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THE CALCULATION OF PER CAPITA PHOSPHORUS OUTPUTS FROM DETERGENTS IN THE LOUGH ERNE CATCHMENT

Simon Patrick

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Palaeoecology Laboratory

Department of Geography
University College London

CONTENTS

ABSTRACT

Owing to the predominantly rural nature of the Lough Erne Catchment, the contribution of detergent P to the lake is considered to come primarily from domestic sources. The role, form and content of P in such detergents is reviewed, and the significance of its degradation from condensed to orthophosphate forms is discussed.

By utilising and manipulating published information, per capita detergent P consumption and hence output is calculated for the Northern Ireland (0.08 g.P. person^{-1} day^{-1} [1951] - 1.67 g.P. person^{-1} day^{-1} [1981]), and Republic of Ireland (0.03 g.P. person^{-1} day^{-1} [1951] - 1.1 g.P. person^{-1} day^{-1} [1981]) sections of the study area. The methods used are considered to provide data directly applicable to the problem and area in question, while the inadequacies of other published estimates for detergent P output are highlighted.

ABBREVIATIONS USED IN TEXT

CSO	Central Statistics Office.
D.O.E.	Department of the Environment.
I.D.A.P.A.	Irish Detergent and Allied Products Association.
P	Phosphorus.
Pers. Comm.	Personal Communication.
SDW	Sewage Disposal Works.
S.D.I.A.	Soap and Degergent Industry Association.
STPP	Sodium Tripolyphosphate.

INTRODUCTION

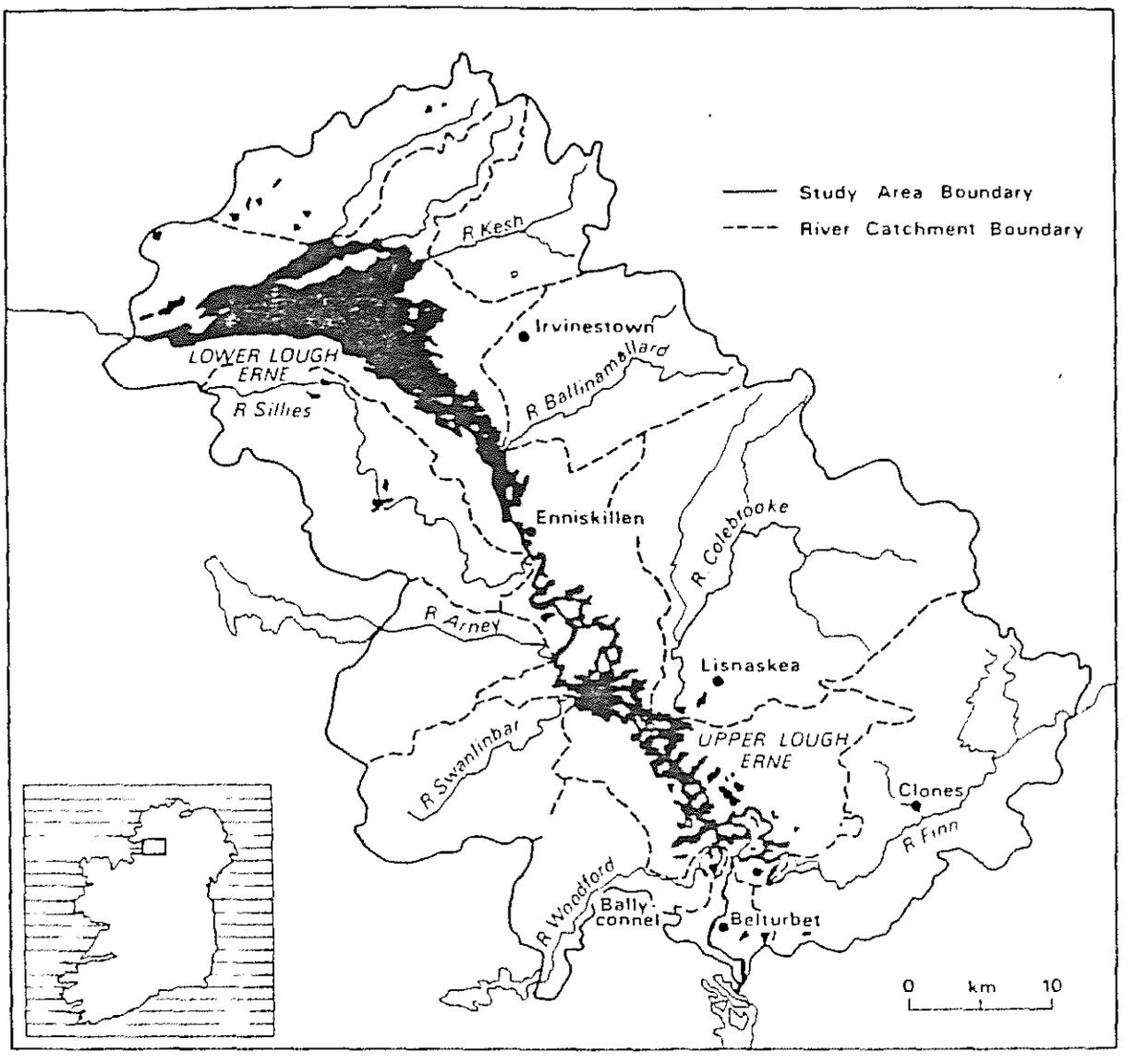
From the results of a palaeolimnological survey of Lough Erne by Battarbee (1977), it has been hypothesised that the progressive eutrophication of the lake system stems from the increased input of nutrients from domestic and industrial point sources, rather than from a diffuse source such as agriculture.

A modern phosphorus (P) budget has been constructed for the Lough by Gibson et al. (1980). A research project funded by the S.S.R.C., seeks to examine the contention that the increased P loading is a result of changing sanitary systems, and changes in the provision of sanitary facilities and of inputs to these systems, during the past 100 years. The study area involved is outlined in Figure 1.

Two broad themes are central to this research. One involves documenting the changes in sanitary systems by which P is transported to water courses and the lake. The other is to examine changes in the inputs to such systems which will also directly affect the magnitude of P outputs. A previous paper in this series (Patrick and Battarbee 1981), has studied the influence of dietary change on the potential domestic P loading. It was found that despite major changes in the type of diet since 1850, there was little evidence for a significant change in per capita P excretion. An output of 1.2 g.P. person^{-1} day^{-1} was considered representative for the study area for the period 1850-1980. The present paper documents the contribution of detergents, the other major source of P in sewage.

Since P rich detergents first appeared on the North American market in the late 1940s, their role as a major contributor of P to lakes has been recognised and well documented. In the U.S.A., where the P content of detergents has generally been higher than in Europe, it was estimated that by 1969 detergents accounted for over 50% of P in municipal sewage (Vallentyne 1974).

FIG.1. THE LOUGH ERNE STUDY AREA



By the mid 1960s the contribution of detergent P to surface waters was such that certain badly affected countries introduced legislation to reduce the P content of detergents. In 1973 Canada and certain states in the U.S.A. reduced the permitted level to 5% as P_2O_5 (Shannon 1980).

Such a move is not considered economically or politically viable in Britain or Ireland (e.g. Lund 1980), although the role of detergents in contributing to problems of nutrient enrichment is recognised. Thake (1978) for example, considered that between 30 and 40% of available P in Lough Neagh was contributed by detergents.

In the U.K. synthetic detergent washing powders were introduced later than in the U.S.A. By the mid-1950s their use had increased to the extent that detergents[1] became a significant source of P in sewage. They competed with, eroded, and eventually replaced the position of conventional soap powders in the domestic detergent market. However since 1977 production and sales of synthetic detergent powders in the U.K. have levelled off as the market reached saturation point (Fig.2) (Lund 1980).

In estimating per capita outputs of P from detergents in the Lough Erne region, this study concentrates on documenting the changing contributions from domestic washing powders, since in the context of Ireland these are the predominant source of detergent P. Washing-up liquids contain P only at trace levels (Devey and Harkness 1973), and automatic dishwashers that use P rich detergents, are still rare.

Industrial detergents can also be excluded. In many regions detergent from industrial sources may make a major contribution to the P output from a catchment. Although P levels in industrial detergents are generally much lower than found in domestic washing powders (S.D.I.A. pers. comm. 1983), a significant loading may occur because of the quantities involved.

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[1] The term 'detergent is used in the sense of a washing or cleaning material and includes soap based products (Ministry of Housing and Local Government 1956). Thus in this study the term encompasses both synthetic detergent and soap based washing powders.

However, in a predominantly rural and non industrial area such as the Lough Erne Basin, the inclusion of industrial detergent figures, unless specifically available for the few industrial concerns within the region, would lead to an overestimate of the per capita contribution of detergent P.

During interviews with various creamery managers (milk processing together with meat processing comprise the only significant industry in the region), brand names of cleansing materials, and estimates of quantities used, were obtained. On conferring with manufacturers only orthophosphoric acid, used for descaling pipes and pasteurising machinery, was found to contain a significant P content. However such small quantities of this cleansing agent were used in the creameries that it was deemed an insignificant source of P.

The use of published estimates of per capita detergent P output is precluded by the requirement to work with data expressing the contribution of domestic detergents. Table 1 and the subsequent discussion (pages 18-19) reveal the unsuitability of published data for use in this study. In particular the assumption frequently encountered that detergents contribute 50% of P to sewage is misguided in a historical context. Given the relative stability of P output from metabolic waste (Patrick and Battarbee 1981), and in view of the increase in per capita detergent P consumption until very recently (see Fig.4 and Table 7), it is unlikely that detergents could contribute 50% of P in sewage in 1964 (Vollenweider 1971); 1971 (D.O.E. 1971); and 1980 (D.O.E. 1980).

The calculation of figures relating to domestic consumption of detergent, respresentative of the general situation in the Lough Erne region, is thus a central part of this study. As all detergent P is eventually discharged with the washing water, per capita consumption is equivalent to per capita output.

Owing to the commercial sensitivity of the detergent industry,

Table 1. PUBLISHED DATA RELATING TO THE PROPORTION AND PER CAPITA CONTRIBUTION OF DETERGENT P IN SEWAGE

Date	Source	Method of Calculation	Per Capita Contribution g.P. day^{-1}	Proportion of Sewage % P
1959	Vollenweider (1971)	Production figures	0.65	
1961	Prat & Giraud (1964)	Production figures	1.27	
1964	Vollenweider (1971)	Surfactant material consumpton		50
1969	Devey & Harkness (1973)	Anionic surface active material consumption	1.73	
1970	Ministry of Technology (1970)	Surface active material consumption	1.2	46
1971	D.O.E. (1971)	c/f SDW effluent with laboratory detergent free effluent		50
1970-71	Devey & Harkness (1973)	Measured P content of sewage using detergent: P ratio	mean 1.92	
1978	D.O.E. (1978)	STPP consumption	1.32	40-50
1980	D.O.E. (1980)			50
1980	Lund (1980)	Literature		40-50
1981	Gray (1981)	Analysis of SDW effluent (N. Ireland)		45

dominated in recent years by two major producers - Lever Brothers and Proctor and Gamble - there is a marked lack of detailed published information concerning aspects such as production and consumption, chemical formulation and market share of washing powders. A further complication is the complete absence of published information for the Republic of Ireland.

The above problems were largely circumvented with the assistance of the Soap and Detergent Industry Association (S.D.I.A.), providing information relating to the U.K.; and the Irish Detergent and Allied Products Association (I.D.A.P.A.) and Lever Brothers (Ireland) Ltd., providing information for the Republic. In the following sections information provided by members of these bodies is referenced under the organisations they represent, acknowledgement of individuals concerned is made on page 20.

THE ROLE AND FORM OF P IN DOMESTIC DETERGENTS

The basic ability of modern synthetic detergents to remove dirt is provided by the combination of the surface active properties of synthetic surfactants with the actions of a P based 'builder' (Gilbert and De Jong 1978). In the search for the most suitable builder both condensed phosphates and orthophosphates have been used. For many years the most commonly used material has been Sodium Tripolyphosphate ($Na_5P_3O_{10}$) or 'STPP', a condensed phosphate.

Forziati (1972) considers STPP to be the ideal builder, its role being primarily that of a sequestering agent. In aqueous solution it forms strongly bound and soluble complexes with magnesium and calcium ions responsible for the hardness of water. Table 2 details the major properties of STPP, which Vallentyne (1974) summarises as:

1. To soften water.
2. To create and maintain high alkalinity.
3. To remove dirt particles.

Table 2. MAJOR PROPERTIES OF STPP (AFTER GILBERT AND DE JONG 1978)

1) It forms soluble and strong complexes with Ca and Mg ions.

2) It disperses particulate dirt.

3) It provides mild buffered alkalinity.

4) It is non hydroscopic.

5) It forms crystalline anhydrous and hydrated salts.

6) It is toxicologically acceptable.

7) It has relatively low cost.

So common has STPP been as the P formulation in washing powders, that in deriving the P content of such powders the S.D.I.A. (pers. Comm. 1983) advise that all detergents produced in Britain and Ireland from the mid-1950s be assumed to contain P as STPP.[2]

Of particular significance is the ready and complete hydrolysis to orthophosphate of STPP in aqueous solution. This degradation occurs at different rates depending on the immediate environment in which the condensed phosphate is placed. Van Wazer (1958) found hydrolytic degradation of condensed phosphates in aqueous solution, at neutral PH, and at room temperature was slow. However when such conditions varied the rate of hydrolysis was extremely fast. In particular it will occur quicker in a medium where enzymatic activity predominates, such as in domestic sewage (e.g. Davies and Wilcomb 1967, Sawyer and McCarthy 1967, and Cooper and Bailey 1973).

Perry et al. (1975) suggest that a very high percentage of hydrolysis occurs in sewers before effluent reaches a SDW. Gray (1981) reports that polyphosphates hydrolyse to orthophosphates in a matter of hours. Heinke and Norman (1969) observed that on contact with activated sludge the rate

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[2] To convert STPP to P divide by 4

of hydrolysis was some 50 times faster than in untreated wastewater. Work of Englebrecht and Morgan (1959) and Devey and Harkness (1973) suggests a somewhat less rapid but no less complete process. Table 3 lists the major environmental factors affecting the rate of hydrolysis.

Table 3. FACTORS AFFECTING HYDROLYSIS OF CONDENSED PHOSPHATES IN DECREASING ORDER OF EFFECTIVENESS (AFTER VAN WAZER 1958)

1.	Temperature:	Greater as temperature increases, reaction rate approximately doubles per $5^{o}C$ incease.
2.	P.H.	Greater with increased acidity.
3.	Enzymes:	As much as 10^{5}-10^{6} faster.
4.	Colloidal gels:	As much as 10^{4}-10^{5} faster.
5.	Complexing cations:	Manyfold faster in most cases.
6.	Concentration:	Rate is proportional.
7.	Ionic environment in solution	Several fold change.

As any hydrolysis that has not occurred under micorbial processes in SDWs will take place via similar processes in water courses and lakes, (e.g. Clesceri and Lee 1965, Shannon and Lee 1966, and Reynolds 1978), albeit at a slower rate, it may be assumed that all detergent P will be present in a lake in an orthophosphate form.

The contention of e.g. (Forziati 1972, and Alexander 1978) that all detergent P reaching a lake becomes biologically available is thus supported. Finstein and Hunter (1967) recognise that condensed phosphates are relatively unavailable to photosynthetic plants, but that this changes entirely with their degradation to the orthophosphate form. Similarly weight is lent to the assumption that runs throughout this research project, that the majority of P in sewage effluent is potentially biologically available (e.g. Smith 1977, Oglesby and Schaffner 1978).

DETERMINATION OF PER CAPITA DETERGENT P OUTPUT

The amount of P from domestic detergents reaching a watercourse will, ignoring at present the role of differing sanitary systems, depend upon the P content of washing powder and their per capita consumption.

1. P content

Even accepting the assumption that all P in washing powders has been in the form of STPP, a degree of variation exists between different brands and has existed temporally within the same brand. Fortunately in dealing with the U.K. and the Republic of Ireland we are examining comparable products, the two major manufacturers being common to both countries.

(a) Synthetic Detergent Powders

Devey and Harkness (1973) quote a survey of U.K. synthetic detergent washing powders carried out in 1957 which gave a range of 8 - 30% by weight of STPP (2-7.5% P). Another survey in circa 1972 showed this range to be 24 - 43% STPP (3-10% P) (Table 4). A sample of 11 products (D.O.E. 1971) yielded a range of 21.5-39.7% STPP (5.5-10.4% P), with a mean of 31.2% STPP (8.2% P).

Although some increase is thus detectable since 1957, the S.D.I.A. (pers. comm. 1983) suggest that a minimum of error would result in ascribing a value of 30% by weight STPP (7.5% P) for all synthetic detergent powders during the history of their production in the British Isles. Such a figure is supported by other Authorities (e.g. Reynolds 1978).

Assigning a value to encompass all brands also avoids the problems that would be involved in attempting to account for the market shares of the various products at different times. A Price Commission report (1978) recognised that owing to the sensitivity of the market the leading companies conduct their own research into market size and market share, which not only differ from independent estimates, but from each other.

Table 4. STPP CONTENT OF DETERGENTS CIRCA 1972, (AFTER DEVEY AND HARKNESS 1973)

Brand of Detergent	STPP Content by Weight %	P Content by Weight %
Coop Blue	34.3	8.
Daz	35.9	9.0
Dreft	24.2	6.1
Ariel	31.2	7.8
Tide	36.0	9.0
Radiant	36.3	9.1
Omo	32.8	8.2
Surf	42.8	10.7
Oxydol*	7.9	2.0
Fairy Snow*	16.6	4.2
Persil*	15.0	3.8

*Soap powders

(b) Soap Powders

A factor often forgotten in calculating per capita detergent P output is that modern soap powders also contain STPP in their formulations. The 1957 survey referred to by Devey and Harkness (1973) (see above), found a range of STPP content by weight of 12-14% (3-3.5% P).

The S.D.I.A. (pers. comm. 1983) advise that a historical analysis of the STPP content of soap powders is somewhat complicated. Early formulations were marketed for different areas of water hardness, therefore the same brand could contain different amounts of STPP. Before circa 1962 the addition of STPP to soap powders was not universal within the British Isles. Since 1962 the content has varied between 7.5 and 10% (1.9-2.4% P).

The S.D.I.A. recommend that STPP in soap powder be ignored prior to 1962 and ascribe a figure of 7.5% (1.9% P) as representative of most formulations since 1962.

2. Detergent Consumption

Before settling for the method of calculating per capita consumption by utilising published data, two other methods were attempted.

A question was originally included in the 'rural sanitation surveys'

by which aspects of the role of septic tanks were examined (Patrick and Battarbee 1982), to ascertain per capita consumption within the river catchments of the study area. Many respondents found difficulty in estimating representative consumption over a specific time period. Consequently the results varied so greatly and inconsistently, (for instance in no catchment was a correlation between family size and washing powder consumption found), that this approach was soon abandoned.

Another attempt to obtain data at the local level involved requesting the two largest and longest established retail stores, situated in Enniskillen, to provide sales figures for washing powders for as many years as possible. However as sales information, even for recent years, were unavailable this method was also abandoned.

With the failure of attempts to assess washing powder consumption at the local level, and in the absence of published sales or production figures at a regional level, recourse was made to national summaries.

Given that the producing companies consider there to be little regional variation in consumption of washing powders within the U.K. (S.D.I.A. pers. comm. 1983) or the Republic (I.D.A.P.A. pers. comm. 1983), this method provided information that could be considered applicable to the study area.[3]

To obtain valid historical data, the utilisation of a long running and consistent source was essential. Remarks of the Economist Intelligence Unit (1961) suggested that this would be difficult to obtain.

> "A proper analysis of the household and industrial markets for washing products is precluded by the absence of official statistics and by the reticence of the major producers regarding their own analysis of the situation." (p.28).

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[3] Regional comparability was however lacking in the early 1950s immediately following the introduction of synthetic detergents in the U.K. Information from Puplett (1956) (see Table 5) suggests that the first distribution of synthetic detergents in Northern Ireland may have occurred up to two years after their original launch in the south east of England.

Similarly Vollenweider (1971) recognised that many of the "available statistics are incomplete or the various existing data for a country are self contradictory." (p.121). Sources, discussed below, were however found to provide most of the information required for both the U.K. and the Republic.

Table 5. INTRODUCTION OF PRINCIPAL SYNTHETIC DETERGENT BRANDS (AFTER PUPLETT 1956)

Brand	Dreft	Wisk	Tide	Surf	Daz
Launch Date	July 1948	Sept. 1948	May 1950	Sept. 1952	April 1953
Area of Launch	London	London/S.E.	London	London/S.E.	London S.E
Time to National Distribution (England & Wales) Months	15	7	23	8	5
Time to National Distribution (Scotland) Months	18	14	29		3

(a) United Kingdom

The major source of information was a Government publication "The Business Monitor", which occurs in two series.

a) "Business Monitor, Soap and Detergents" P20 1958-1971. (annually 1958-1961, quarterly 1962-1971).

b) "Business Monitor, Soap and Detergents" PQ275, 1972-1983. (quarterly)

Between 1958-1972 these statistics include a breakdown of synthetic detergent powder sales by U.K. manufacturers on the home wholesale/retail markets (Table 6, Figure 2). Identical information is provided for soap powders between 1962-1972. The level of detail of this information allows a clear distinction to be made between domestic and other detergent products, a distinction deemed essential in the context of this study, and one that other official statistics do not make (e.g. see Price Commission 1978).

From 1972 to the present additional relevant information is provided

by details of imported synthetic detergent powders for the domestic market. The proportion of total detergent powder sales that imports represent is small, varying from 0.23% in 1972 to 1.34% in 1980.

After 1972 no breakdown is provided on the sales of soap powders on the home market. By 1972 two brands - 'Persil' and 'Fairy Snow' - produced by rival manufacturers, dominated the soap powder market. Information was therefore particularly sensitive and not divulged (S.D.I.A. pers. comm. 1983). Sales figures for soap powders between 1972-1981 therefore had to be extrapolated from the market share of total washing powder sales that soap powders represented during this period.

Three independent estimates of this share at different dates were available. Evidence from the S.D.I.A. (pers. comm. 1983) and the Price Commission (1978), produces a figure of 22.5% in 1977. Further evidence from the S.D.I.A. (pers. comm. 1983) gives a figure of 11% for 1982. Substituting data for individual years derived from Table 6 in the formula below, permits the calculation of domestic soap powder sales during the period in question (Fig. 3).

$$B=A(100-Ax)/Bx$$

Where B = Soap powder sales.
A = Synthetic detergent powder sales (from Table 5).
Ax = Synthetic detergent powder sales as percentage. of total washing powder sales (100-Bx).
Bx = Soap powder sales as percentage of total washing powder sales.

To account for synthetic detergent powder consumption before 1958 it was also necessary to extrapolate with the evidence from another source.

Data from the Economist Intelligence Unit (1961) concerning U.K. sales of domestic synthetic detergent powder is available for 1950, 1959, and 1960. The figures for 1959 and 1960 of 158504 tonnes and 162568 tonnes respectively, are sufficiently similar to the 'Business Monitor' figures for the same years (see Table 6), to suggest the validity of utilising the 1950 figure (35562 tonnes) as a suitable 'origin' for synthetic detergent powder

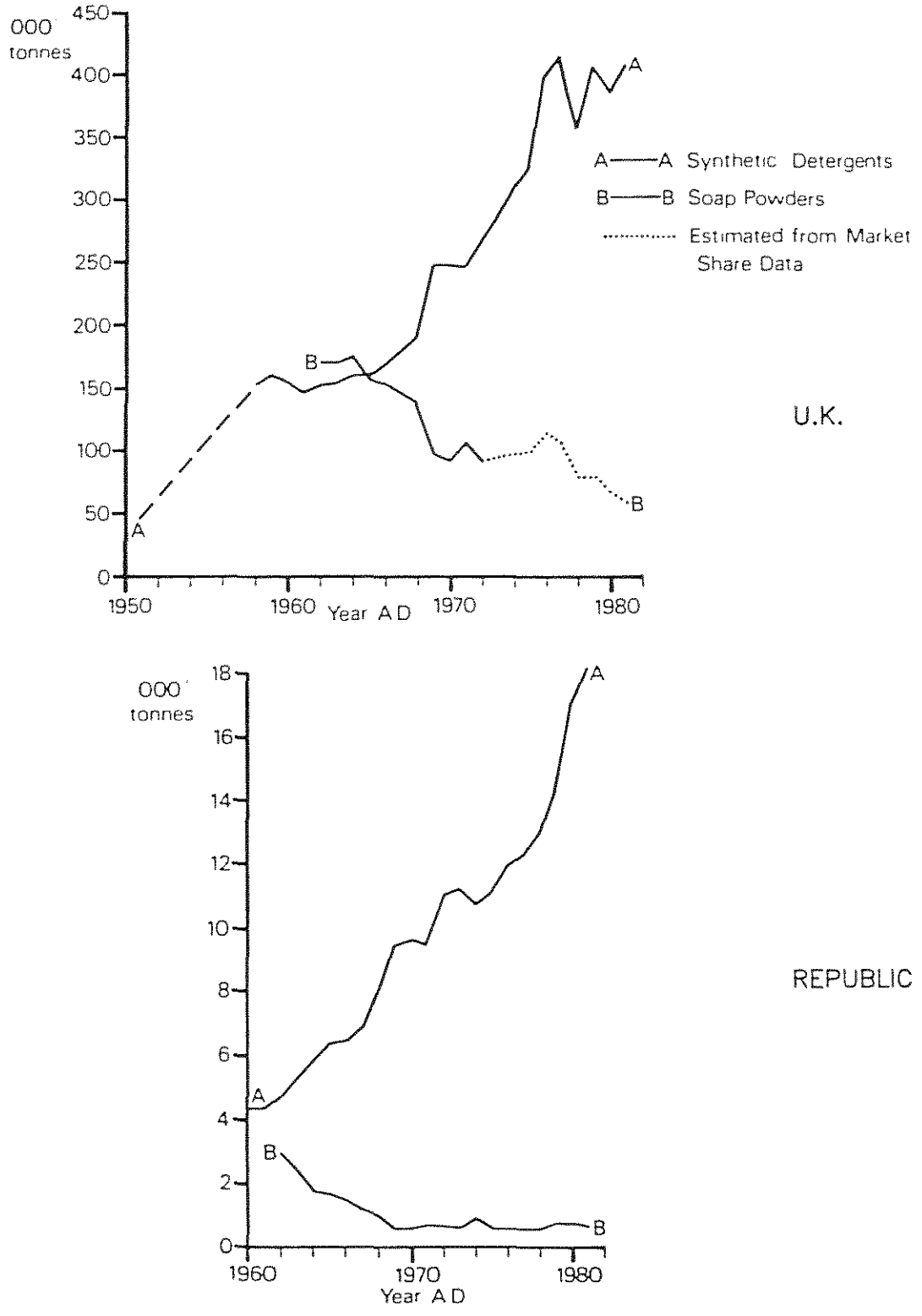

FIG.2. SALES OF DOMESTIC DETERGENTS IN THE U.K. AND THE REPUBLIC OF IRELAND

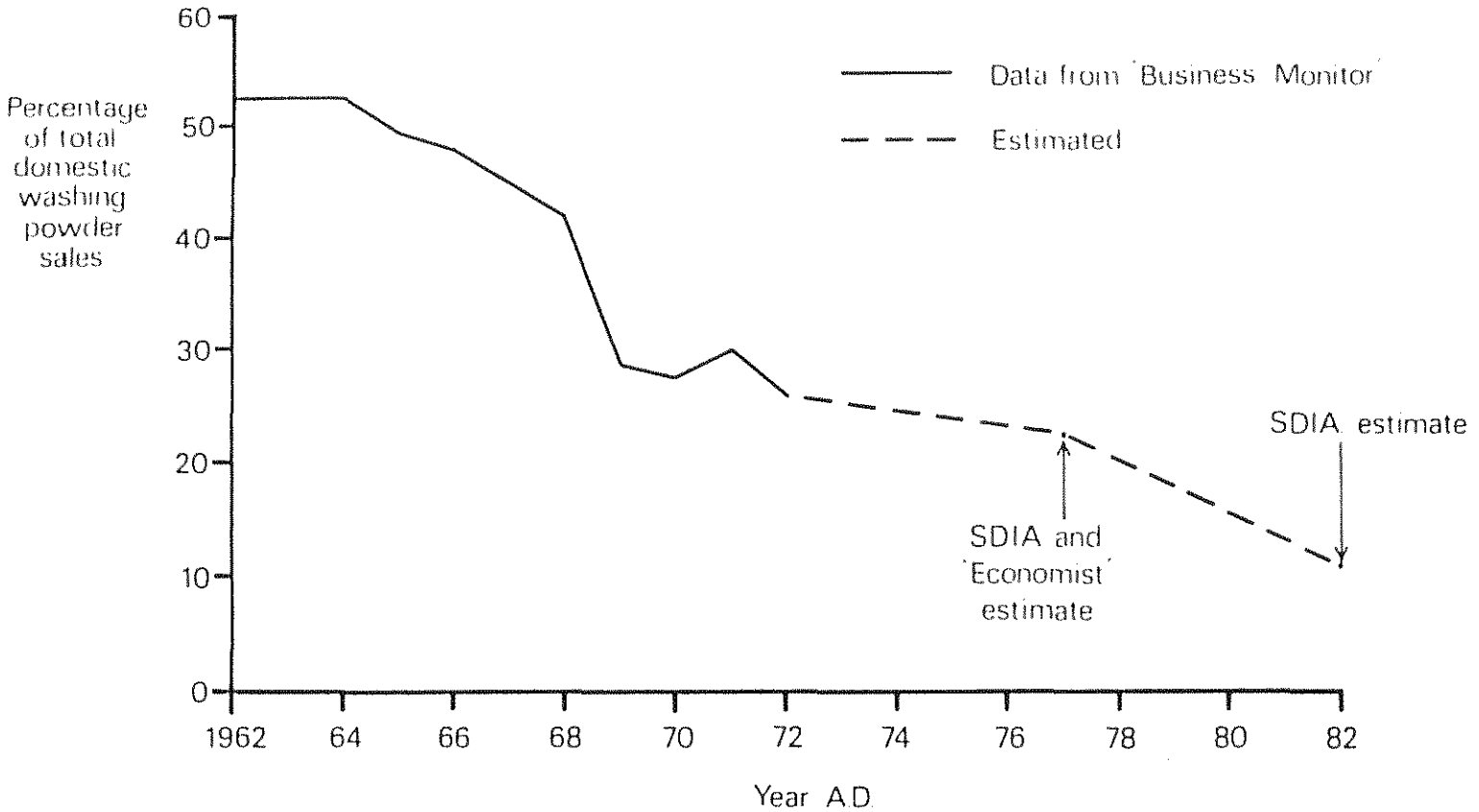

FIG.3. SOAP POWDER SALES AS A PERCENTAGE OF TOTAL DOMESTIC DETERGENT SALES IN THE U.K.

consumption in the U.K.

Figure 2 portrays the consumption figures for synthetic detergent and soap powders in the U.K. between 1950-1982. The trend for synthetic detergent powders reveals the rapid 'take off' of consumption in the mid-1950s, followed by a decade of little growth preceding another decade of sustained expansion before the market, despite fluctuations levelled off after 1977.

Sales of synthetic detergent powders surpassed those of soap powders in 1965, from which date the share of soap powders in the domestic market had declined to 11% by 1982.

(b) Republic of Ireland

Consideration of consumption figures for the Republic is less complicated than for the U.K., the only available source of information being the concise data provided by Lever Brothers (Ireland) Ltd. (pers. comm. 1983), portrayed in Table 6 and Figure 2.

1960 represents the 'base year' for the sale of synthetic detergents in the Republic, they were not officially marketed in the country until that time (I.D.A.P.A. pers. comm. 1983). The growth in use of these powders is more consistent than that exhibited in the U.K., while the relative demise of soap powders is more marked, they comprised only 3.5% of the market in 1982. Synthetic detergent powder sales had already exceeded those of their soap based competitors by 1960.

Table 6. U.K. AND REPUBLIC OF IRELAND CONSUMPTION OF DOMESTIC DETERGENTS (TONNES)

Date	U.K.		Republic[4]	
	Synthetic Detergent Powder[1,2]	Soap Powder[1,3]	Synthetic Detergent Powder	Soap Powder
1950	35562			
1958	152204			
1959	160129			
1960	156268		4400	3350
1961	147632		4445	3305

(Table 6 contd.)

1962	153525	170087	4749	3051
1963	153424	170493	5397	2552
1964	159520	176284	5901	1821
1965	159926	157589	6423	1727
1966	167445	155252	6556	1566
1967	179333	146209	6900	1252
1968	190306	137877	8042	1088
1969	24893=	98861	9576	656
1970	247510	93375	9738	662
1971	245884	106583	9505	795
1972	268383	93699	11112	688
1973	286727	95576	11380	620
1974	309420	97712	10830	970
1975	326344	99107	11100	600
1976	398425	115671	12000	600
1977	412626	106400	12400	600
1978	354187	80398	13000	600
1979	405964	80220	14300	700
1980	384127	67787	17100	800
1981	405003	60518	18289	761

1 From 'Business Monitor' statistics.
2 1950 figure from Economist Intelligence Unit (1961).
3 1970-1981 figures estimated from market share trend.
4 Data from Lever Brothers (Ireland) Ltd.

3. Per Capita P Outputs from Domestic Detergents

Utilising the information on consumption compiled and discussed above, and following the assumption that between 1950-1981 synthetic detergent powders contained 7.5% P by weight (see p.10), and that from 1962 soap powders contained 1.9% P by weight (see p.11), per capita consumption and hence potential output of P was calculated using mid-year population estimates for the U.K. (C.S.O. 1982), and the Republic (S.A.I. 1963-1982).

To compensate for the postulated delayed diffusion of synthetic detergents to Northern Ireland, per capita consumption figures between 1950-1956 have been lagged two years behind those for the U.K. in general. Similarly a two year lag was introduced for the same period on the regression based data for the Republic (see below).

Reference to Figure 4 and Table 7 shows that in Northern Ireland per capita consumption rose steadily from 0.02 $g.P.day^{-1}$ in 1950 to 1.6 $g.P.day^{-1}$ in 1977, around which level it has fluctuated since. In the Republic per

capita consumption throughout the period was below that of the U.K. However in rising from 0.3 g.P.day^{-1} in 1960 to 1.1 g.P.day^{-1} in 1981, the underlying trend was remarkably similar.

Although synthetic detergent powders were not marketed in the Republic until the early 1960s, it is known that in the border areas such as Counties Cavan and Monaghan, such products were purchased in the North and brought across the open border (I.D.A.P.A. pers. comm. 1983). In order to account for P output from detergents between 1950-1960 in the part of the Republic lying within the study area, the trend of per capita output from 1960-1981 was regressed back in time using the equation:

$$y = 0.3405+0.0293(x)$$

Where x = years since 1960.

(see Fig. 4).

Table 7. PER CAPITA OUTPUT OF DETERGENT P IN THE STUDY AREA 1950-1981 (g.P. Day^{-1})

Date	N. Ireland	Republic
1950	0.04	0
1951	0.09	0.03
1952	0.15	0.06
1953	0.20	0.09
1954	0.25	0.12
1955	0.31	0.18
1956	0.36	0.22
1957	0.49	0.26
1958	0.60	0.29
1959	0.63	0.30
1960	0.61	0.32
1961	0.57	0.32
1962	0.76	0.40
1963	0.75	0.44
1964	0.78	0.46
1965	0.76	0.49
1966	0.75	0.49
1967	0.81	0.51
1968	0.84	0.59
1969	1.02	0.68
1970	1.00	0.69
1971	1.01	0.67
1972	1.07	0.77
1973	1.14	0.78
1974	1.23	0.73
1975	1.29	0.73
1976	1.57	0.77
1977	1.61	0.79
1978	1.38	0.82
1979	1.57	0.88
1980	1.47	0.99
1981	1.67	1.10

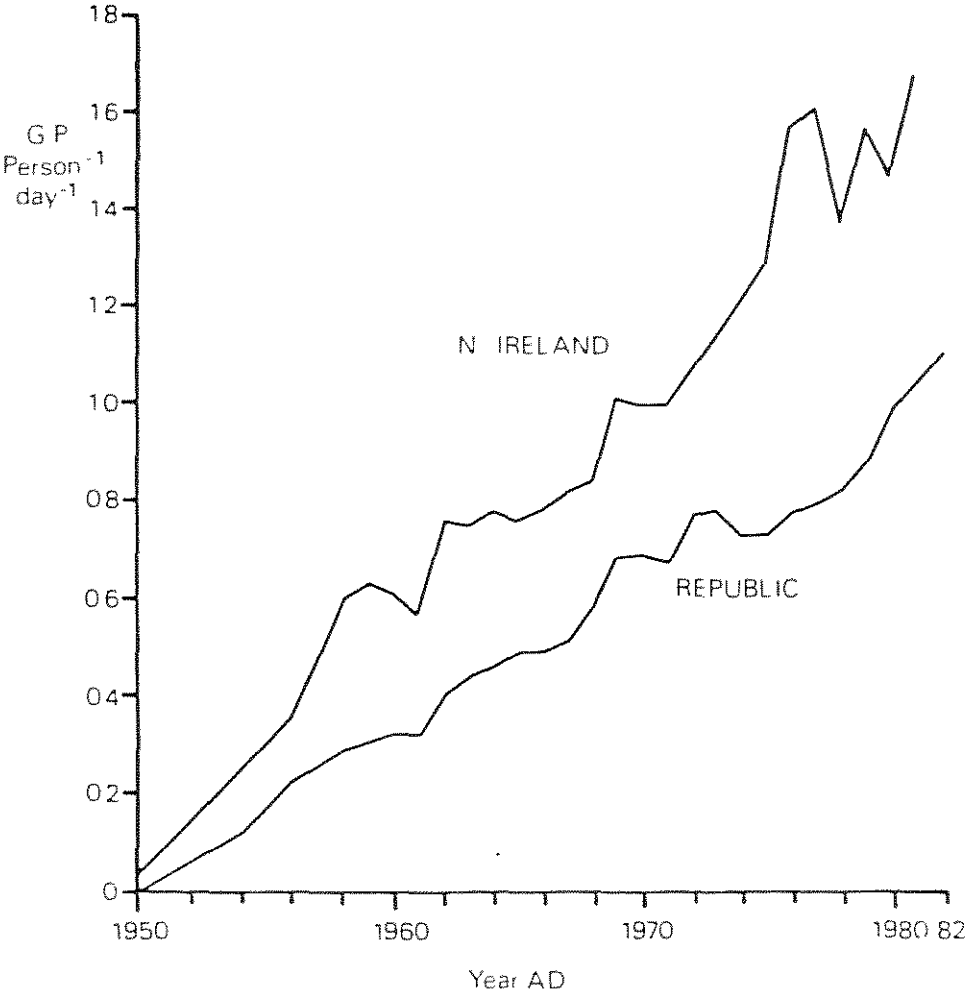

FIG.4. PER CAPITA OUTPUT OF DETERGENT P IN THE STUDY AREA 1950–1981

DISCUSSION

In view of the comments on page 5, it is pertinent to compare the per capita figures calculated in this study with other published data (Table 1). It is also of interest to note that in the context of this study, P from detergents could be considered to contribute 50% of the P in sewage (1.2 g.P. person day) in 1974 in Northern Ireland, and at a date yet to be reached in the Republic (see Fig.4).

These observations apply to a particular area where domestic sources are considered to be the predominant contributors of detergent P, and the contribution from metabolic sources is set at 1.2 g.P. person^{-1} day^{-1}. As such they should be related to other regions with care. The remarks of page 5 are however reinforced, as it is obviously incorrect, in a historical context, to assume that detergents are responsible for 50% of P in sewage.

With regards to the specific per capita figures presented in Table 1, consideration of the method of their derivation explains much of their variation from the results produced in this study.

National Production figures quoted by Prat & Giraud (1964), give a per cap figure of 1.27 g.P. Person^{-1} day^{-1}. This is 0.7 g.P. person^{-1} day^{-1} in excess of the corresponding figure apparent from Table 7.

The data of Devey and Harkness (1973), relating to 1970-1971 are from SDWs in a region where an industrial contribution must be considered (Upper Tame district). In addition the detergent P data was derived from the measured detergent content of sewage by means of a detergent:P ratio, which did not account for the negligible P content of washing up liquids. The resultant mean of 1.92 g.P. person^{-1} day^{-1} is thus almost double that obtained for the same date in this study (1 g.P. person^{-1} day^{-1}). In 'correcting' the detergent:P ratio to allow for the STPP content of soap powders, Devey and Harkness quote 1971 production figures of 210,000 tons (213,360 tonnes) of soap powder per annum, and 360,000 tons (365,760 tonnes)

of synthetic detergent powder per annum. Reference to Table 6 shows these figures to be excessive, and must result from the use of data relating to some aggregation of production of detergent products. When relating their proposed detergent:P ratio to figures fo_ the consumption of anionic surface active material in the U.K., their results are apparently reinforced, a per capita figure of 1.73 g.P. day^{-1} being obtained.

Jaag (in Vollenweider 1971) also utilised production data to arrive at per capita consumption. His figure of 320,000 tons (325,120 tonnes) for 1959 is a gross overestimate (c.f. Table 6), though peculiarly he produces a per capita figure (0.65 g.P. day^{-1}) directly comparable to that produced for the same year in this study (Table 7).

Affirmation of the validity of the method used in this study is found with the assumption of the D.O.E. (1978) that 110,000 tonnes of STPP were consumed in that year by a population of 57 million in the U.K. If corrected to a mid-year estimate of 55.835 million (C.S.O. 1982), this figure reveals a per capita consumption of 1.35 g.P. day, very similar to that of 1.37 g.P. day calculated in this study.

While no nationwide applicability is claimed, the strength of the data in this study is that it is derived from material that may be considered directly relevant to conditions in the region in question.

Treated as a separate entity, and disassociated from important factors such as demographic change and sanitary provision, it is not possible in this paper to determine the precise magnitude of the role of detergents in the eutrophication of Lough Erne. It would however seem particularly significant that the trend in per capita P output (Fig.4), follows a similar upward path over the same time period, as the idealised productivity curve postulated for Lough Erne by Battarbee (1977).

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