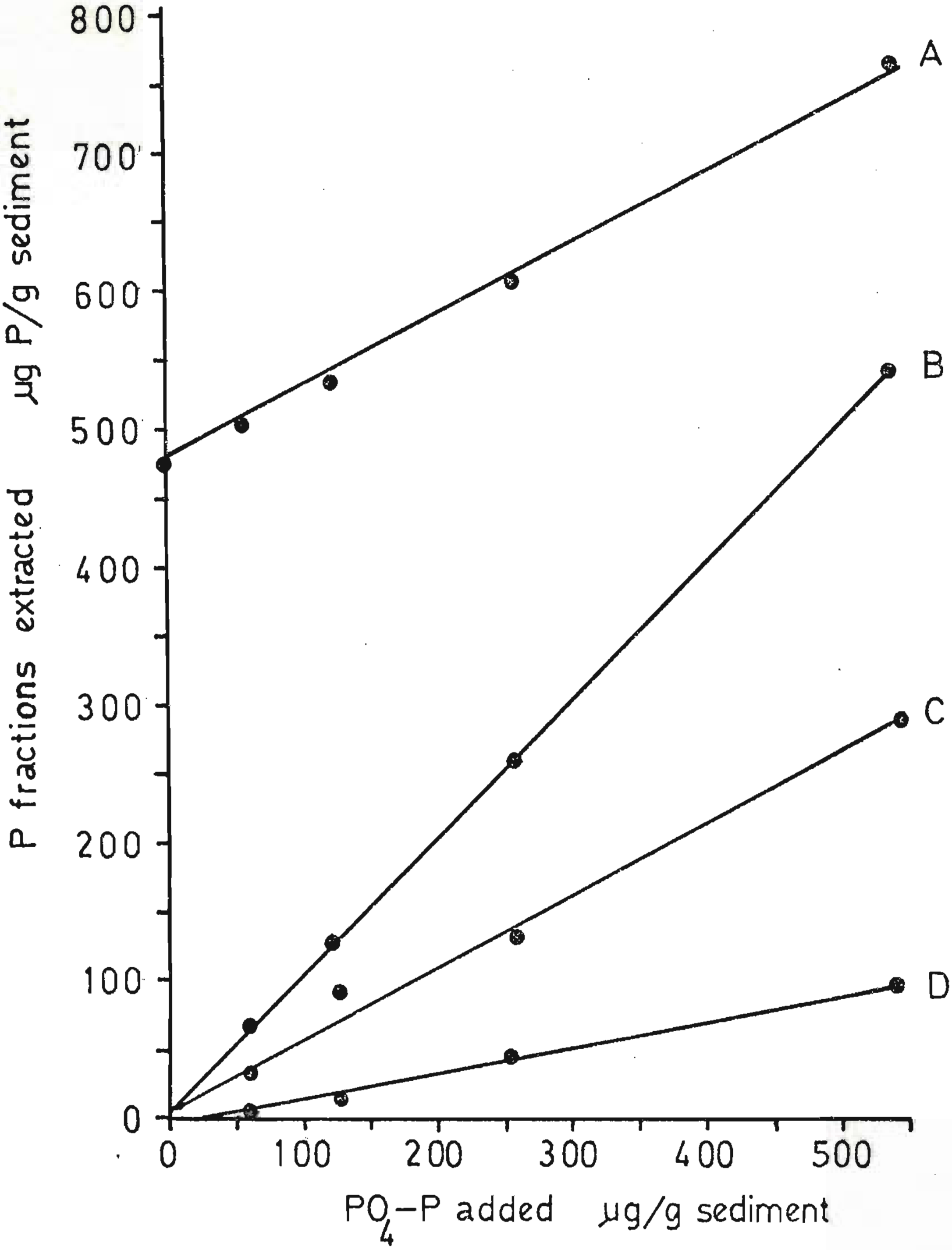


Fig. 3.13.

Acid extractable P (A), expected increase in P content (B), measured increase in P content (C) and available P (D) in subsamples of air dried Midmar Dam sediments following equilibration with PO_4-P solutions of varying concentration. The following regression equations were obtained for the data :

(A) $Y = 0.51x + 483.6$ $r = 0.99$

(B) $Y = 1.0x + 0$ $r = 1.00$

(C) $Y = 0.5x + 9.96$ $r = 0.99$

(D) $Y = 0.18x - 3.5$ $r = 0.99$

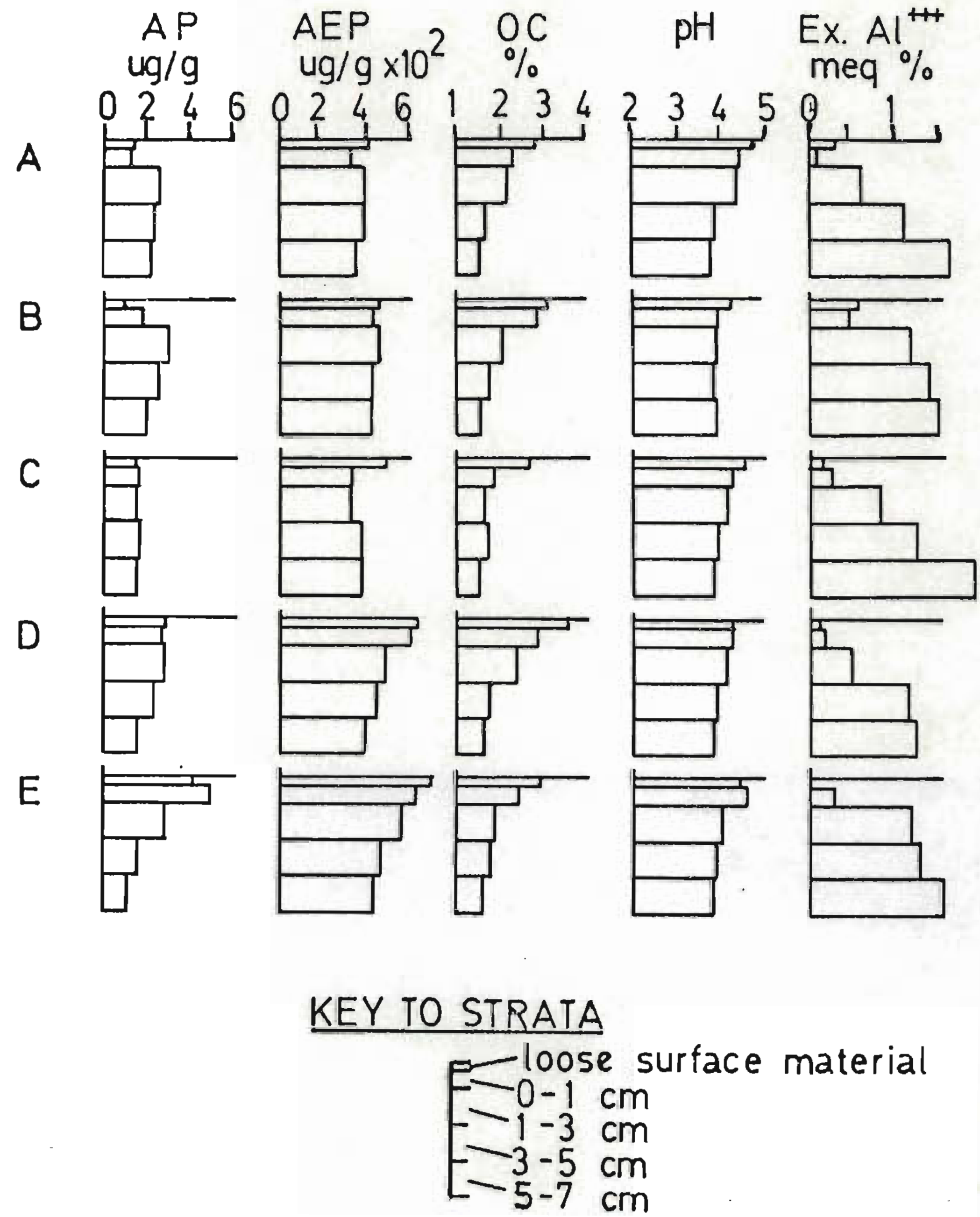


Fig. 3.14.

Available P (AP), acid extractable P (AEP), organic carbon (OC), pH and exchangeable Al^{+++} (Ex Al^{+++}) concentrations measured in stratified sediment cores from the open water (A), the unenriched column (B), the column +P (C), the column +N (D) and the column N+P (E).

TABLE 3.1 Growth limiting nutrients in the open water, unenriched column, column +P, column +N and column N+P.

N indicates nitrogen is limiting

P indicates phosphorus is limiting

= indicates nitrogen and phosphorus equally limiting.

The shaded area represents the period during which enrichment was temporarily stopped.

SITE	WEEKS									
	1	7	12	16	20	25	31	37	44	52
Open water	=	P	P	P	=	P	P	=	=	P
Unenriched column	=	=	P	=	=	=	N	=	=	N
Column +P	=	=	N	N	N	N	N	P	N	=
Column +N	=	P	P	P	P	=	P	N	N	=
Column N+P	N	=	N	N	N	=	P	N	N	N

TABLE 3.2.

Yields in PAAP-N spikes (A), soluble available N (SAN) calculated from PAAP-N spike yields (B), NO_3-N concentrations (C) and the percentage of SAN represented by NO_3-N (D) in the open water and isolation columns.

WEEKS	OPEN WATER				UNENRICHED COLUMN				COLUMN +P				COLUMN +N				COLUMN N+P			
	A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D
	YIELD mg l^{-1}	SAN mg l^{-1}	NO_3-N mg l^{-1}	$\frac{NO_3\text{-N}}{SAN} \times 100$	YIELD mg l^{-1}	SAN mg l^{-1}	NO_3-N mg l^{-1}	$\frac{NO_3\text{-N}}{SAN} \times 100$	YIELD mg l^{-1}	SAN mg l^{-1}	NO_3-N mg l^{-1}	$\frac{NO_3\text{-N}}{SAN} \times 100$	YIELD mg l^{-1}	SAN mg l^{-1}	NO_3-N mg l^{-1}	$\frac{NO_3\text{-N}}{SAN} \times 100$	YIELD mg l^{-1}	SAN mg l^{-1}	NO_3-N mg l^{-1}	$\frac{NO_3\text{-N}}{SAN} \times 100$
1	22	0.63	0.18	29	21	0.60	0.15	25	17	0.49	0.14	29	18	0.51	0.30	59	22	0.63	0.25	40
7	33	0.94	0.18	19	36	1.03	0.19	18	19	0.54	0.15	28	84	2.40	1.54	64	65	1.86	0.99	53
12	21	0.60	0.29	48	18	0.51	0.28	55	18	0.51	0.21	41	89	2.54	2.04	80	83	2.37	1.94	82
16	22	0.63	0.23	37	20	0.57	0.22	39	15	0.43	0.12	28	60	1.71	1.40	82	39	1.11	0.65	59
20	18	0.51	0.30	59	10	0.29	0.20	69	17	0.49	0.03	6	25	0.71	0.86	121	16	0.46	0.13	28
25	28	0.80	0.37	46	27	0.77	0.31	40	14	0.40	0.07	18	18	0.51	0.23	45	24	0.69	-	-
31	39	1.11	0.09	8	37	1.06	0.26	25	21	0.60	0.12	20	23	0.66	0.04	6	27	0.77	0.24	31
37	14	0.40	0.25	63	24	0.69	0.11	16	49	1.40	0.04	3	26	0.74	0.19	26	28	0.80	0.23	29
44	12	0.34	0.08	24	6	0.17	0.04	24	2	0.06	0.02	33	11	0.31	0.13	42	5	0.14	0.06	43
52	10	0.29	0.05	17	11	0.31	0.05	16	11	0.31	0.05	16	17	0.49	0.15	31	14	0.40	0.08	20
$\bar{x}$				35				33				22				56				43

TABLE 3.3.

Yields in PAAP-P spikes (A), soluble available P (SAP) calculated from PAAP-P spike yields (B), SRP concentrations (C) and the percentage of SAP represented by SRP (D) in the open water and isolation columns.

- indicates no data available.

OPEN WATER

WEEKS	A: YIELD mg l^{-1}	B: SAP µg l^{-1}	C: SRP µg l^{-1}	D: $\frac{SRP}{SAP} \times 100$
1	15	19	21	111
7	21	26	17	65
12	12	15	10	67
16	13	16	22	138
20	18	22	20	91
25	17	21	25	119
31	12	15	-	-
37	11	14	UD	5
44	11	14	12	86
52	6	7	UD	5
$\bar{X}$				75

UNENRICHED COLUMN

WEEKS	A: YIELD mg l^{-1}	B: SAP µg l^{-1}	C: SRP µg l^{-1}	D: $\frac{SRP}{SAP} \times 100$
1	19	24	21	88
7	28	35	15	43
12	8	10	10	100
16	14	17	17	100
20	20	25	20	80
25	28	35	25	71
31	11	14	-	-
37	13	16	3	19
44	5	6	3	50
52	21	26	UD	5
$\bar{X}$				61

COLUMN +P

WEEKS	A: YIELD mg l^{-1}	B: SAP µg l^{-1}	C: SRP µg l^{-1}	D: $\frac{SRP}{SAP} \times 100$
1	18	22	27	123
7	20	25	20	125
12	32	40	40	100
16	36	45	70	156
20	115	143	78	55
25	28	35	52	149
31	10	12	-	-
37	30	37	3	8
44	9	11	3	27
52	12	15	UD	5
$\bar{X}$				83

COLUMN +N

WEEKS	A: YIELD mg l^{-1}	B: SAP µg l^{-1}	C: SRP µg l^{-1}	D: $\frac{SRP}{SAP} \times 100$
1	16	20	17	85
7	21	26	10	38
12	9	11	13	118
16	11	14	20	143
20	18	22	20	91
25	17	21	23	133
31	11	14	-	-
37	54	67	77	115
44	42	52	132	254
52	15	19	10	53
$\bar{X}$				114

COLUMN N+P

WEEKS	A: YIELD mg l^{-1}	B: SAP µg l^{-1}	C: SRP µg l^{-1}	D: $\frac{SRP}{SAP} \times 100$
1	85	106	17	16
7	50	62	700	1129
12	240	298	1096	368
16	90	112	248	221
20	36	45	75	167
25	18	22	15	68
31	13	16	-	-
37	86	107	220	206
44	38	47	179	381
52	46	57	64	112
$\bar{X}$				296

TABLE 3.4.

Frequency of occurrence of selected SRP to SAP (soluble available P calculated from bioassay yields) proportions expressed as a percentage and grouped according to arbitrarily selected ranges of SRP. Samples from the open water and all columns are included.

SRP µg l⁻	*n*	SRP as a proportion of SAP 0-49%	50-99%	100-149%	150-200%	>200%
>100	6	0	0	0	0	1.00
25-100	11	0	0.18	0.64	0.18	0
10-25	20	0.15	0.60	0.25	0	0
<10	8	1.00	0	0	0	0

TABLE 3.5.

Correlation coefficients (r) between sediment parameters measured in stratified sediment cores from the open water and isolation columns. A significant correlation (P = 0.001) is indicated by * (n = 25)

AEP = Acid extractable P

AP = Available P

OC = Organic carbon

Al^{+++} = Exchangeable Al^{+++}

	AEP	AP	OC	Al^{+++}
pH	+0.33	+0.24	+0.62 *	-0.83 *
Al^{+++}	-0.37	0.16	-0.79 *	
OC	+0.65 *	+0.23		
AP	+0.72 *			

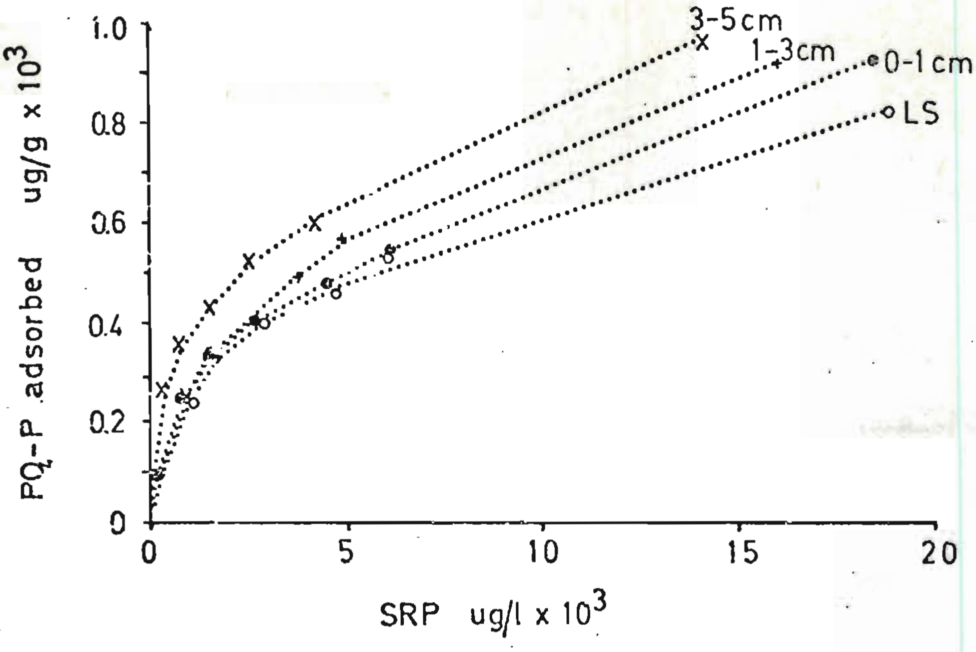


Fig. 4.1. PO_4-P adsorption isotherms for the loose surface material (LS) 0-1cm, 1-3cm and 3-5cm strata in the Midmar Dam sediments.

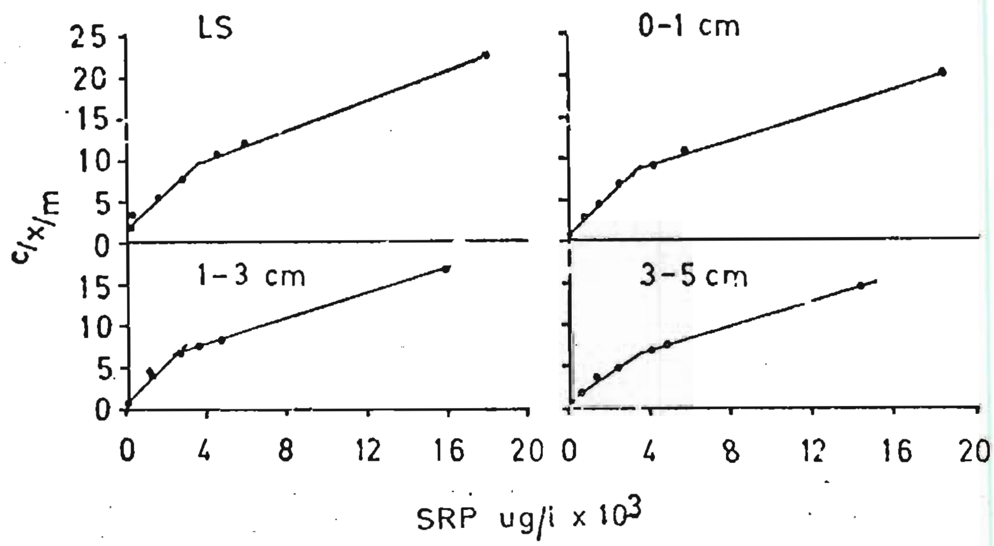


Fig. 4.2. Langmuir plots of the adsorption data. The following regression lines for the first linear regions of the plots were obtained.

LS	$y = 0.00227x + 1.06$	$r^2 = 0.90$
0-1	$y = 0.00233x + 0.80$	$r^2 = 0.99$
1-3	$y = 0.00232x + 1.05$	$r^2 = 0.93$
3-5	$y = 0.00186x + 0.343$	$r^2 = 0.97$

$$c/x/m = \frac{\text{SRP at equilibrium (mg } l^{-1})}{PO_4\text{-P adsorbed by sediment (mg } g^{-1})}$$

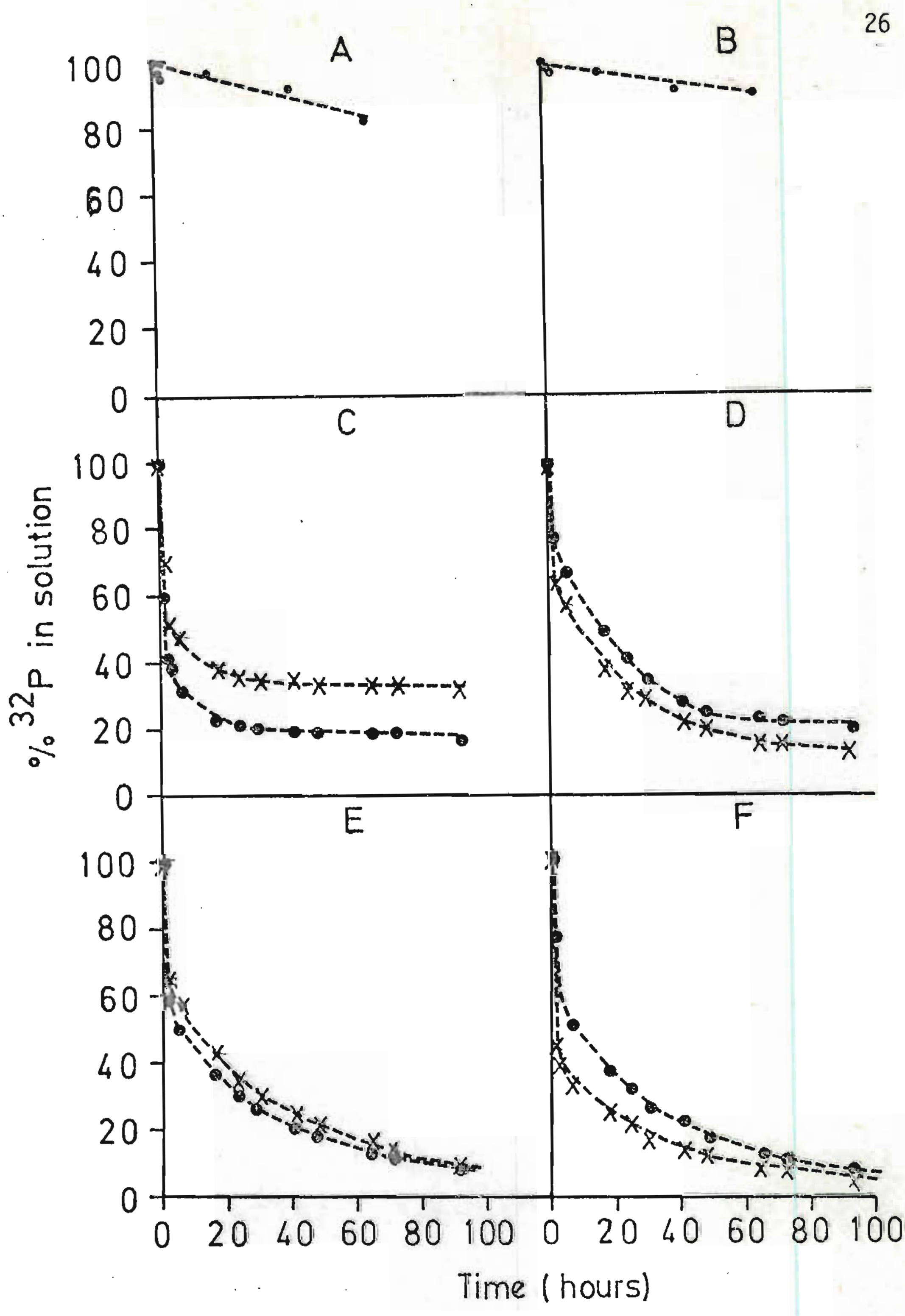


Fig. 4.3.

Uptake of ^{32}P from solution in an unenriched control containing no sediment (A), an enriched control containing no sediment (100μg PO_4-P l^{-1}) (B), in unenriched sediment/water systems (C), and in a series of sediment/water systems enriched as follows: 50μg PO_4-P l^{-1} (D), 100μg PO_4-P l^{-1} (E) and 200μg PO_4-P l^{-1} (F).

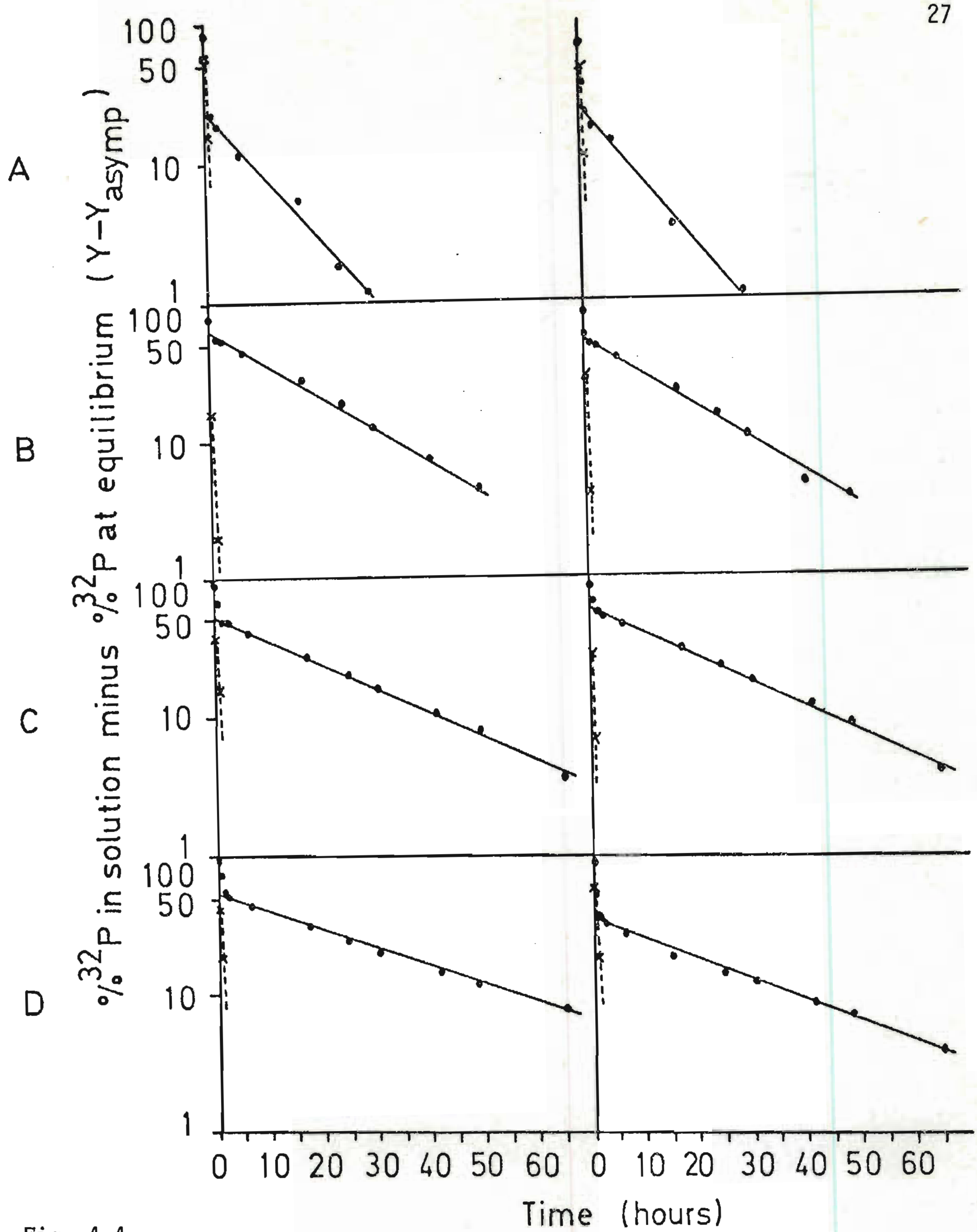


Fig. 4.4.

Semilog plots of the percentage of ^{32}P in solution minus the percentage of ^{32}P in solution at equilibrium ($Y - Y_{asymp}$) against time for the data from ^{32}P uptake experiments in unenriched sediment/water systems (A) and in a series of sediment/water systems enriched as follows: 50 μg PO_4-P ℓ^{-1} (B), 100 μg PO_4-P ℓ^{-1} and 200 μg PO_4-P ℓ^{-1} (D). The broken lines represent the data for the rapid phase of uptake adjusted as described in the methods (section 2.2.2).

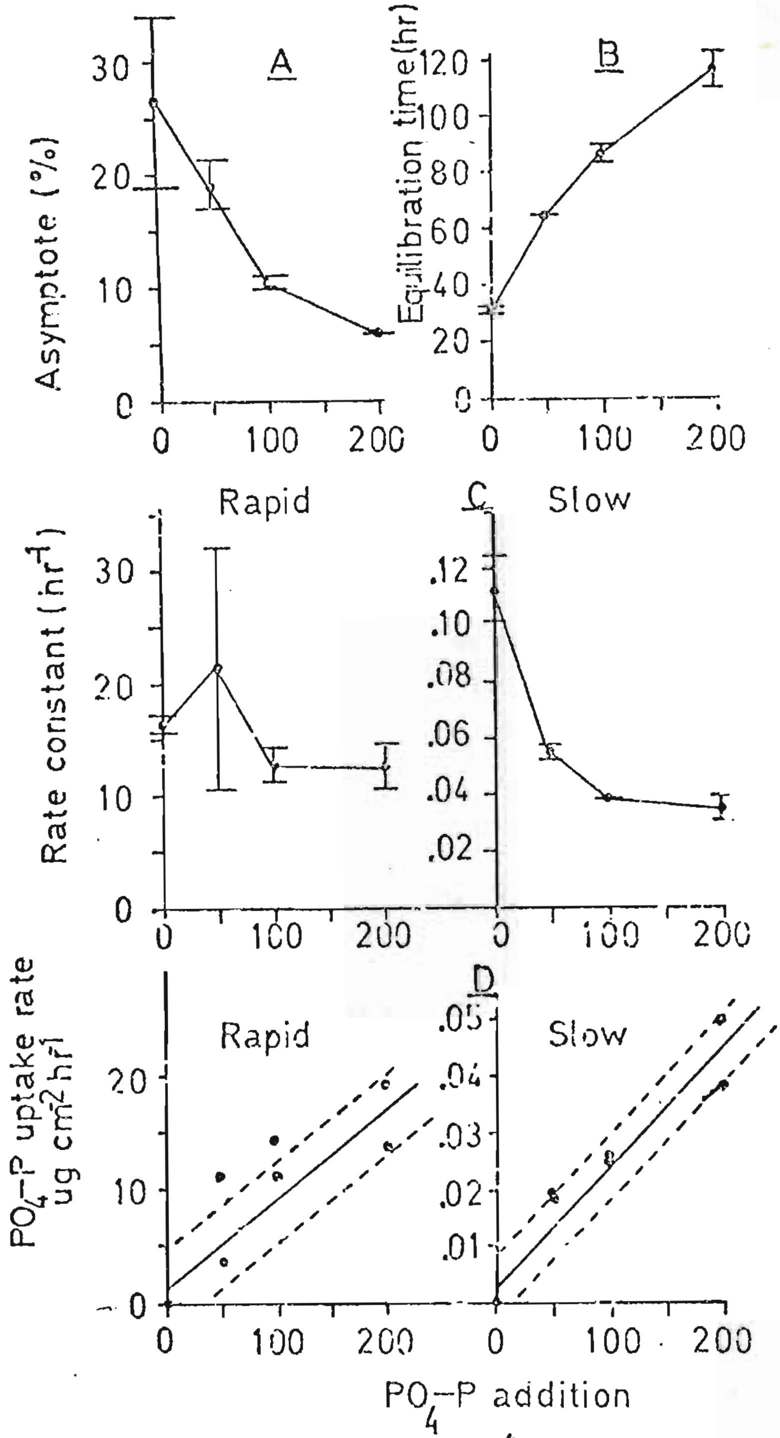


Fig. 4.5.

The influence of increasing PO_4-P enrichment in sediment/water systems on :

A) asymptote levels attained in solution as a percentage of total ^{32}P ($\bar{x}$ and range),

B) the time required for equilibrium to be established ($\bar{x}$ and range),

C) the rate constants (k) for the rapid and slow phases of uptake ($\bar{x}$ and range)

D) the PO_4-P uptake rates (solid line obtained by linear regression analysis, broken lines indicate 95% confidence limits).

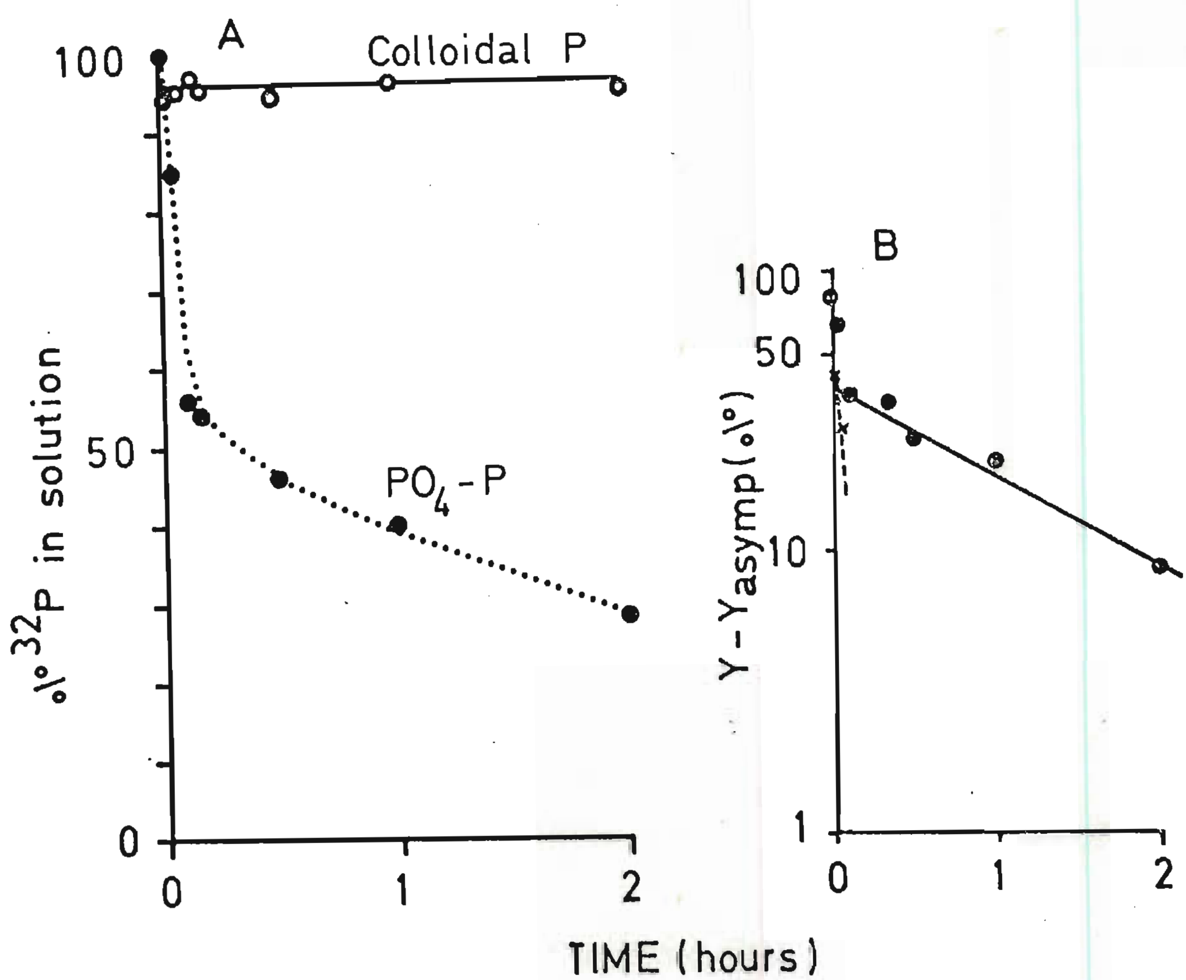


Fig. 4.6.

A) Uptake of labelled PO_4-P and colloidal P from Midmar Dam filtrate by intact sediment cores.

B) Semilog plots of the percentage of ^{32}P in solution minus the percentage of ^{32}P in solution at equilibrium ($Y - Y_{asymp}$) against time for the labelled PO_4-P uptake data. The broken line represe data for the rapid phase of uptake adjusted as described in the methods (section 2.2.2).

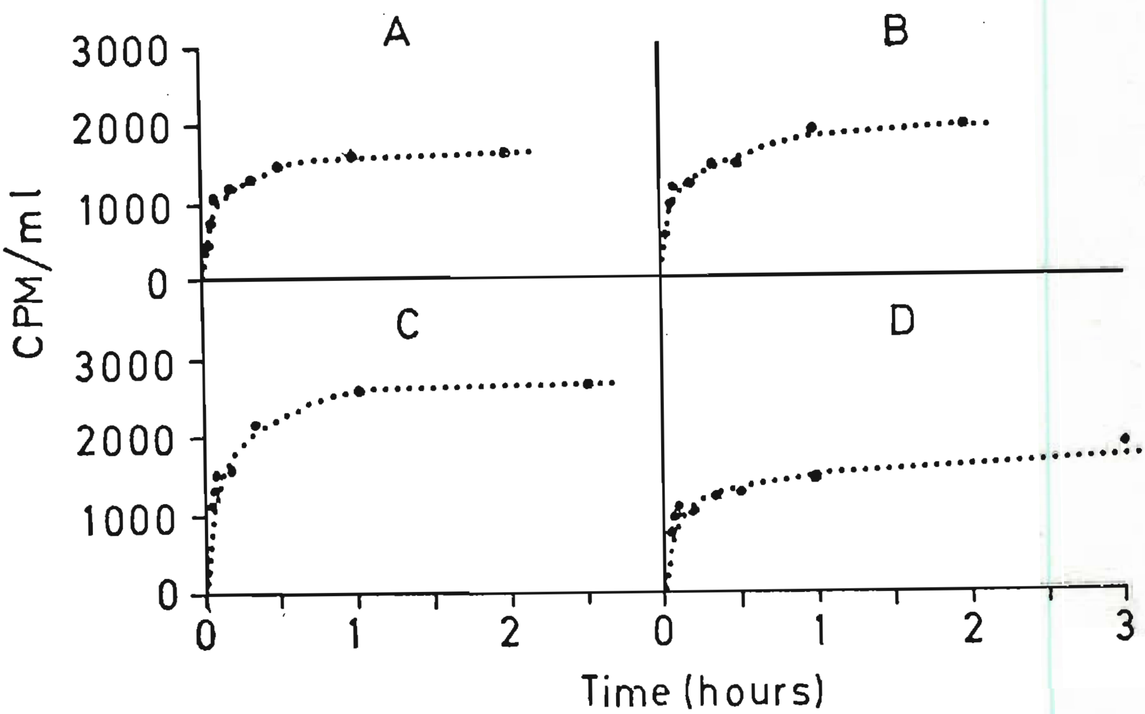


Fig. 4.7.

Release of ^{32}P from intact sediment cores into solution following previous enrichment with PO_4-P as follows : no enrichment (A), 50 μg PO_4-P ℓ^{-1} (B), 100 μg PO_4-P ℓ^{-1}(C) and 200 μg PO_4-P ℓ^{-1}(D). Expressed as counts per minute per ml of solution.

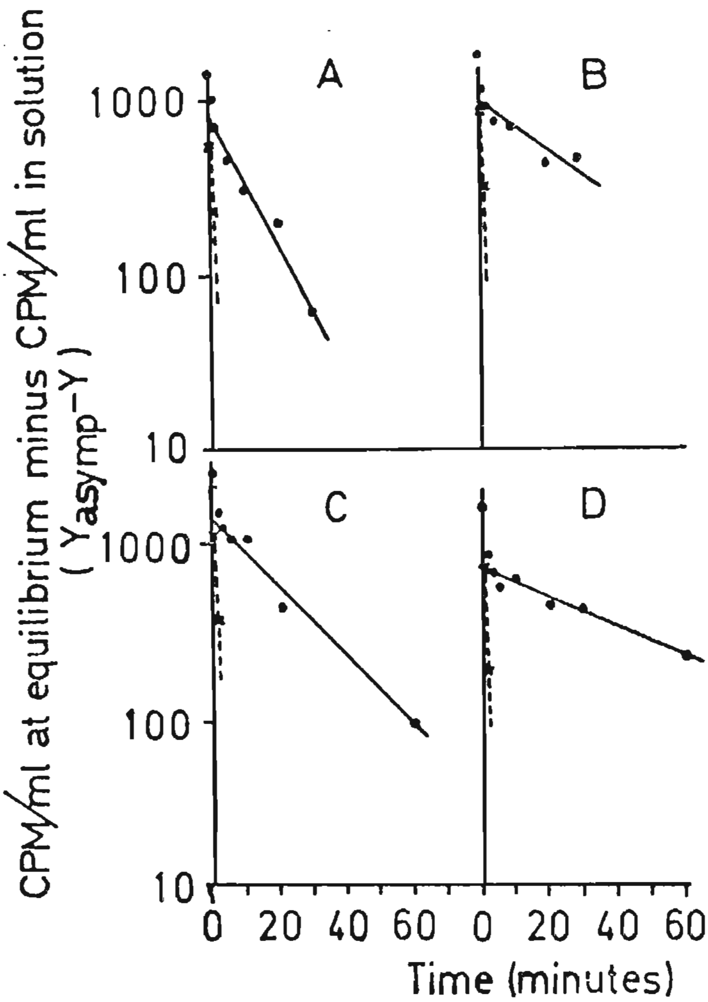


Fig. 4.8.

Semilog plots of the ^{32}P concentration in solution at equilibrium (CPM ml^{-1}) minus the ^{32}P concentration in solution (Y_{asymp} - Y) against time for the data for ^{32}P release experiments in sediment/ water systems following previous enrichment with PO_4-P as follows: no enrichment (A), 50 μg PO_4-P ℓ^{-1} (B), 100 μg PO_4-P ℓ^{-1} (C) and 200 μg PO_4-P ℓ^{-1} (D). The broken lines represent the data for the rapid phase of release adjusted as described in the methods (section 2.2.2)

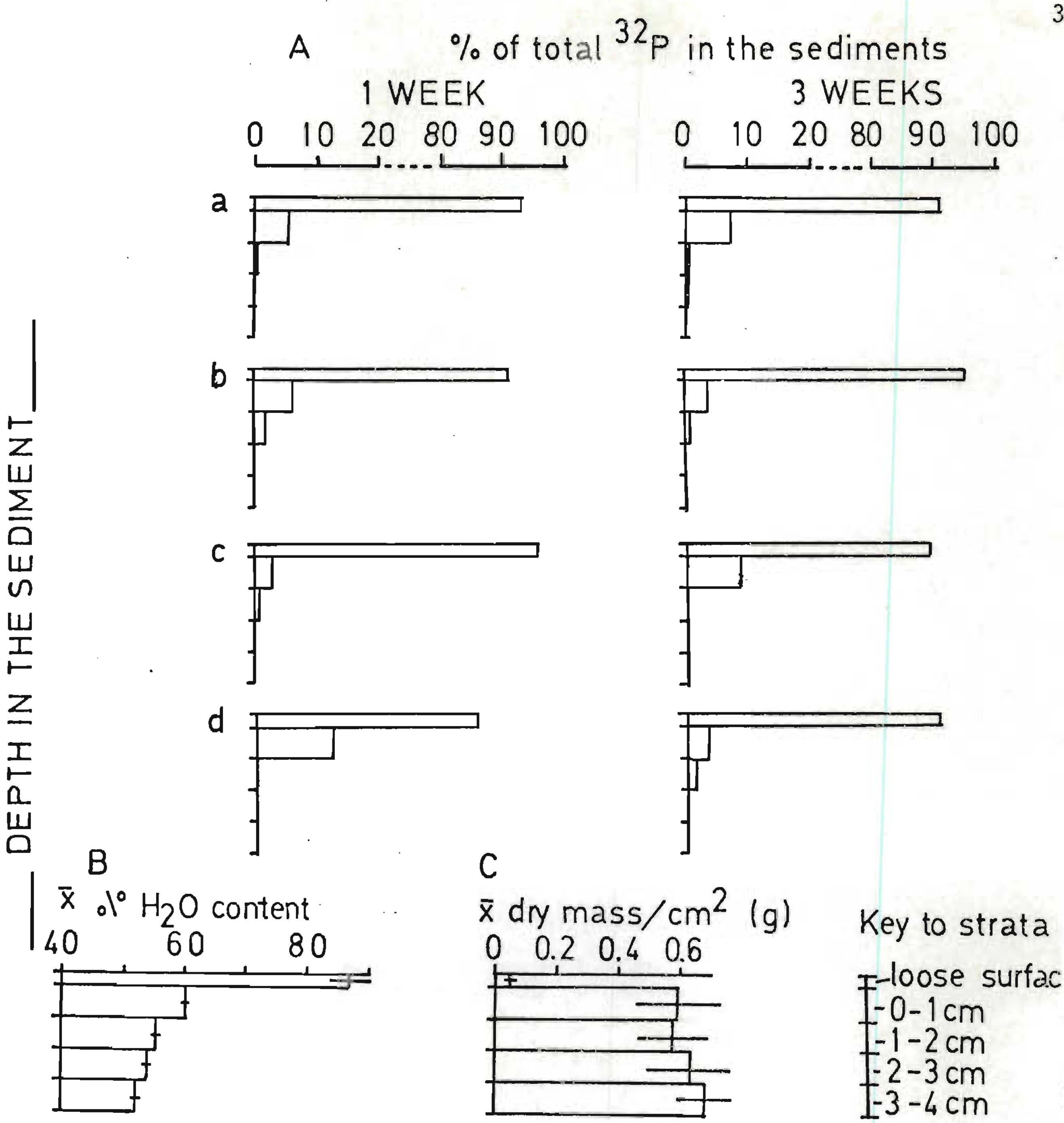


Fig. 4.9.

A) Vertical distribution of ^{32}P in Midmar Dam sediment cores after 1 and 3 weeks equilibration under unenriched conditions (A) and and during enrichment with 50 (B), 100 (C) and 200 (D) $\mu g\ l^{-1} PO_4$-P.

B) Vertical profile of water content in Midmar Dam sediment cores. Mean for all values plotted with one standard deviation (horizontal bars).

C) Dry mass content of the strata used during this investigation. Mean for all values plotted with one standard deviation (horizontal bars)

TABLE. 4.1. P adsorption maxima (b), bonding energy constants (k), organic carbon (OC), exchangeable Al^{3+} (Al^{3+}), pH, available P (AP) and acid extractable P (AEP) in stratified Midmar Dam sediment cores, and the correlation between b and k and the other parameters measured. r_b = correlation coefficients between b and the other parameters, r_k = correlation coefficients between k and the other parameters

Depth of sediment	b $\mu g\ g^{-1}$	k $\ell \mu g^{-1}$ x 10^{-2}	OC %	Al^{+++} meq%	pH	AP $\mu g\ g^{-1}$	AEP $\mu g\ g^{-1}$
LS	440	0.21	2.85	0.28	4.75	1.45	415
0-1 cm	429	0.29	2.30	0.10	4.40	1.35	330
1-3 cm	431	0.22	2.20	0.60	4.35	2.63	390
3-5 cm	538	0.54	1.65	1.15	3.80	2.37	360
Correlation Coefficients							
r_b	-	-	-0.76**	0.09	-0.85*	0.41	-0.172
r_k	-	-	-0.86*	0.17	-0.92*	0.33	-0.462

* significant P = 0.05

** significant P = 0.10

LS = Loose surface material

TABLE 4.2. Data describing uptake of $^{32}PO_4$-P in control systems containing no sediment

r^2 = coefficient of determination, Y_0 = Y intercept

k = rate constant

PO -P added μg ℓ^{-1}	r^2	Y_0 % ^{32}P	k hr^{-1}
0	0.920	98.6	.0024
100	0.320	96.7	.0008

TABLE 4.3. Data describing the uptake of the PO_4-P fraction from Midmar Dam filtrate by intact sediment cores.

r^2 = coefficient of determination,

Y_0 = Y intercept, k = rate constant and

n = number of data points.

Phase of uptake	r^2	Y_0 %^{32}P	k min^{-1}	n
Rapid Phase	1.0000	42.0	14.73	2
Slow Phase	0.9810	38.4	0.7662	5

TABLE 4.4. Data describing the two phases of ^{32}P uptake by sediments in intact sediment water systems receiving varying loads of PO_4^--P. r^2 = coefficient of determination, Yo = Y intercept, k = rate constant, n = number of data points, MPFR = maximum possible fixation rate. * indicates steady state conditions where MPFR represents exchange rate not uptake rate.

PO_4-P added $\mu g\ \ell^{-1}$		Equil. Time min	SRP in solution $\mu g\ \ell^{-1}$		Asymp. %	FAST PHASE					SLOW PHASE				
			t_0	t_{asymp}		r^2	Yo $\%^{32}P$	k hr^{-1}	n	MPFR $\mu g\ cm^{-2}\ hr^{-1}$	r^2	Yo $\%^{32}P$	k hr^{-1}	n	MPFR $\mu g\ cm^{-2}\ hr^{-1}$
0	1	31	16	16	19.0	1.00	57.9	16.05	2	1.7 *	1.00	23.1	.1011	6	.010 *
	2	30	16	16	34.0	1.00	41.2	17.47	2	1.9 *	0.99	24.7	.1241	5	.013 *
	$\bar{x}$	31.5	16	16	26.5	1.00	49.6	16.76	2	1.8 *	1.00	23.9	.1126	6	.011 *
50	1	65	67	14	21.5	1.00	15.2	10.62	2	3.73	1.00	63.3	.0535	8	.019
	2	65	67	16	17.0	1.00	28.6	32.64	2	11.02	1.00	54.4	.0563	8	.019
	$\bar{x}$	65	67	15	19.3	1.00	21.9	21.63	2	7.37	1.00	58.9	.0549	8	.019
100	1	90	115	16	10.0	1.00	39.0	11.37	2	7.46	1.00	51.0	.0388	9	.025
	2	85	115	16	11.0	1.00	28.4	14.20	2	9.31	1.00	60.6	.0399	9	.026
	$\bar{x}$	87.5	115	16	10.5	1.00	33.7	12.79	2	8.39	1.00	55.8	.0394	9	.026
200	1	122	210	18	6.0	1.00	40.3	10.72	2	13.63	1.00	53.8	.0302	10	.038
	2	110	210	16	6.0	1.00	57.0	14.83	2	19.06	1.00	37.1	.0387	10	.050
	$\bar{x}$	116	210	17	6.0	1.00	48.7	12.78	2	16.34	1.00	45.5	.0345	10	.044

TABLE 4.5. Data describing the release of ^{32}P by sediments in intact sediment water systems following enrichment with varying loads of PO_4-P. r^2 = coefficient of determination, Yo = Y intercept, k = rate constant, n = number of data points, MPRR = maximum possible release rate.

PO -P added µg ℓ^{-1}	Asym. CPM ml^{-1}	SRP µg ℓ^{-1}	^{32}p Released as a % of total ^{32}p applied	RAPID PHASE					SLOW PHASE				
				r^2	Y_0 CPM $m\ell^{-1}$	k min^{-1}	n	MPRR µg cm^2hr^{-1}	r^2	Y_0 CPM $m\ell^{-1}$	k min^{-1}	n	MPRR µg cm^2hr^{-1}
0	1500	7	0.70	1.00	600	1.7509	2	4.87	0.9641	909	0.0869	6	0.242
50	1900	9	0.80	1.00	875	2.0118	2	7.19	0.7730	1053	0.0317	6	0.113
100	2600	7	1.00	1.00	1200	2.4643	2	6.85	0.9721	1384	0.0467	6	0.130
200	1600	9	0.70	1.00	925	3.2737	2	11.71	0.9287	698	0.0191	7	0.053
$\bar{x}$	1900	8.0	0.80	1.00	900	2.3752	2	7.655	0.9095	1011	0.0461	6	0.134

TABLE. 4.6. A comparison of P release rates measured from a variety of lake sediments

A = aerobic ; AA = anaerobic ; * = whole lake study

Sediment Source	Oxygen Status	P Release Rate mg m^{-2} d^{-1}	Reference
Lake Warner (U.S.)	A	1.2	Fillos and Swanson (1975)
" "	AA	26 (max)	"
Gnadensee(Germany)	A	1.2 - 9.4	Banoub (1975)
Lake Esrom(Denmark)	A	8 - 9	Kamp Nielsen (1975a)
" "	AA	16.2	Kamp Nielsen (1975b)
Lake Furesø(Denmark)	AA	17.0	Kamp Nielsen (1974)
Lake Erie (U.S.)	AA	13.0	Burns (1976)
Lough Neagh(Ireland)	*	20 - 48	Stevens et al.(1976)
" "	A	9.7 - 18.7	Rippey (1976)
Lake Mohegan(U.S.)	AA	3 - 11	Fillos (1976)
" "	A	2 - 9	"
Lake Glaningen (Sweden)	A	47	Ryding and Forsberg(1976)
Lake Ramsjön (Sweden)	A	13	" "
Lake Ryssbysjön (Sweden)	A	9	" "
Lake Sadra Bergundasjön(Sweden)	AA	22 - 49	Bengtsson (1975)
East Twin Lake(U.S.)	*	0.7 - 2.3	Cooke *et al.* (1977)
West Twin Lake(U.S.)	*	0.8 - 2.6	" "
Lake Mossø (Denmark)	A	4.5 - 8.6	Van Bo Riemann (1977)
Lake Trumen(Sweden)	AA	0.65 - 14.0	Bengtsson *et al.*(1975)
Lake Mendota(U.S.)	A	0 - 51	Gallepp (1979)
Midmar Dam (S.A.)	A	0 - 32	This study

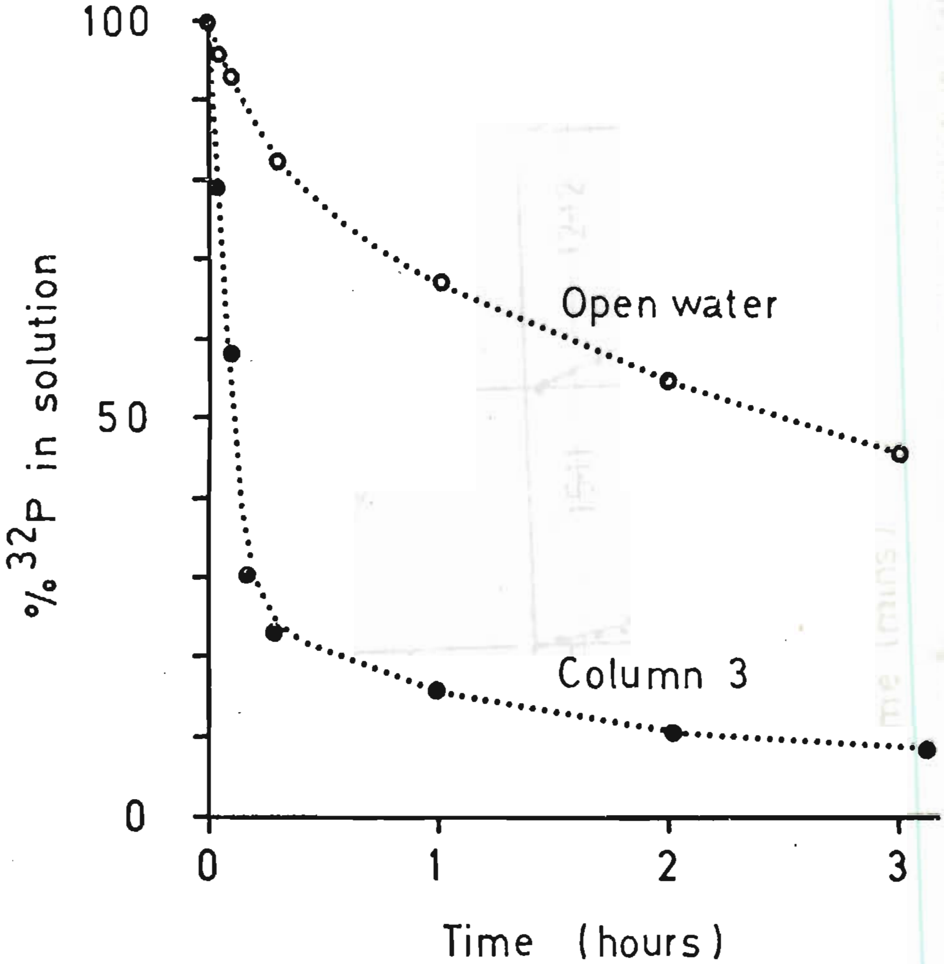


Fig. 5.1.

Examples of ^{32}P transfer curves in the open water and in column 3 on May 23, 1978.

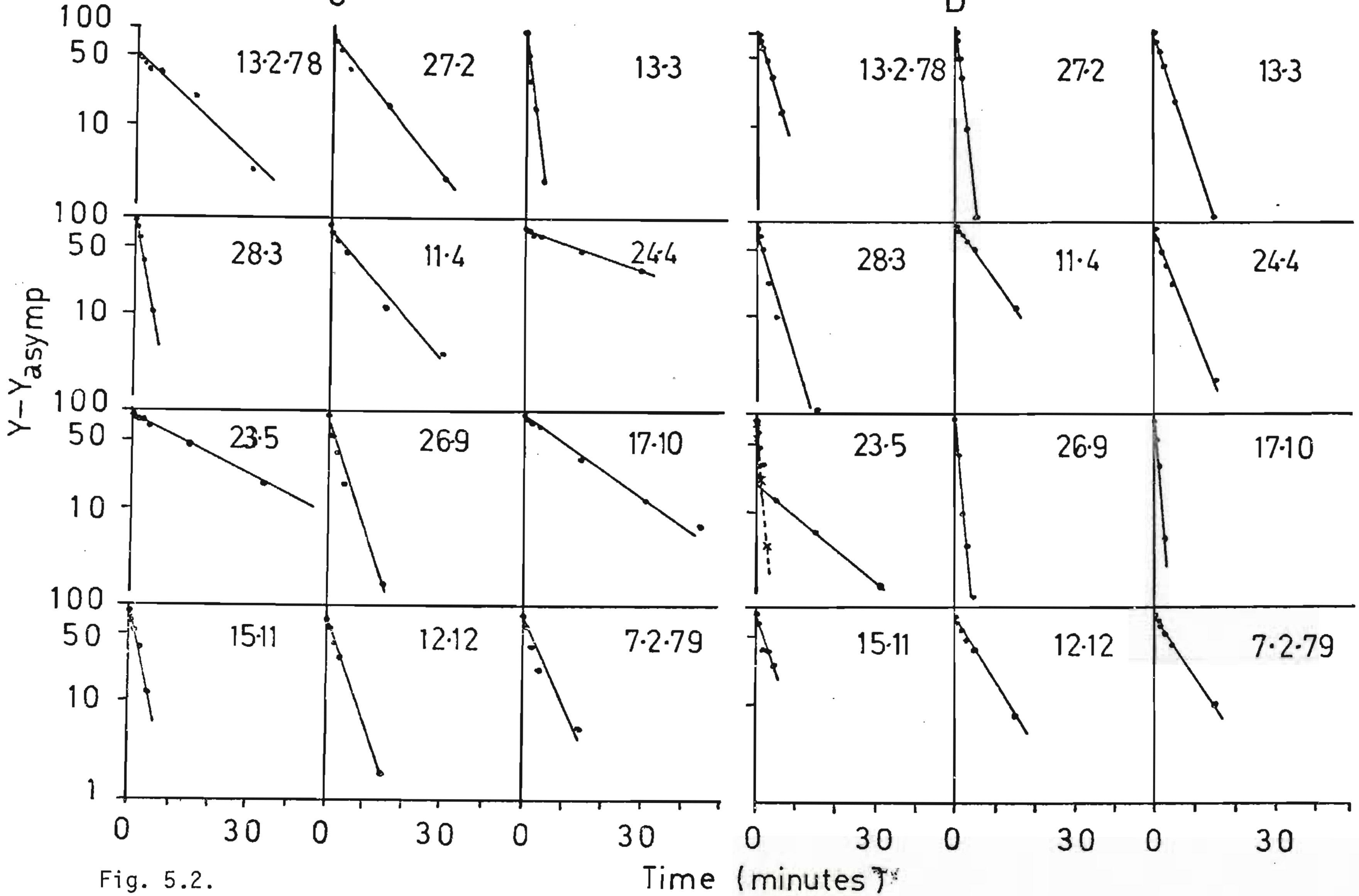


Fig. 5.2.

C-D. Semilog plots of the percentage of ^{32}P in solution minus the percentage of ^{32}P in solution at equilibrium ($Y - Y_{asymp}$) against time for the ^{32}P uptake data obtained in water sampled in column 2 (C) and column 3 (D). When the uptake was diphasic the rapid phase was adjusted as described in the methods (section 2.3.1.) and plotted using broken lines.

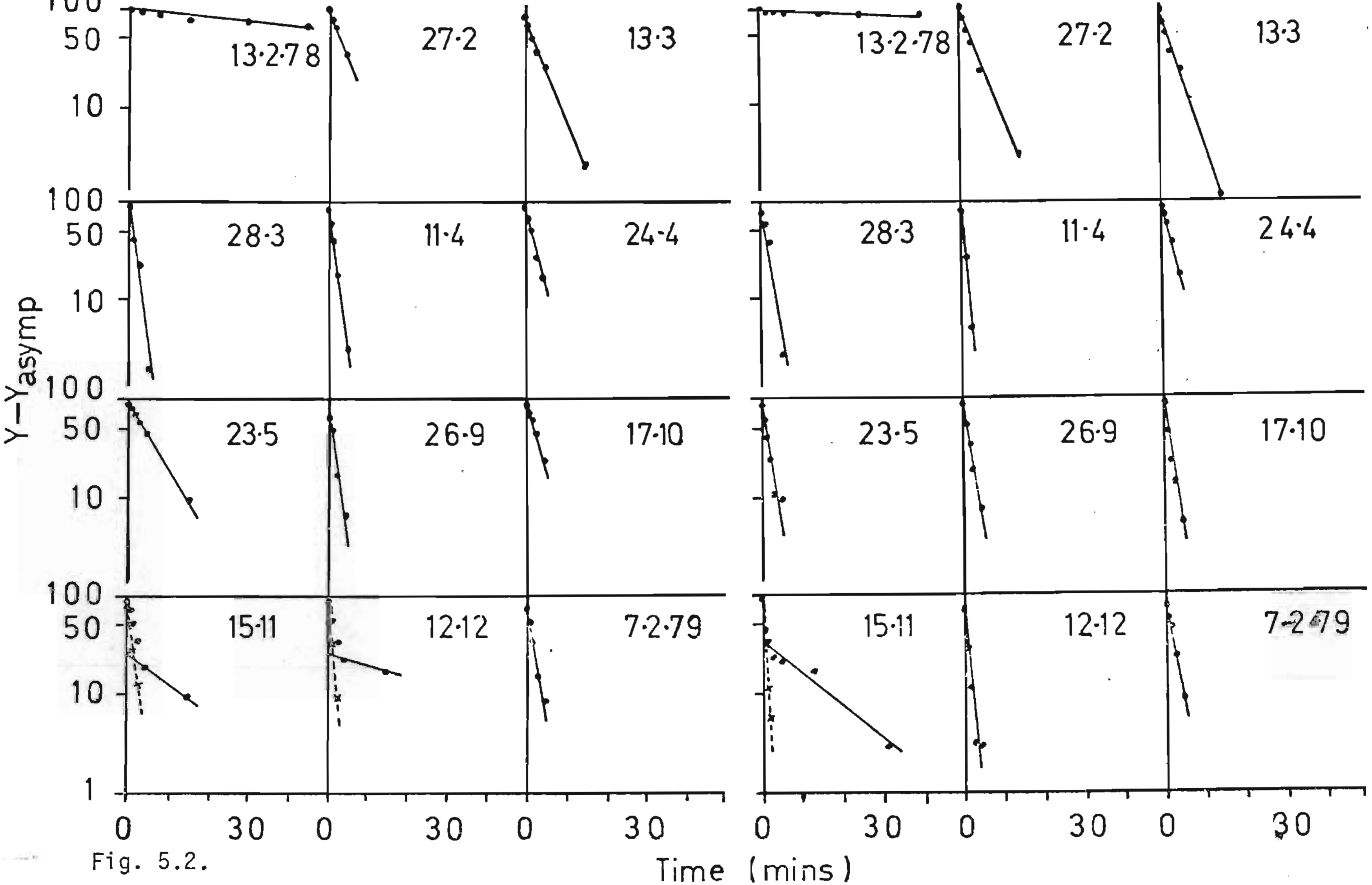


Fig. 5.2.

E-F. Semilog plots of the percentage of ^{32}P in solution minus the percentage of ^{32}P in solution at equilibrium ($Y - Y_{asymp}$) against time for the ^{32}P uptake data obtained in water sampled in column 4 (E) and column 5 (F). When the uptake was diphasic the rapid phase was adjusted as described in the methods (section 2.3.1) and plotted using broken lines.

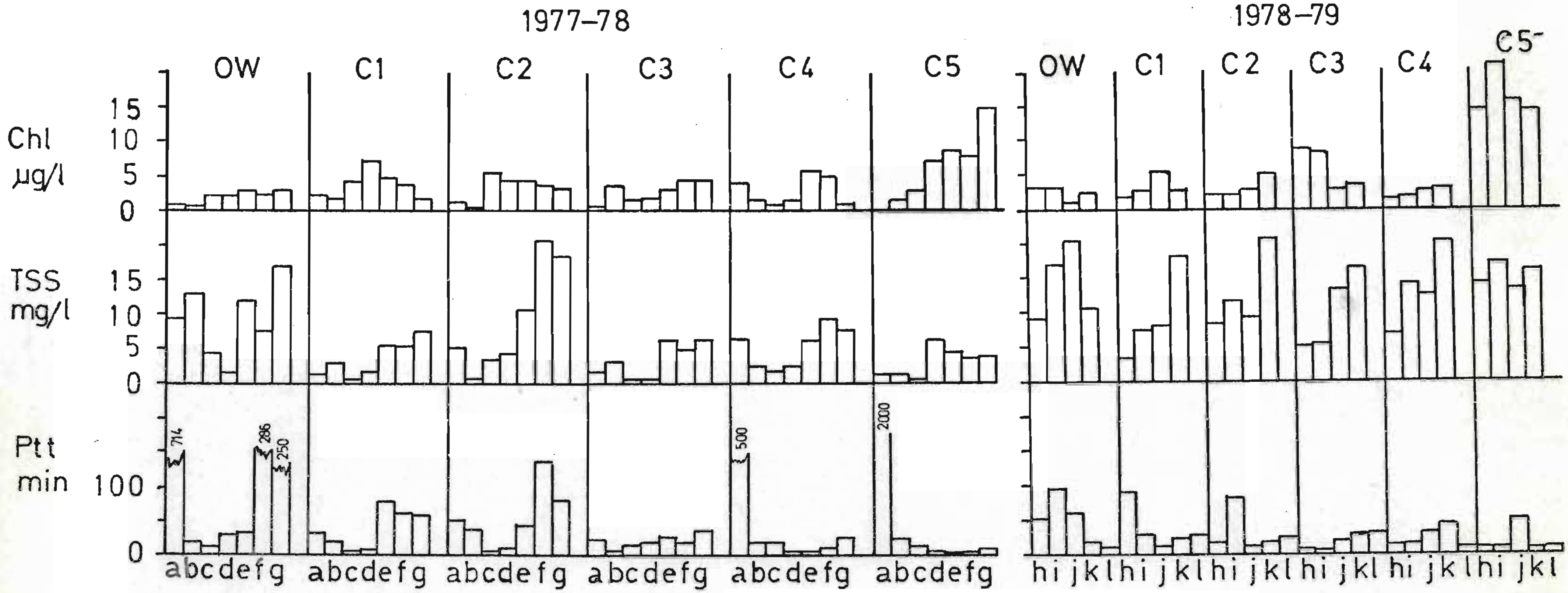


Fig. 5.3.

Chlorophyll (Chl), TSS and P turnover time (Ptt) measured in the open water (OW) and in the columns (C1 - C5) during 1977-78 and 1978-79. NO_3-N loading rates during 1977-78 were as follows : C1 - unenriched, C2 - 25 µg ℓ^{-1} week^{-1}, C3 - 50 µg ℓ^{-1} week^{-1}, C4 - 100 µg ℓ^{-1} week^{-1} and C5 - 200 µg ℓ^{-1} week^{-1}. During 1978-79 C1 remained unenriched and the other columns were enriched with 200 µg NO_3-N ℓ^{-1} week^{-1}. Measurements were made on the following dates: 13-2-78 (a), 27-2 (b), 13-3 (c), 28-3 (d), 11-4 (e), 24-4 (f), 23-5 (g), 26-9 (h), 17-10 (i), 15-11 (j), 12-12 (k) and 7-2-79(l)

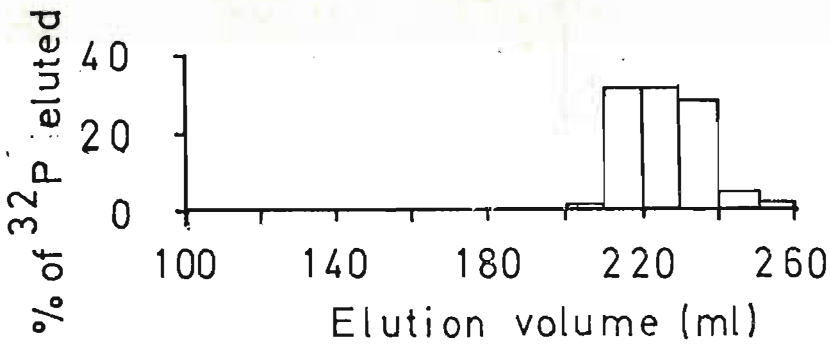


Fig. 5.4.

Distribution of ^{32}P in $^{32}PO_4$-P stock solution following fractionation.

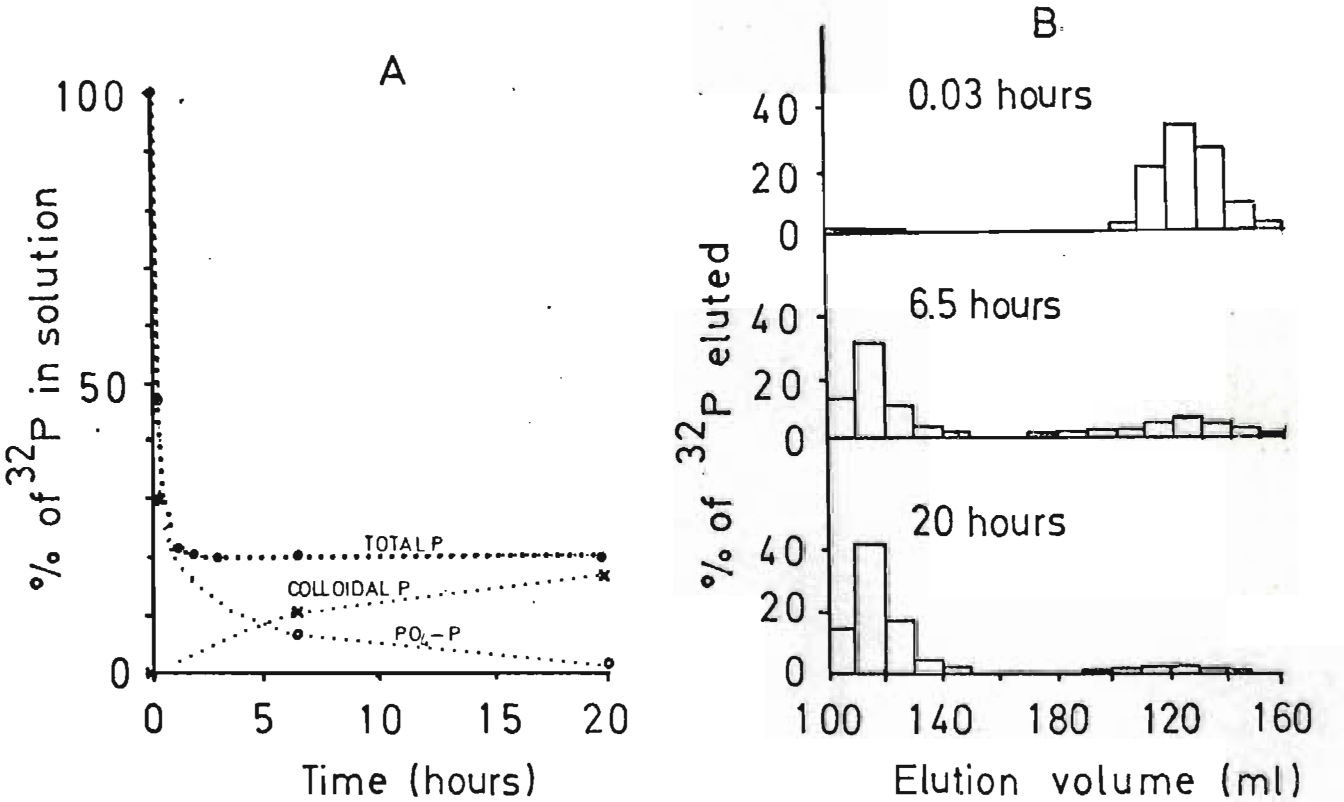


Fig. 5.5.

A) Proportions of total ^{32}P, $^{32}PO_4$-P and colloidal ^{32}P remaining in solution during a ^{32}P uptake experiment undertaken on water sampled from column 5 in October, 1978.

B) Distribution of the soluble P fractions at different times during the experiment, following fractionation.

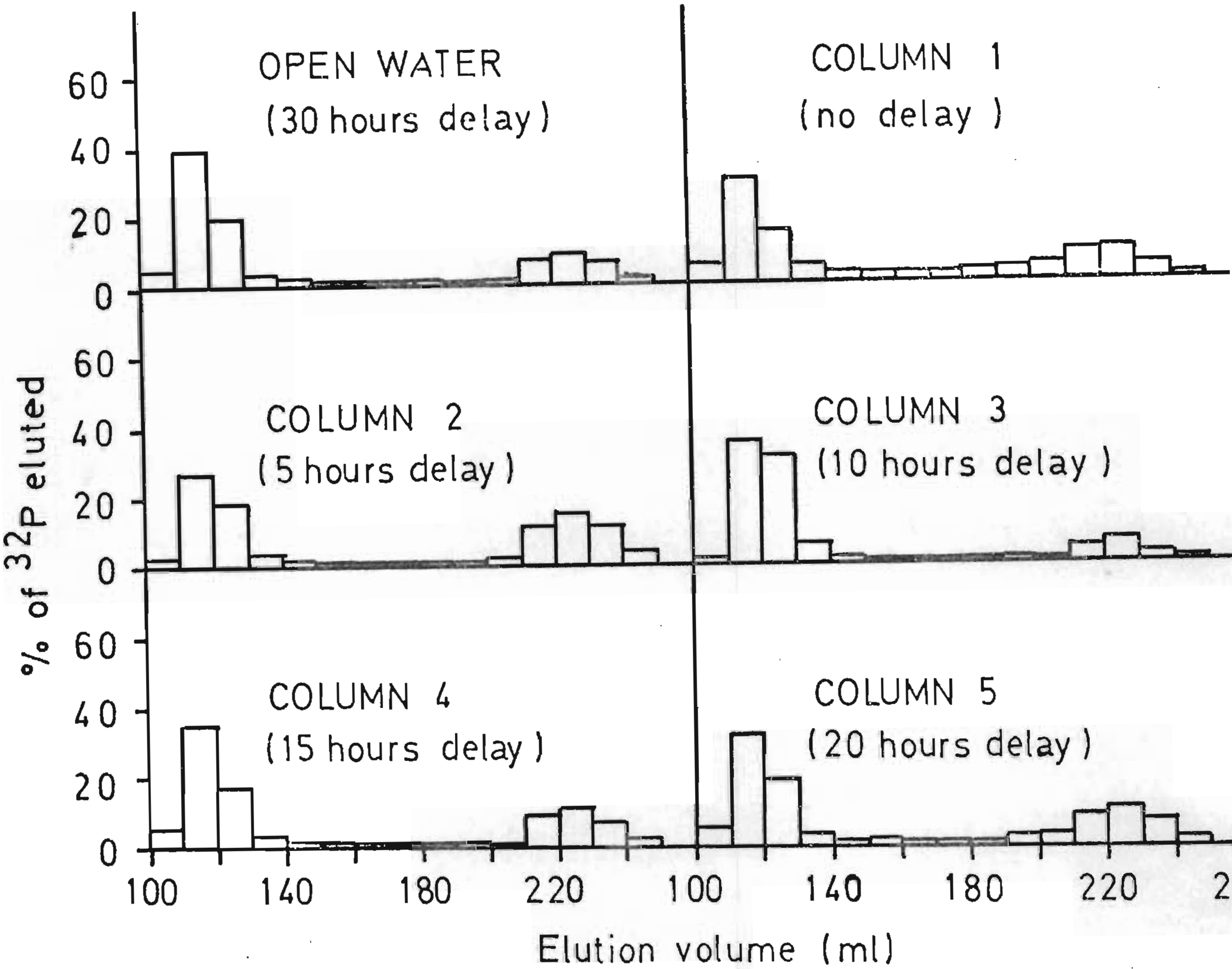


Fig. 5.6.

Distribution of ^{32}P in 9 hour filtrate from the routine ^{32}P uptake experiments in the open water and isolation columns on November 14, 1978, following fractionation. (Column 1 remained unenriched while the other columns were enriched with 200μg l^{-1} NO_3-N week^{-1}. Delays between filtration and fractionation are indicated).

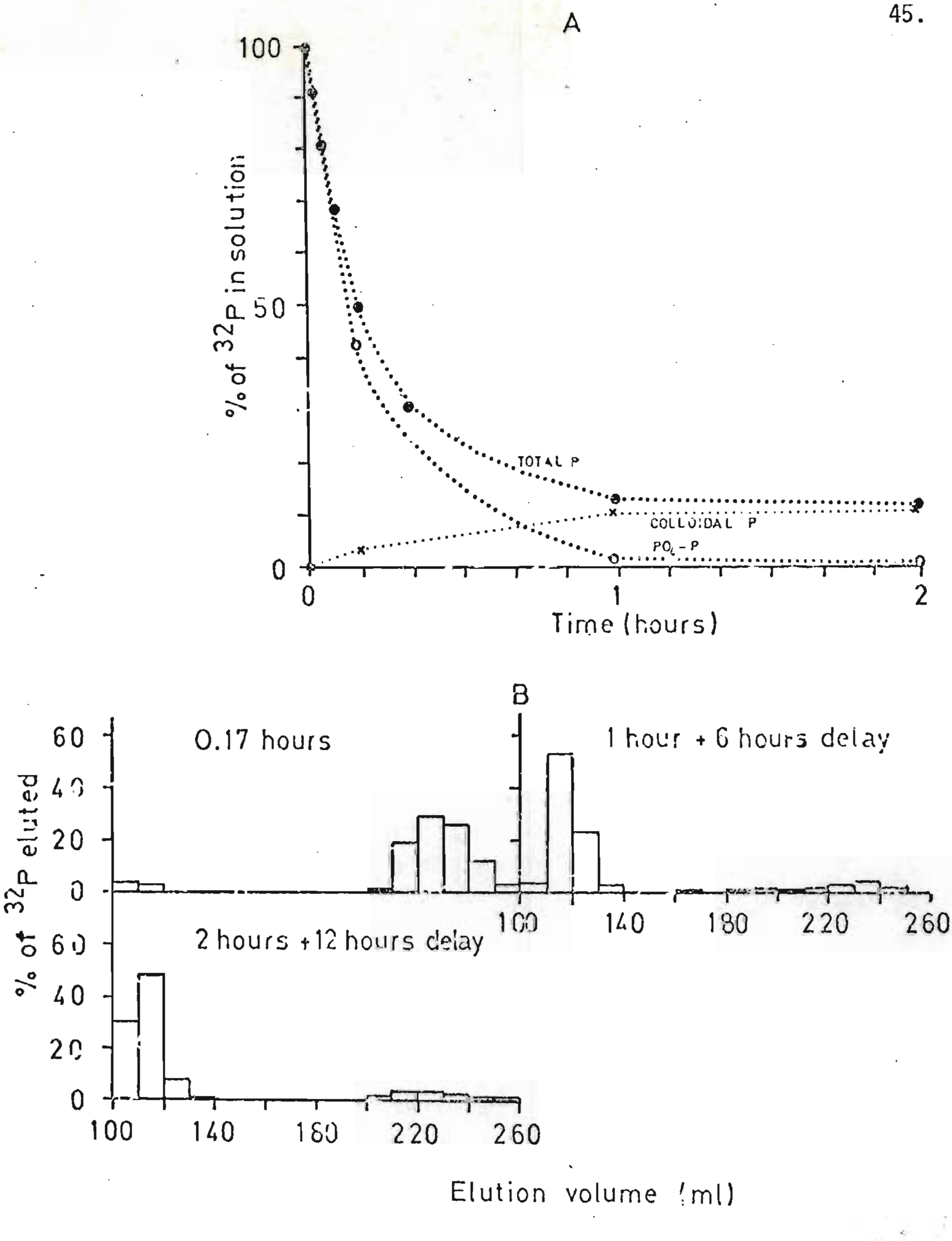


Fig. 5.7.

A) Proportions of total soluble ^{32}P, $^{32}PO_4$-P and colloidal ^{32}P remaining in solution during a ^{32}P uptake experiment undertaken on water sampled from column 5 in March, 1979.

B) Distribution of the soluble P fractions at different times during the experiment, following fractionation. Delays between filtration and fractionation are indicated.

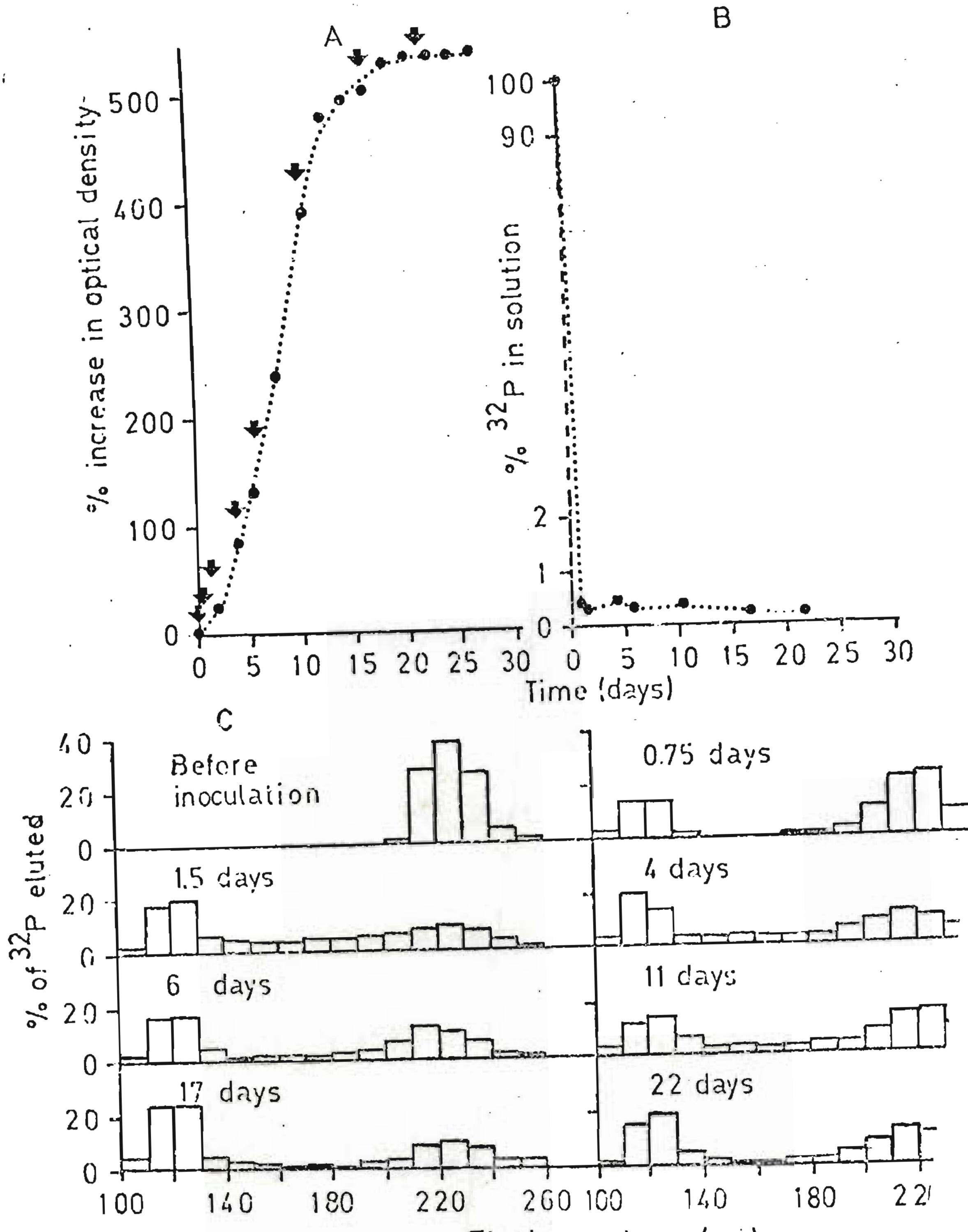


Fig. 5.8.

A) Growth curve for *Anabaena flos-aquae*. Arrows indic points at which fractionations were undertaken.

B) Proportion of ^{32}P remaining in solution during

C) Distribution of soluble P fractions at differ the experiment, following fractionation.

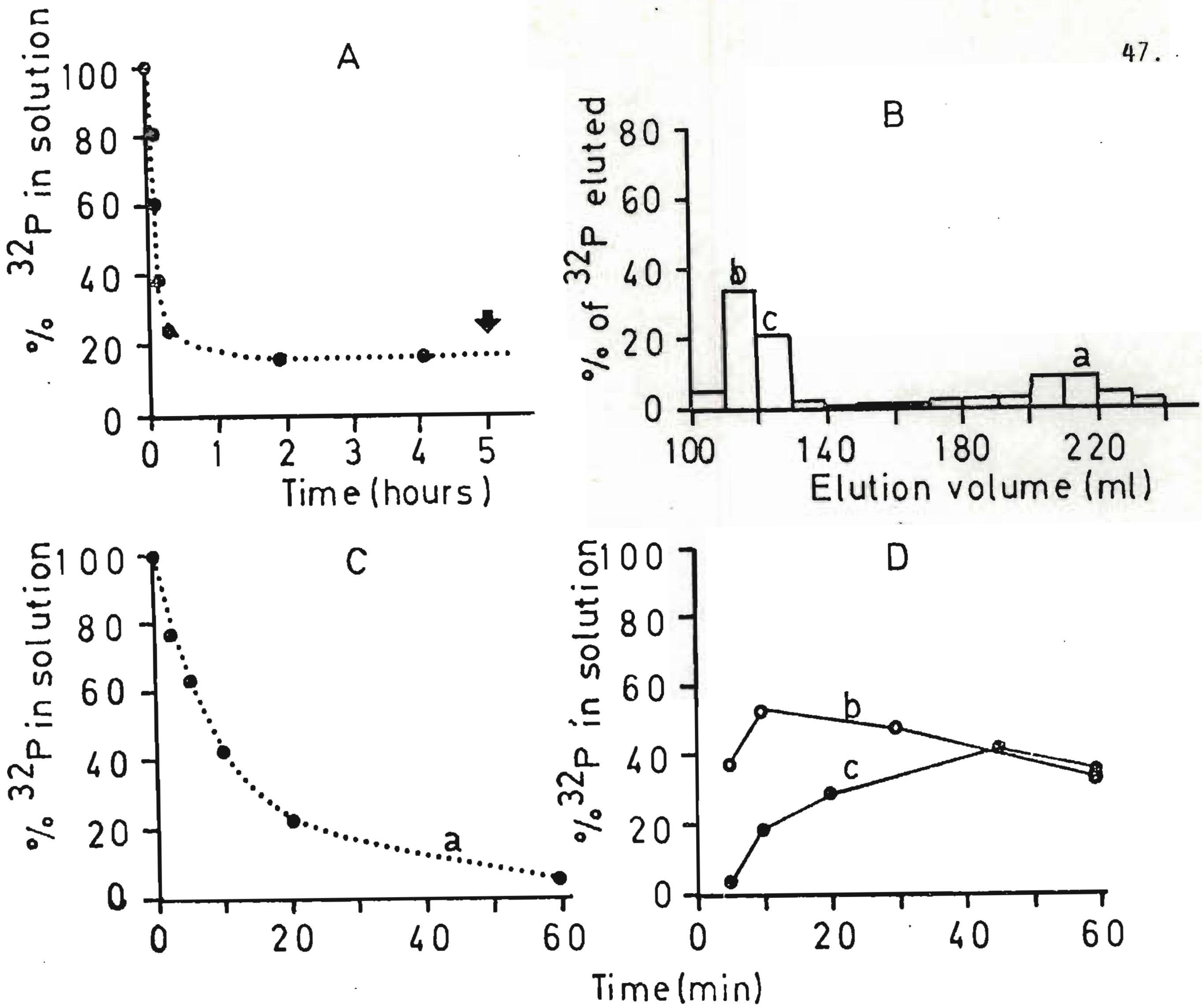


Fig. 5.9.

A) ^{32}P transfer curve obtained from Midmar Dam surface water on February 8, 1979. The arrow indicates the point at which soluble P was fractionated.

B) Distribution of soluble P fractions following fractionation.

C) Transfer curve for the $^{32}PO_4$-P fraction (a) in the original dam water sample.

D) Transfer curves for the colloidal ^{32}P fraction (b and c) in the original dam water sample.

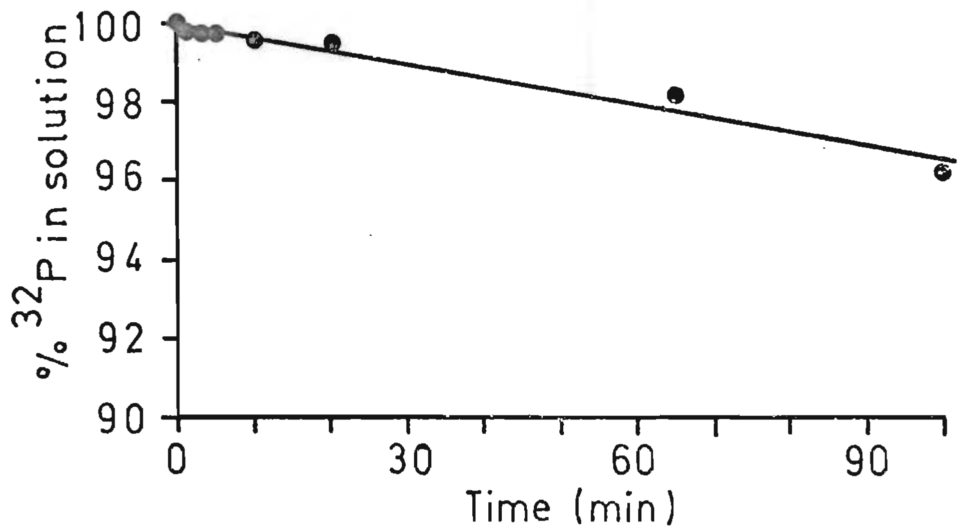


Fig. 5. 10.

^{32}P transfer in filtered Midmar Dam water. Linear regression equation $y = -0.035x + 99.98$,

$r^2 = 0.97$

TABLE 5.1a.

Data describing the exponential ^{32}P transfer curves obtained in the open water and isolation columns during 1977-78. The following NO_3-N enrichment regimes were used : Column 1 - unenriched, Column 2 - 25 µg ℓ^{-1} week^{-1}, Column 3 - 50 µg ℓ^{-1} week^{-1}, Column 4 - 100 µg ℓ^{-1} week^{-1} and Column 5 - 200 µg ℓ^{-1} week^{-1}. Coefficient of determination = r^2, rate constant (min^{-1}) = k, P turnover time (min) = tt and asymptote (% ^{32}P) = Asymp. NR indicates that asymptotic levels were not attained during the experiment and - indicates that no mean was calculated.

Site		12.2.78	27.2.78	13.3.78	28.3.78	11.4.78	24.4.78	23.5.78	$\bar{x}$
Open	r^2	0.95	0.99	0.98	1.00	0.98	0.99	0.98	0.98
Water	k	.0014	.0517	.0839	.0374	0.291	.0035	.0040	.0301
	tt	714	19	12	27	34	286	250	192
	Asymp	NR	5.0	8.0	10.0	19.0	NR	NR	-
Unen-	r^2	0.93	0.99	0.99	1.00	0.99	0.99	0.93	0.97
riched	k	.0334	.0519	.1833	.1198	.0128	.0164	.0171	.0621
column	tt	30	19	6	8	78	61	59	37
(1)	Asymp	9.5	5.0	7.0	13.0	21.0	13.0	10.0	11.2
Column	r^2	0.94	0.99	0.99	1.00	0.97	0.99	0.99	0.98
(2)	k	.0201	.0278	.1739	.1113	.0243	.0074	.0127	.0539
	tt	50	36	5	9	41	135	79	51
	Asymp	55.0	10.0	14.0	6.5	12.0	21.0	10.0	18.4
Column	r^2	0.91	1.00	1.00	0.97	0.99	0.99	0.86	0.96
(3)	k	.0481	.2211	.0727	0.560	.0391	.0572	.0282	.0746
	tt	21	5	14	18	26	18	35	20
	Asymp	8.0	8.0	10.0	3.5	7.0	16.5	10.0	9.0
Column	r^2	0.94	0.98	0.99	0.98	0.99	0.97	1.00	0.98
(4)	k	.0025	.0553	.0550	.1936	.1815	.0923	.0399	.0886
	tt	500	18	18.2	5	6	11	25	69
	Asymp	NR	1.3	23.0	11.5	17.0	9.0	8.0	-
Column	r^2	0.86	0.97	0.99	0.90	0.98	1.00	0.83	0.93
(5)	k	.0005	.0428	.0756	.1734	.2780	.0861	.1159	.1103
	tt	2000	23	13	6	4	5	9	294
	Asymp	NR	<1	13.0	15.5	17.5	14.0	16.0	-

TABLE 5.1b.

Data describing the exponential uptake curves obtained in the open water and isolation columns during 1978-79. Column 1 was unenriched and all other columns received 200 µg NO_3-N ℓ^{-1} $week^{-1}$. Coefficient of determination = r^2, rate constant (min^{-1}) = k, P turnover time (min) = tt and asymptote (% ^{32}P) = Asymp..

Site		26.9.78	17.10.78	14.11.78	12.12.78	7.2.79	$\bar{x}$
	r^2	1.00	0.98	0.88	0.99	1.00	0.97
Open	k	.0195	.0105	.0167	.0591	.1226	.0457
Water	tt	51	95	60	17	8	46
	Asymp	18.0	50.0	11.0	4.5	15.0	19.7
Unen-	r^2	0.99	0.99	0.81	0.99	1.00	0.96
riched	k	.0111	.0372	.0859	.0487	.0386	.0443
Column	tt	90	27	12	21	26	35
(1)	Asymp	7.0	14.0	8.0	13.5	26.0	13.7
Column	r^2	0.98	0.95	0.98	1.00	0.95	0.97
(2)	k	.0647	.0123	.1036	.0621	.0433	.0572
	tt	16	81	10	16	23	29
	Asymp	6.0	5.0	9.2	17.0	22.0	11.8
Column	r^2	0.92	0.99	0.79	0.99	1.00	0.94
(3)	k	.2246	.2793	.0600	.0376	.0352	.1273
	tt	5	4	17	27	28	16
	Asymp	8.0	11.0	4.5	16.0	15.0	10.9
Column	r^2	0.96	1.00	0.82	0.69	0.97	0.89
(4)	k	.0896	.0693	.0335	.0236	.1238	.0680
	tt	11	14	30	42	8	21
	Asymp	8.0	14.0	10	10.5	25.0	13.5
Column	r^2	0.97	0.95	0.89	0.81	1.00	0.92
(5)	k	.1291	.1455	.0215	.1739	.1220	.1184
	tt	8	7	47	5	8	15.2
	Asymp	14.0	15.0	< 1	30.0	25.0	17.0

TABLE 5.2. Data describing the diphasic ^{32}P uptake kinetics detected during the routine ^{32}P uptake experiments. k = rate constant (min^{-1}) and tt = P turnover time.

COLUMN	DATE	RAPID PHASE k	RAPID PHASE tt	SLOW PHASE k	SLOW PHASE tt
3	23.5.78	.2714	3.7	.0189	52.9
4	15.11.78	.1669	6.0	.154	64.9
4	12.12.78	.1874	5.3	.0067	149.2
5	11.11.78	.4652	2.2	.0184	54.3
$\overline{x}$			4.3		80.33

TABLE 5.3. Changes in the relative proportions of soluble P fractions during the ^{32}P uptake experiments conducted on water sampled from column 5 during October 1978. (Expressed as a % of total ^{32}P eluted).

Fraction	Time of fractionation (h)			
	0	0.03	6.5	20
PO_4-P	100	99	31.3	8.5
Colloidal P	0	0.8	60.1	84.8
Intermediate P	0	0.2	8.6	6.7

TABLE 5.4.

Soluble reactive phosphorus (SRP), total dissolved phosphorus (TDP) and particulate phosphorus (PP) measured in the open water and isolation columns at the times P turnover times were determined during the 1977-78 enrichment experiment. All units μg ℓ^{-1}.

SITE		DATE							
		13.2.78	27.2.78	13.3.78	28.3.78	11.4.78	24.4.78	23.5.78	$\bar{x}$
Open Water	SRP	-	1	1	t	1	1	1	-
	TDP	-	3	10	6	8	6	2	5.83
	PP	-	20	8	5	12	9	18	12.0
Unenrich column(1)	SRP	-	1	t	t	2	t	t	-
	TDP	-	5	7	4	8	5	1	5.00
	PP	-	17	17	8	7	8	22	13.17
Column(2)	SRP	-	1	1	1	1	1	2	-
	TDP	-	7	8	4	6	3	3	5.17
	PP	-	11	13	10	17	27	-	15.60
Column (3)	SRP	-	t	1	1	1	1	1	-
	TDP	-	5	8	6	6	4	1	5.00
	PP	-	13	15	3	14	11	-	11.20
Column (4)	SRP	-	t	1	t	t	1	1	-
	TDP	-	5	7	6	5	4	3	4.83
	PP	-	13	11	3	16	17	18	13.00
Column (5)	SRP	-	t	t	t	1	t	0	-
	TDP	-	6	5	4	5	4	1	4.17
	PP	-	12	12	12	14	15	-	13.00

TABLE 5.5 Relative proportions of PO_4-P, colloidal P and intermediate P fractions in 9 hour filtrate from routine ^{32}P uptake experiments in the open water and isolation columns on November 14, 1978, together with other parameters measured in the samples.

Parameter	Site					
	Open water	Column 1	Column 2	Column 3	Column 4	Column 5
PO_4-P % of Total	2.8	0.7	4.2	0.9	2.4	< 1
% of Soluble	23	33	42	17	30	28
Colloidal P % of Tot	8.2	1.1	5.0	3.6	5.0	< 0.1
% of Sol	68	53	50	72	63	59
Intermediate P % of Soluble	9	14	8	11	7	13
Asymptote %	11.0	8.0	9.2	4.5	10	< 1
P Turnover Time(min)	60	12	10	17	30	47
SRP $\mu g\ \ell^{-1}$	2	t	t	t	t	t
TSP $\mu g\ \ell^{-1}$	10	5	8	5	7	7
TP $\mu g\ \ell^{-1}$	22	20	19	18	18	26
TSS mg ℓ^{-1}	20.4	8.1	9.1	13.2	12.4	13.8
Chlorophyll $\mu g\ \ell^{-1}$	2.5	5.1	6.9	4.0	4.2	14.2

SRP = soluble reactive phosphorus

TSP = total soluble phosphorus

TP = total phosphorus

TSS = total suspended solids

t = trace

TABLE 5.6 Correlation coefficients (r) for the proportions of soluble P (as a % of the total ^{32}P eluted) versus total phosphorus (TP), total soluble phosphorus (TSP), total suspended solids(TSS), P turnover time (tt), chlorophyll and asymptote level (Asymp), measured in the open water and columns on November 14, 1978.

Fraction	TP	TSP	TSS	tt	Chlorophyll	Asymp
PO_4-P	-0.064	0.135	-0.636	-0.428	0.240	0.274
Colloidal P	0.095	0.049	0.718*	0.456	-0.386	-0.066

* significant at 0.05 n = 6

TABLE 5.7 Changes in the relative proportions of soluble P fractions during the ^{32}P uptake experiments on water sampled from column 5 during March, 1979. (Expressed as a % of the total ^{32}P eluted).

Fraction	Time of fractionation (h)			
	0	0.17	1	2
PO_4-P	100	89.9	11.4	9.3
Colloidal P	0	8.9	84.0	87.9
Intermediate P	0	1.2	4.6	2.0

TABLE 5.8 Changes in the relative proportions of soluble P fractions during the ^{32}P uptake experiment in an *Anabaena flos-aquae* culture (expressed as a % of the total ^{32}P eluted)

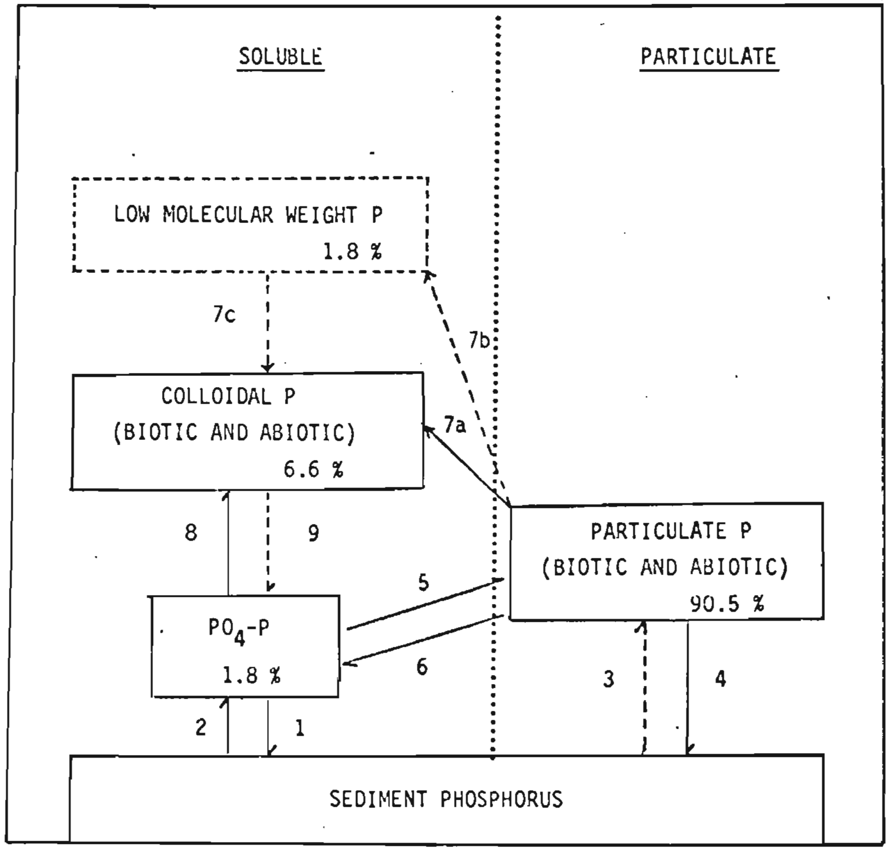
Fraction	Time of fractionation (days)							
	0	0.75	1.5	4	6	11	17	22
PO_4-P	100	71.4	32.1	40.0	43.7	46.0	35.0	48.4
Colloidal P	0	28.7	47.0	36.0	39.0	30.0	52.0	39.4
Intermediate P	0	0	21.9	24.0	17.3	24.0	13.0	12.2

TABLE 5.9 Retention of colloidal P, obtained from a routine soluble P fractionation of Midmar Dam water, on refiltration through 0.45μ membrane filters.

	CPM ml^{-1} before filtration	CPM ml^{-1} after filtration	% Retained
1	4004	1395	65
2	3103	1385	55
$\overline{X}$	-	-	60

TABLE 5.10 Correlation between P turnover time (tt) and chlorophyll(Chl) and total suspended solid (TSS) concentrations in the open water and isolation columns during the 1977-78 (n = 42) and 1978-79 (n = 30) enrichment experiments.

Period Parameters Correlated	1977-78	
	Chl. vs tt	TSS vs tt
r	0.283	.0232
Period	1978-79	
r	0.095	.0502



1: PO_4-P ADSORPTION BY SEDIMENTS.

2: PO_4-P DESORPTION BY SEDIMENTS.

3: SEDIMENT RESUSPENSION.

4: SEDIMENTATION.

5: PO_4-P UPTAKE BY SESTON.

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7a: SESTONIC PRODUCTION OF COLLOIDAL P.

b: SESTONIC PRODUCTION OF LOW MOLECULAR WEIGHT ORGANIC P.

c: INCORPORATION OF LOW MOLECULAR WEIGHT ORGANIC P BY COLLOIDAL P.

8: PO_4-P UPTAKE BY COLLOIDAL P.

9: PO_4-P RELEASE BY COLLOIDAL P.

Fig. 6.1 A conceptual model of P compartments and their interactions in a shallow area of Lake Midmar. (The relative proportions of the soluble P fractions represent mean values from all gel filtration analyses undertaken on water from the dam and isolation columns).

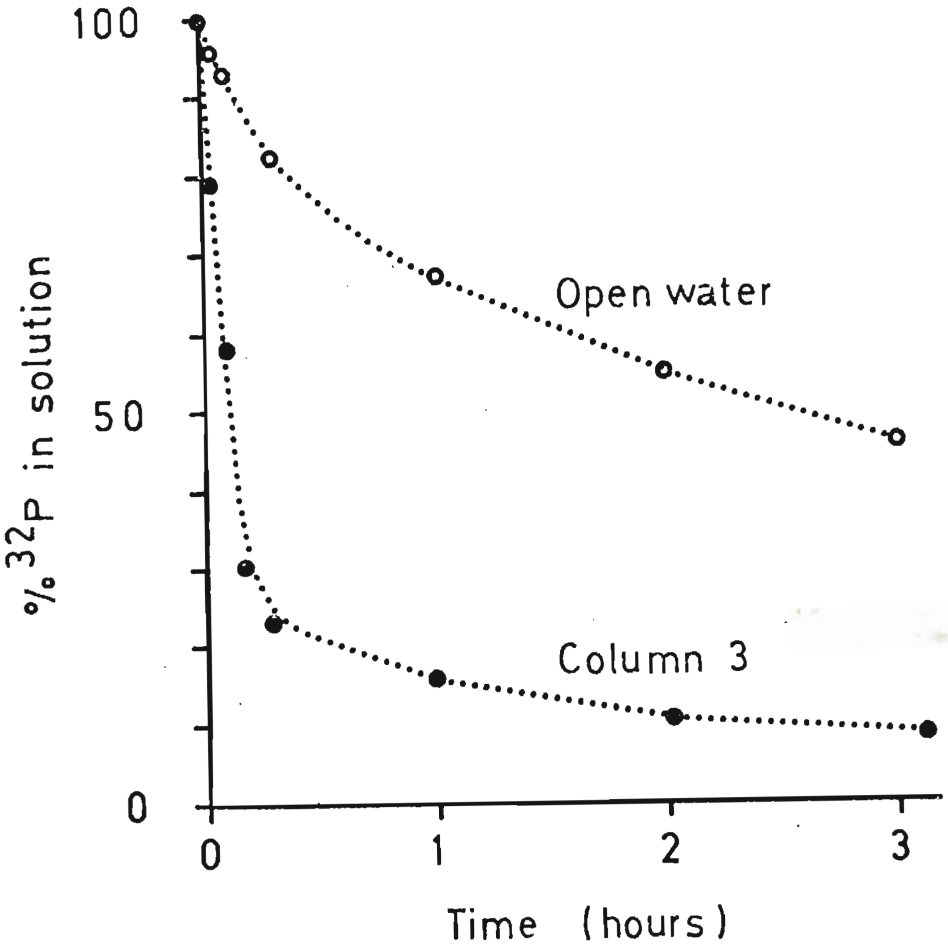


Fig. 5.1.

Examples of ^{32}P transfer curves in the open water and in column 3 on May 23, 1978.

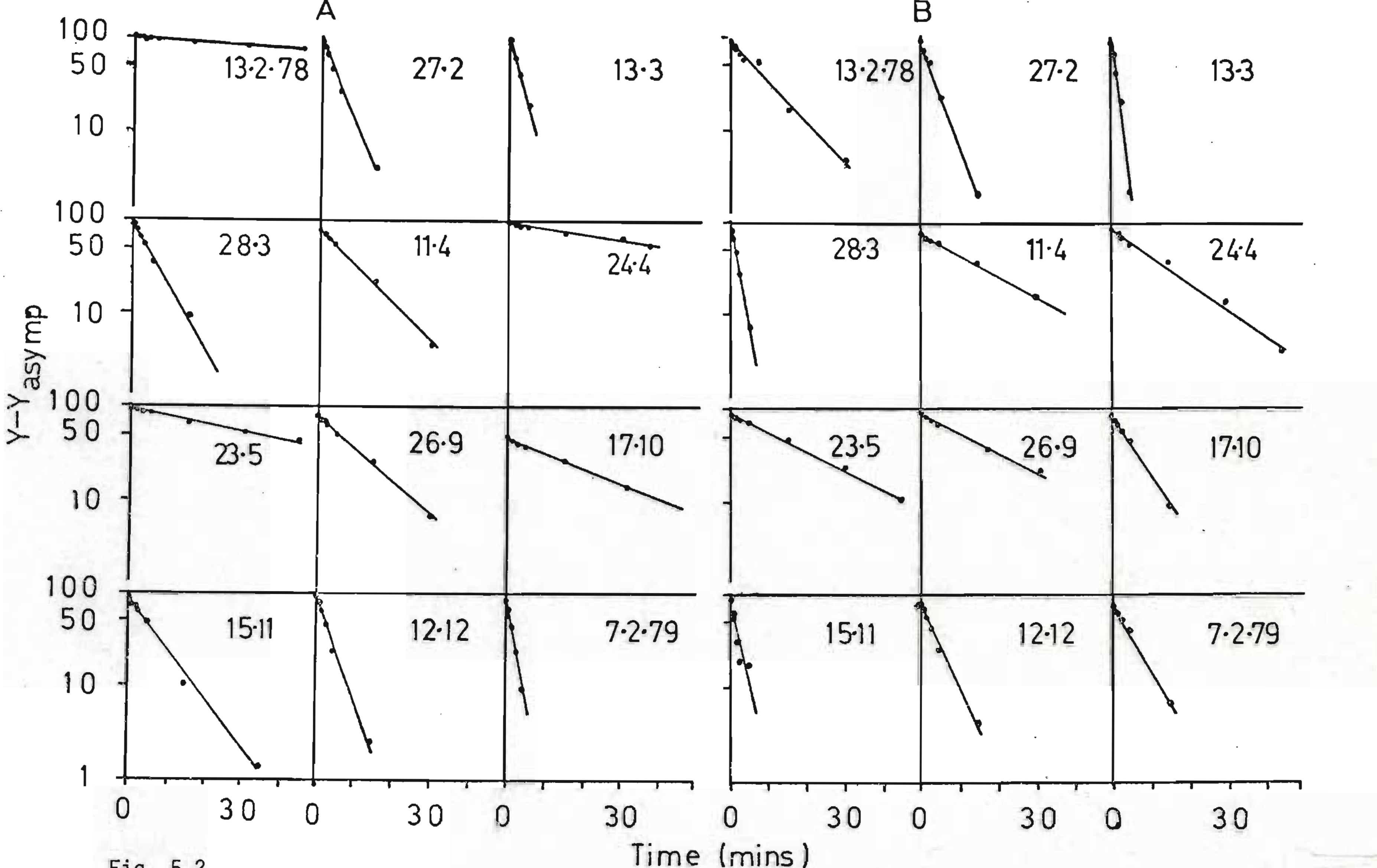


Fig. 5.2.

A-B. Semilog plots of the percentage of ^{32}P in solution minus the percentage of ^{32}P in solution at equilibrium ($Y - Y_{asymp}$) against time for the ^{32}P uptake data obtained in water sampled in the open water (A) and in an unenriched column

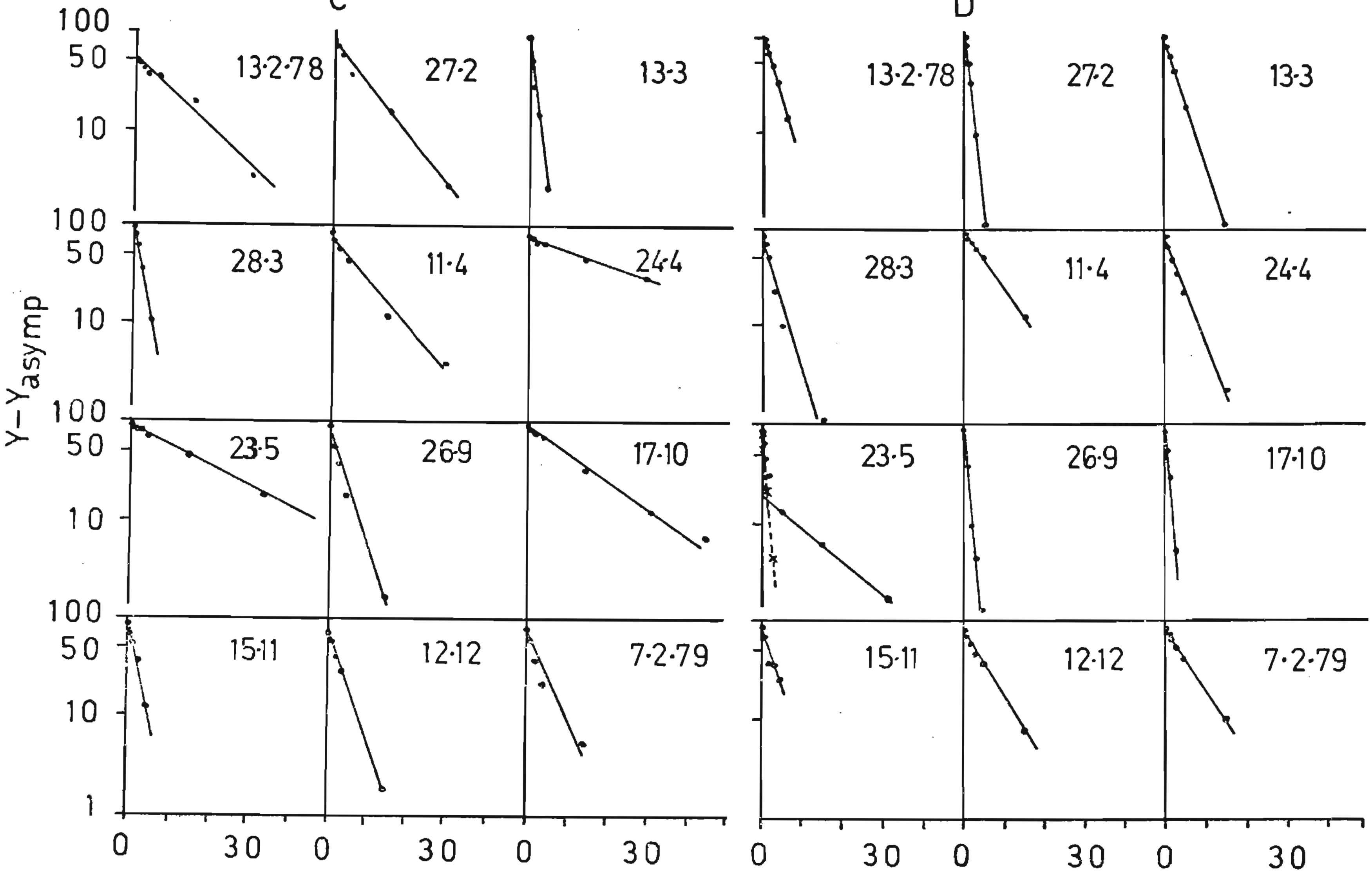


Fig. 5.2.

C-D. Semilog plots of the percentage of ^{32}P in solution minus the percentage of ^{32}P in solution at equilibrium ($Y - Y_{asymp}$) against time for the ^{32}P uptake data obtained in water sampled in column 2 (C) and column 3 (D). When the uptake was diphasic the rapid phase was adjusted as described in the methods (section 2.3.1.) and plotted using broken lines.

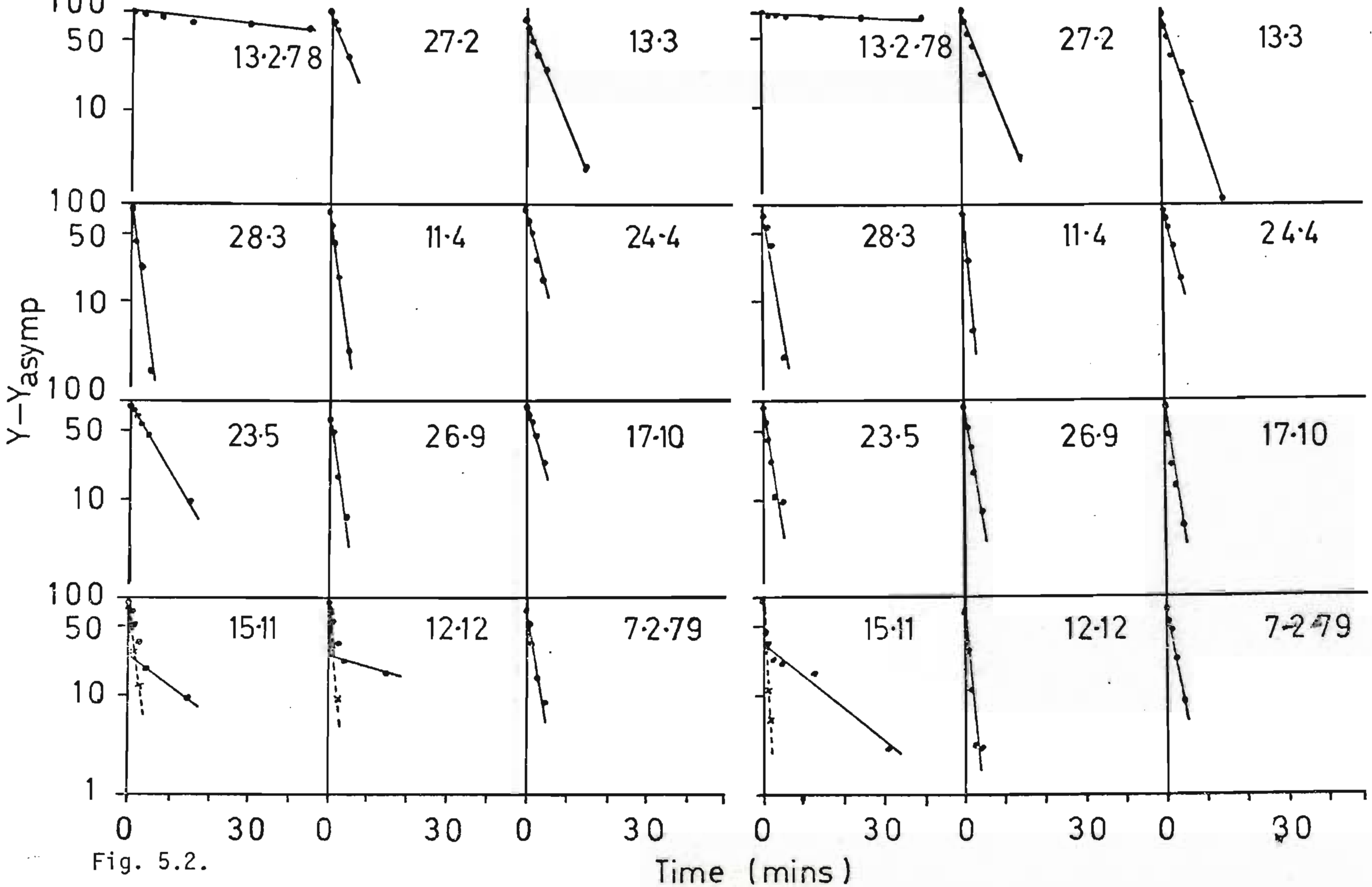


Fig. 5.2.

E-F. Semilog plots of the percentage of ^{32}P in solution minus the percentage of ^{32}P in solution at equilibrium ($Y - Y_{asymp}$) against time for the ^{32}P uptake data obtained in water sampled in column 4 (E) and column 5 (F). When the uptake was diphasic the rapid phase was adjusted as described in the methods (section 2.3.1) and plotted using broken lines.

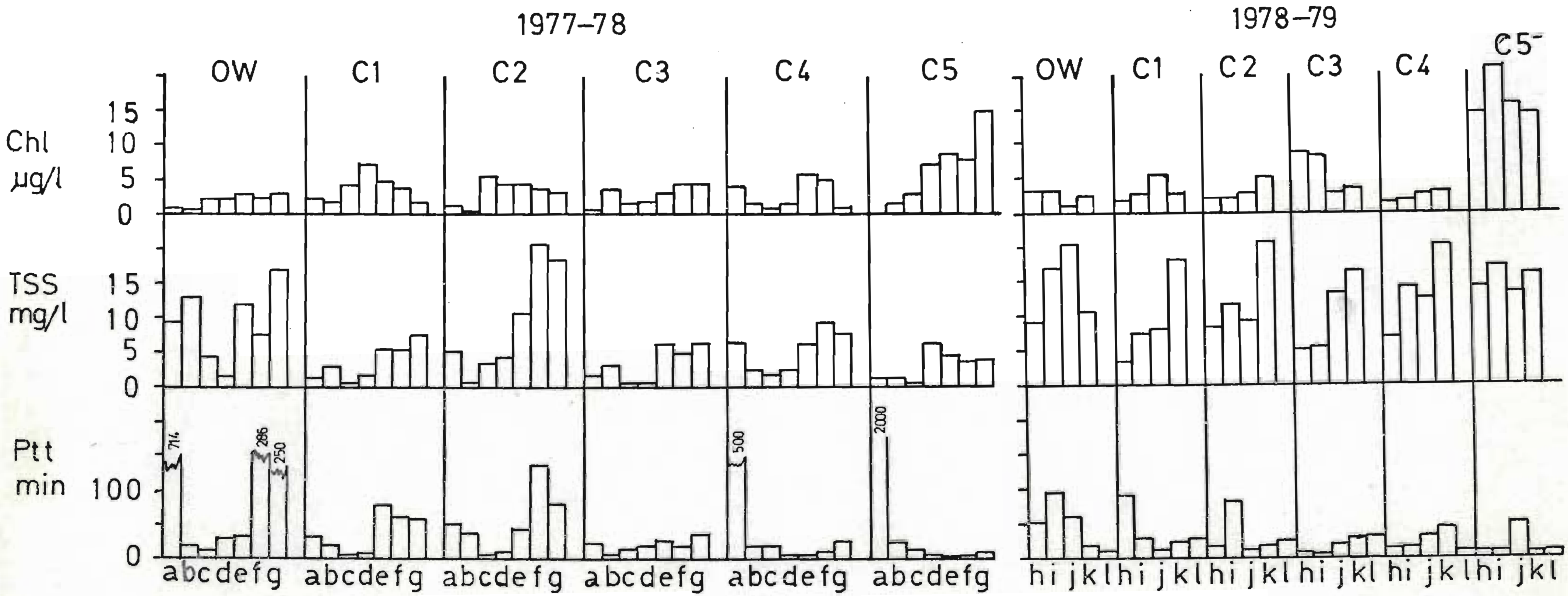


Fig. 5.3.

Chlorophyll (Chl), TSS and P turnover time (Ptt) measured in the open water (OW) and in the columns (C1 - C5) during 1977-78 and 1978-79. NO_3-N loading rates during 1977-78 were as follows : C1 - unenriched, C2 - 25 µg ℓ^{-1} week^{-1}, C3 - 50 µg ℓ^{-1} week^{-1}, C4 - 100 µg ℓ^{-1} week^{-1} and C5 - 200 µg ℓ^{-1} week^{-1}. During 1978-79 C1 remained unenriched and the other columns were enriched with 200 µg NO_3-N ℓ^{-1} week^{-1}. Measurements were made on the following dates: 13-2-78 (a), 27-2 (b), 13-3 (c), 28-3 (d), 11-4 (e), 24-4 (f), 23-5 (g), 26-9 (h), 17-10 (i), 15-11 (j), 12-12 (k) and 7-2-79(l)

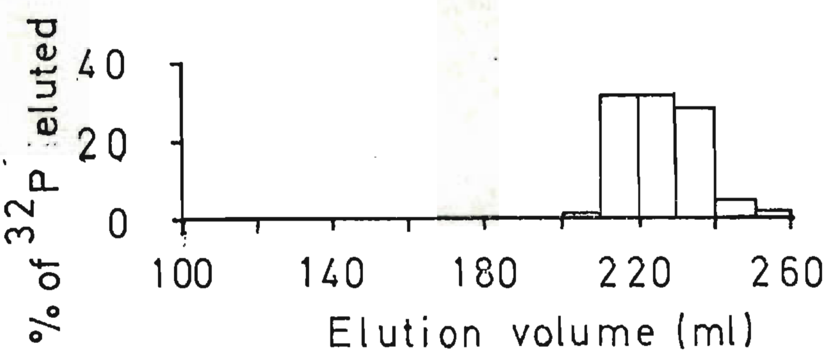


Fig. 5.4.

Distribution of ^{32}P in $^{32}PO_4$-P stock solution following fractionation.

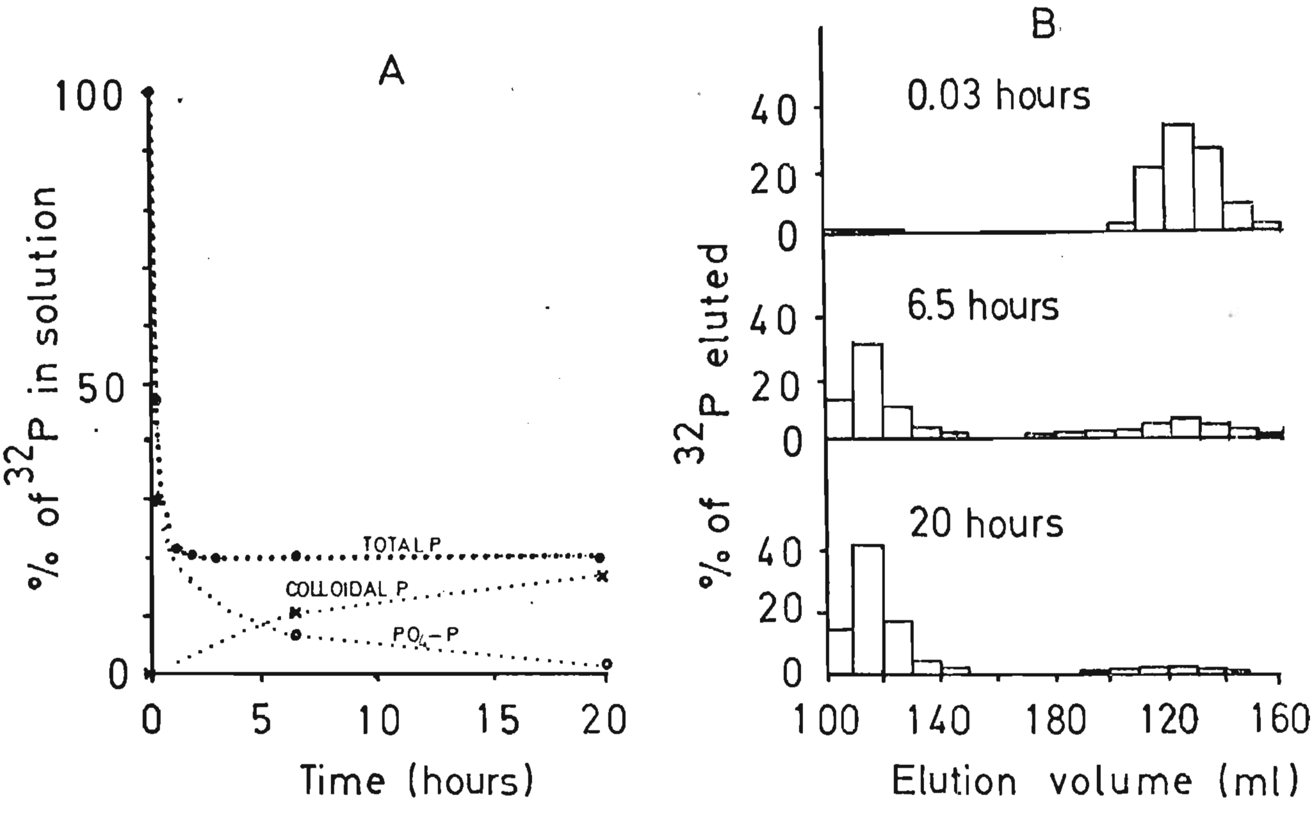


Fig. 5.5.

A) Proportions of total ^{32}P, $^{32}PO_4$-P and colloidal ^{32}P remaining in solution during a ^{32}P uptake experiment undertaken on water sampled from column 5 in October, 1978.

B) Distribution of the soluble P fractions at different times during the experiment, following fractionation.

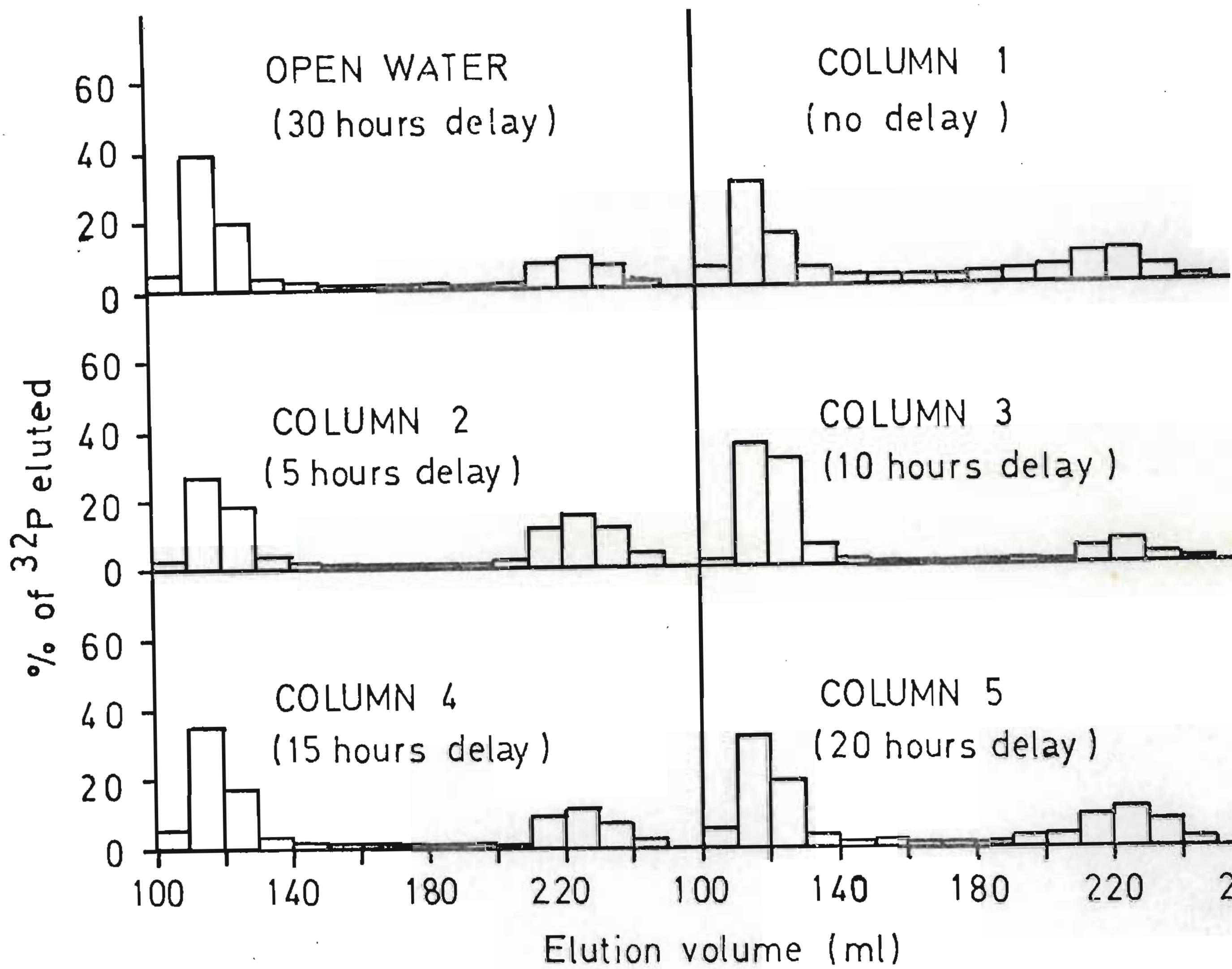


Fig. 5.6.

Distribution of ^{32}P in 9 hour filtrate from the routine ^{32}P uptake experiments in the open water and isolation columns on November 14, 1978, following fractionation. (Column 1 remained unenriched while the other columns were enriched with 200μg l^{-1} NO_3-N week^{-1}. Delays between filtration and fractionation are indicated).

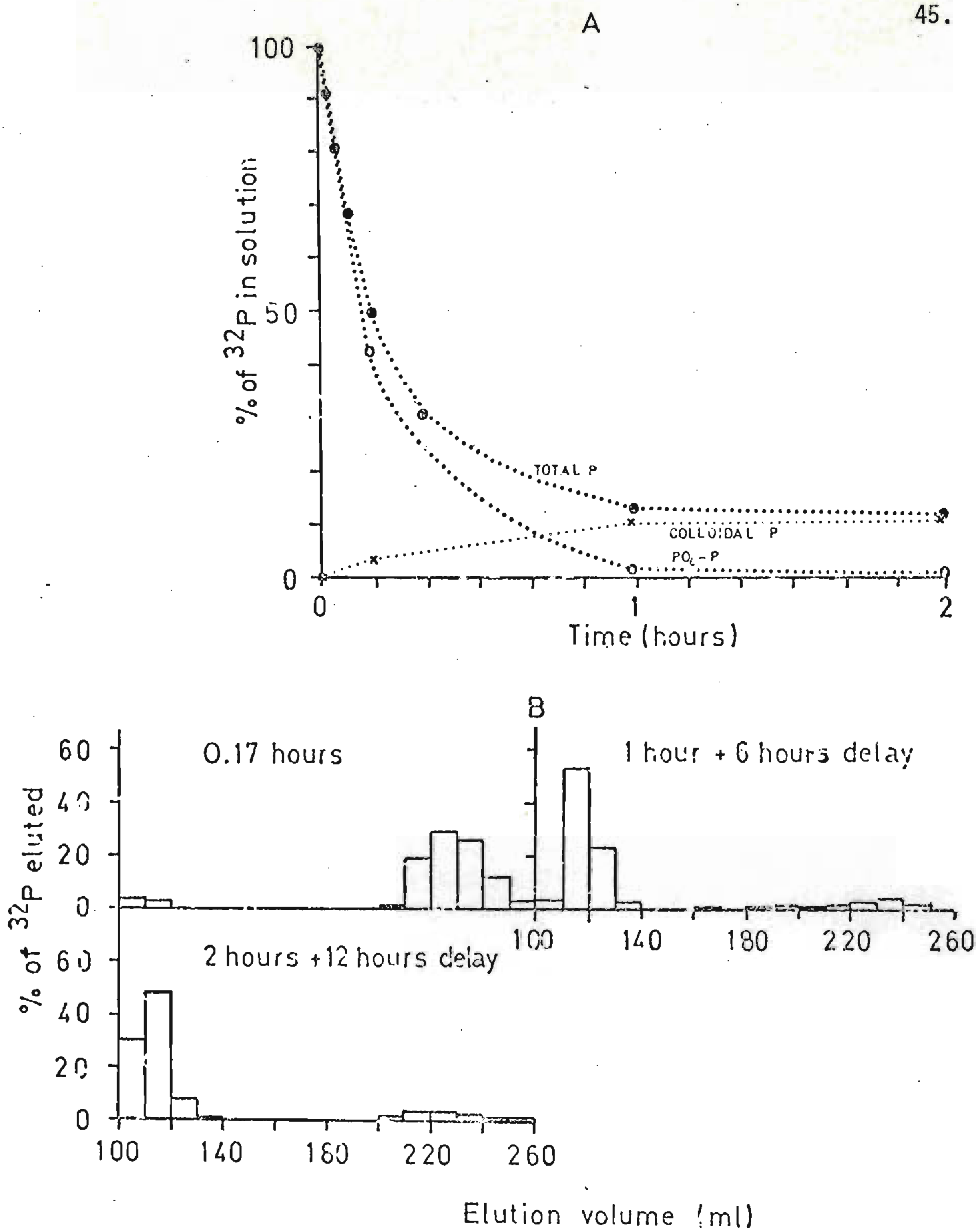


Fig. 5.7.

A) Proportions of total soluble ^{32}P, $^{32}PO_4$-P and colloidal ^{32}P remaining in solution during a ^{32}P uptake experiment undertaken on water sampled from column 5 in March, 1979.

B) Distribution of the soluble P fractions at different times during the experiment, following fractionation. Delays between filtration and fractionation are indicated.

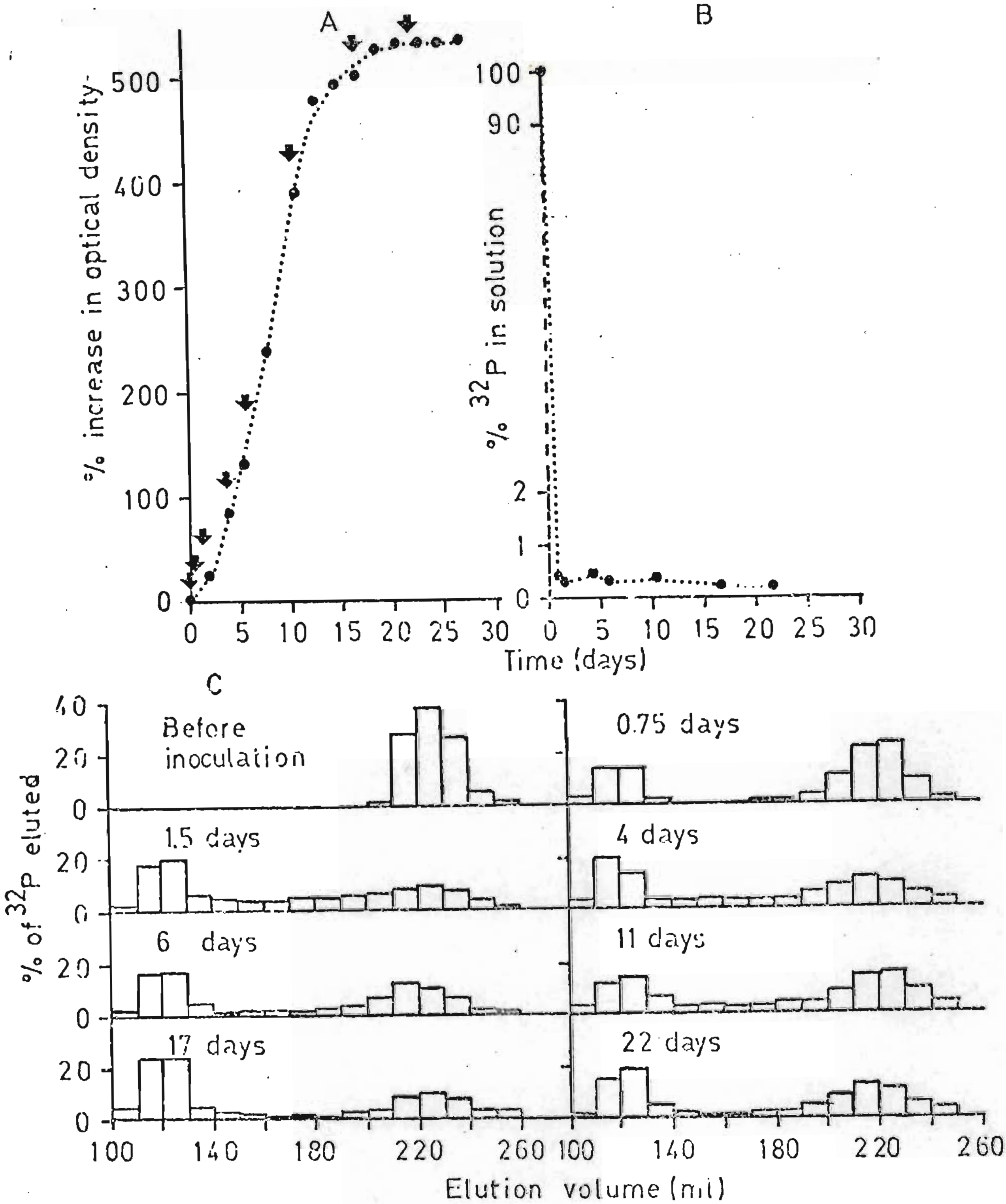


Fig. 5.8.

A) Growth curve for *Anabaena flos-aquae*. Arrows indicate points at which fractionations were undertaken.

B) Proportion of ^{32}P remaining in solution during the experiment.

C) Distribution of soluble P fractions at different times during the experiment, following fractionation.

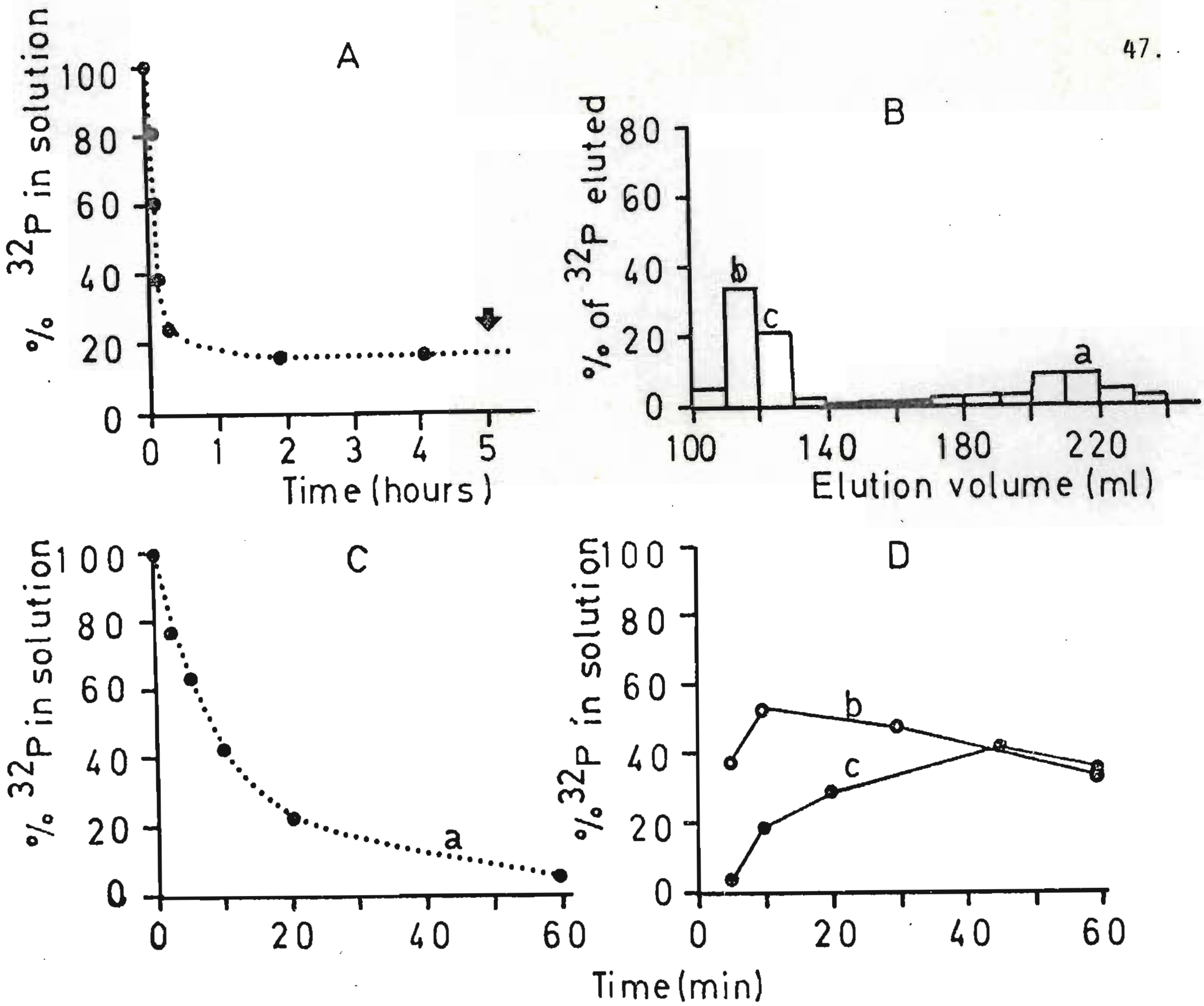


Fig. 5.9.

A) ^{32}P transfer curve obtained from Midmar Dam surface water on February 8, 1979. The arrow indicates the point at which soluble P was fractionated.

B) Distribution of soluble P fractions following fractionation.

C) Transfer curve for the $^{32}PO_4$-P fraction (a) in the original dam water sample.

D) Transfer curves for the colloidal ^{32}P fraction (b and c) in the original dam water sample.

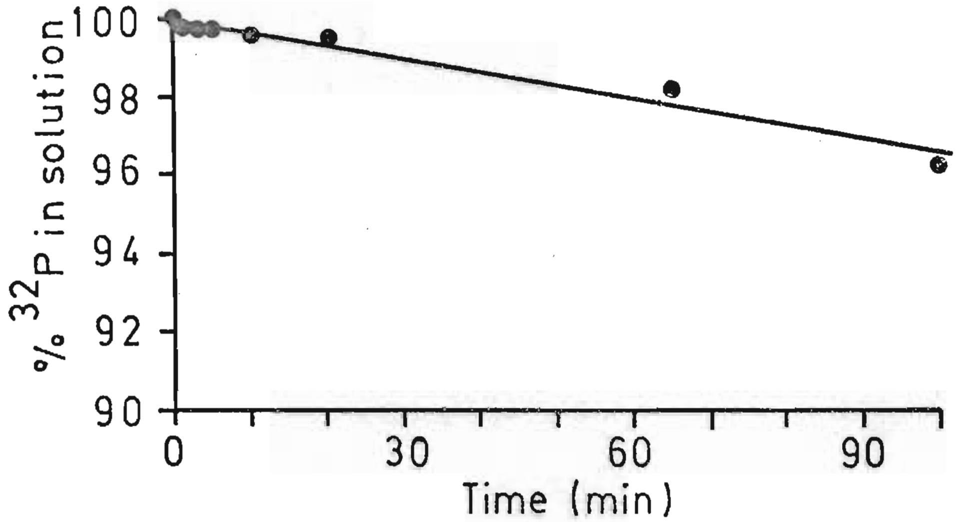


Fig. 5. 10.

^{32}P transfer in filtered Midmar Dam water. Linear regression equation $y = -0.035x + 99.98$,

$r^2 = 0.97$

TABLE 5.1a.

Data describing the exponential ^{32}P transfer curves obtained in the open water and isolation columns during 1977-78. The following NO_3-N enrichment regimes were used : Column 1 - unenriched, Column 2 - 25 µg ℓ^{-1} week^{-1}, Column 3 - 50 µg ℓ^{-1} week^{-1}, Column 4 - 100 µg ℓ^{-1} week^{-1} and Column 5 - 200 µg ℓ^{-1} week^{-1}. Coefficient of determination = r^2, rate constant (min^{-1}) = k, P turnover time (min) = tt and asymptote (% ^{32}P) = Asymp. NR indicates that asymptotic levels were not attained during the experiment and - indicates that no mean was calculated.

Site		12.2.78	27.2.78	13.3.78	28.3.78	11.4.78	24.4.78	23.5.78	$\bar{x}$
Open Water	r^2	0.95	0.99	0.98	1.00	0.98	0.99	0.98	0.98
	k	.0014	.0517	.0839	.0374	0.291	.0035	.0040	.0301
	tt	714	19	12	27	34	286	250	192
	Asymp	NR	5.0	8.0	10.0	19.0	NR	NR	-
Unenriched column (1)	r^2	0.93	0.99	0.99	1.00	0.99	0.99	0.93	0.97
	k	.0334	.0519	.1833	.1198	.0128	.0164	.0171	.0621
	tt	30	19	6	8	78	61	59	37
	Asymp	9.5	5.0	7.0	13.0	21.0	13.0	10.0	11.2
Column (2)	r^2	0.94	0.99	0.99	1.00	0.97	0.99	0.99	0.98
	k	.0201	.0278	.1739	.1113	.0243	.0074	.0127	.0539
	tt	50	36	5	9	41	135	79	51
	Asymp	55.0	10.0	14.0	6.5	12.0	21.0	10.0	18.4
Column (3)	r^2	0.91	1.00	1.00	0.97	0.99	0.99	0.86	0.96
	k	.0481	.2211	.0727	0.560	.0391	.0572	.0282	.0746
	tt	21	5	14	18	26	18	35	20
	Asymp	8.0	8.0	10.0	3.5	7.0	16.5	10.0	9.0
Column (4)	r^2	0.94	0.98	0.99	0.98	0.99	0.97	1.00	0.98
	k	.0025	.0553	.0550	.1936	.1815	.0923	.0399	.0886
	tt	500	18	18.2	5	6	11	25	69
	Asymp	NR	1.3	23.0	11.5	17.0	9.0	8.0	-
Column (5)	r^2	0.86	0.97	0.99	0.90	0.98	1.00	0.83	0.93
	k	.0005	.0428	.0756	.1734	.2780	.0861	.1159	.1103
	tt	2000	23	13	6	4	5	9	294
	Asymp	NR	<1	13.0	15.5	17.5	14.0	16.0	-

TABLE 5.1b.

Data describing the exponential uptake curves obtained in the open water and isolation columns during 1978-79. Column 1 was unenriched and all other columns received 200 μg NO_3-N ℓ^{-1} $week^{-1}$. Coefficient of determination = r^2, rate constant (min^{-1}) = k, P turnover time (min) = tt and asymptote (% ^{32}P) = Asymp..

Site		26.9.78	17.10.78	14.11.78	12.12.78	7.2.79	$\bar{x}$
	r^2	1.00	0.98	0.88	0.99	1.00	0.97
Open	k	.0195	.0105	.0167	.0591	.1226	.0457
Water	tt	51	95	60	17	8	46
	Asymp	18.0	50.0	11.0	4.5	15.0	19.7
Unen-	r^2	0.99	0.99	0.81	0.99	1.00	0.96
riched	k	.0111	.0372	.0859	.0487	.0386	.0443
Column	tt	90	27	12	21	26	35
(1)	Asymp	7.0	14.0	8.0	13.5	26.0	13.7
Column	r^2	0.98	0.95	0.98	1.00	0.95	0.97
(2)	k	.0647	.0123	.1036	.0621	.0433	.0572
	tt	16	81	10	16	23	29
	Asymp	6.0	5.0	9.2	17.0	22.0	11.8
Column	r^2	0.92	0.99	0.79	0.99	1.00	0.94
(3)	k	.2246	.2793	.0600	.0376	.0352	.1273
	tt	5	4	17	27	28	16
	Asymp	8.0	11.0	4.5	16.0	15.0	10.9
Column	r^2	0.96	1.00	0.82	0.69	0.97	0.89
(4)	k	.0896	.0693	.0335	.0236	.1238	.0680
	tt	11	14	30	42	8	21
	Asymp	8.0	14.0	10	10.5	25.0	13.5
Column	r^2	0.97	0.95	0.89	0.81	1.00	0.92
(5)	k	.1291	.1455	.0215	.1739	.1220	.1184
	tt	8	7	47	6	8	15.2
	Asymp	14.0	15.0	< 1	30.0	25.0	17.0

TABLE 5.2. Data describing the diphasic ^{32}P uptake kinetics detected during the routine ^{32}P uptake experiments. k = rate constant (min^{-1}) and tt = P turnover time.

COLUMN	DATE	RAPID PHASE		SLOW PHASE	
		k	tt	k	tt
3	23.5.78	.2714	3.7	.0189	52.9
4	15.11.78	.1669	6.0	.154	64.9
4	12.12.78	.1874	5.3	.0067	149.2
5	11.11.78	.4652	2.2	.0184	54.3
$\overline{x}$			4.3		80.33

TABLE 5.3. Changes in the relative proportions of soluble P fractions during the ^{32}P uptake experiments conducted on water sampled from column 5 during October 1978. (Expressed as a % of total ^{32}P eluted).

Fraction	Time of fractionation (h)			
	0	0.03	6.5	20
PO_4-P	100	99	31.3	8.5
Colloidal P	0	0.8	60.1	84.8
Intermediate P	0	0.2	8.6	6.7

TABLE 5.4.

Soluble reactive phosphorus (SRP), total dissolved phosphorus (TDP) and particulate phosphorus (PP) measured in the open water and isolation columns at the times P turnover times were determined during the 1977-78 enrichment experiment. All units $\mu g\ \ell^{-1}$.

SITE		DATE							
		13.2.78	27.2.78	13.3.78	28.3.78	11.4.78	24.4.78	23.5.78	$\overline{x}$
Open Water	SRP	-	1	1	t	1	1	1	-
	TDP	-	3	10	6	8	6	2	5.83
	PP	-	20	8	5	12	9	18	12.0
Unenrich column(1)	SRP	-	1	t	t	2	t	t	-
	TDP	-	5	7	4	8	5	1	5.00
	PP	-	17	17	8	7	8	22	13.17
Column(2)	SRP	-	1	1	1	1	1	2	-
	TDP	-	7	8	4	6	3	3	5.17
	PP	-	11	13	10	17	27	-	15.60
Column (3)	SRP	-	t	1	1	1	1	1	-
	TDP	-	5	8	6	6	4	1	5.00
	PP	-	13	15	3	14	11	-	11.20
Column (4)	SRP	-	t	1	t	t	1	1	-
	TDP	-	5	7	6	5	4	3	4.83
	PP	-	13	11	3	16	17	18	13.00
Column (5)	SRP	-	t	t	t	1	t	0	-
	TDP	-	6	5	4	5	4	1	4.17
	PP	-	12	12	12	14	15	-	13.00

TABLE 5.5 Relative proportions of PO_4-P, colloidal P and intermediate P fractions in 9 hour filtrate from routine ^{32}P uptake experiments in the open water and isolation columns on November 14, 1978, together with other parameters measured in the samples.

Parameter	Site					
	Open water	Column 1	Column 2	Column 3	Column 4	Column 5
PO_4-P % of Total	2.8	0.7	4.2	0.9	2.4	< 1
% of Soluble	23	33	42	17	30	28
Colloidal P % of Tot	8.2	1.1	5.0	3.6	5.0	< 0.1
% of Sol	68	53	50	72	63	59
Intermediate P % of Soluble	9	14	8	11	7	13
Asymptote %	11.0	8.0	9.2	4.5	10	< 1
P Turnover Time(min)	60	12	10	17	30	47
SRP µg ℓ^{-1}	2	t	t	t	t	t
TSP µg ℓ^{-1}	10	5	8	5	7	7
TP µg ℓ^{-1}	22	20	19	18	18	26
TSS mg ℓ^{-1}	20.4	8.1	9.1	13.2	12.4	13.8
Chlorophyll µg ℓ^{-1}	2.5	5.1	6.9	4.0	4.2	14.2

SRP = soluble reactive phosphorus

TSP = total soluble phosphorus

TP = total phosphorus

TSS = total suspended solids

t = trace

TABLE 5.6 Correlation coefficients (r) for the proportions of soluble P (as a % of the total ^{32}P eluted) versus total phosphorus (TP), total soluble phosphorus (TSP), total suspended solids(TSS), P turnover time (tt), chlorophyll and asymptote level (Asymp), measured in the open water and columns on November 14, 1978.

Fraction	TP	TSP	TSS	tt	Chlorophyll	Asymp
PO_4-P	-0.064	0.135	-0.636	-0.428	0.240	0.274
Colloidal P	0.095	0.049	0.718*	0.456	-0.386	-0.066

* significant at 0.05 n = 6

TABLE 5.7 Changes in the relative proportions of soluble P fractions during the ^{32}P uptake experiments on water sampled from column 5 during March, 1979. (Expressed as a % of the total ^{32}P eluted).

Fraction	Time of fractionation (h)			
	0	0.17	1	2
PO_4-P	100	89.9	11.4	9.3
Colloidal P	0	8.9	84.0	87.9
Intermediate P	0	1.2	4.6	2.0

TABLE 5.8 Changes in the relative proportions of soluble P fractions during the ^{32}P uptake experiment in an *Anabaena flos-aquae* culture (expressed as a % of the total ^{32}P eluted)

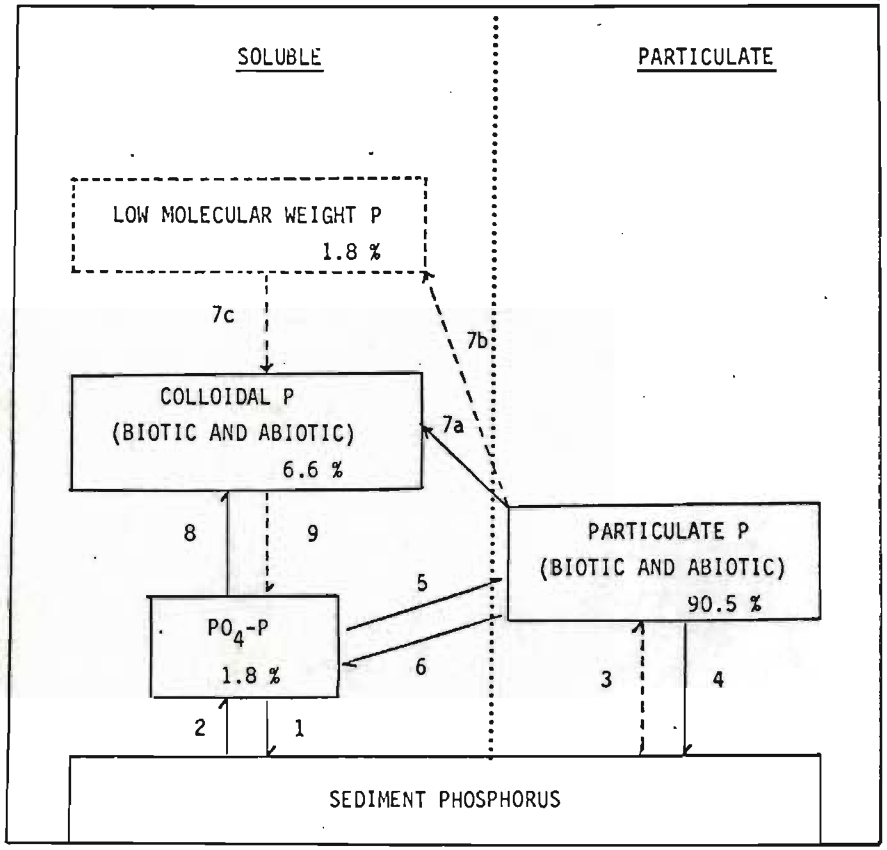
Fraction	Time of fractionation (days)							
	0	0.75	1.5	4	6	11	17	22
PO_4-P	100	71.4	32.1	40.0	43.7	46.0	35.0	48.4
Colloidal P	0	28.7	47.0	36.0	39.0	30.0	52.0	39.4
Intermediate P	0	0	21.9	24.0	17.3	24.0	13.0	12.2

TABLE 5.9 Retention of colloidal P, obtained from a routine soluble P fractionation of Midmar Dam water, on refiltration through 0.45μ membrane filters.

	CPM ml^{-1} before filtration	CPM ml^{-1} after filtration	% Retained
1	4004	1395	65
2	3103	1385	55
$\overline{X}$	-	-	60

TABLE 5.10 Correlation between P turnover time (tt) and chlorophyll(Chl) and total suspended solid (TSS) concentrations in the open water and isolation columns during the 1977-78 (n = 42) and 1978-79 (n = 30) enrichment experiments.

Period Parameters Correlated	1977-78	
	Chl. vs tt	TSS vs tt
r	0.283	.0232
Period	1978-79	
r	0.095	.0502



1: PO_4-P ADSORPTION BY SEDIMENTS.

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3: SEDIMENT RESUSPENSION.

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7a: SESTONIC PRODUCTION OF COLLOIDAL P.

b: SESTONIC PRODUCTION OF LOW MOLECULAR WEIGHT ORGANIC P.

c: INCORPORATION OF LOW MOLECULAR WEIGHT ORGANIC P BY COLLOIDAL P.

8: PO_4-P UPTAKE BY COLLOIDAL P.

9: PO_4-P RELEASE BY COLLOIDAL P.

Fig. 6.1 A conceptual model of P compartments and their interactions in a shallow area of Lake Midmar. (The relative proportions of the soluble P fractions represent mean values from all gel filtration analyses undertaken on water from the dam and isolation columns).