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CMSS, a decision support system, was developed for the Murrumbidgee catchment, (81 948km²). The simple computer program needs neither a technical nor computing background to set-up. This pilot study demonstrated the application of the system to a specific area as an initial phase prior to its application to major catchments in New South Wales.

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This book, published following an international workshop, provides a valuable reference resource on the state of knowledge of both pathways and mechanisms associated with phosphorus losses from field and catchments.

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This paper reviews the utilisation of fertilisers in precision farming as part of an integrated management system. The distinguishing factor is the acknowledgement that significant variability exists not only between fields but also within them.

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ALTERNATING AEROBIC AND ANAEROBIC CONDITIONS TO INCREASE PHOSPHATE REMOVAL FROM WASTEWATER

Traditional wastewater treatment plants do not exceed P efficiencies of 30%. The Phostrip, Bardenpho and A/O processes, recently developed and implemented in sewage plants have substantially improved this P recovery. This paper, focusing on A/O, describes the optimisation of this process in a laboratory-scaled single basin, by alternating sequences of aerobic and anaerobic phases.

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HIGH NUTRIENT REMOVAL IN THE THREE-SLUDGE SEWAGE TREATMENT

This three stage concept combines a high-loaded activated sludge plant plus a settler for the biological removal of P, with two biofilm reactors for nitrification and denitrification (by adding a carbon source). A pilot unit (2-3p.e.) showed that sufficient residence time for bacteria activity was critical in P removal (to 1mg/l) but that N reactors were relatively flow insensitive. A patent is pending.

INTERNATIONAL p.7

SECONDARY SETTLING TANKS

Over the last 25 years the adverse effect of wastewater discharges on the aquatic environment has led to stringent legislation controlling treatment plant outputs. This International Association on Water Quality (IAWQ) report concentrates on improved activated sludge systems and the need to back this treatment stage with a well designed SST thereby ensuring effluent quality under fluctuating influent quality and quantity conditions.

AUSTRALIA

DARLING RIVER ALGAL BLOOMS

The National Resource Management Centre (NRMS) has recently finished a three year project in the Darling River at Bourke, the geographical centre of the well-documented 1991 algal bloom. The purpose was to study whether nutrients or other factors were limiting algal growth.

The Vollenweider model, developed from European and N.American research, was initially used to study a series of weir pools connected by short riverine stretches. It was found that Chlorophyll-a concentrations v. total P loading did not match levels predicted by the model developed for deep lakes, and in a riverine context can only be considered as indicative. So, what is limiting algal growth in the Darling River?

This has led to the development of two hypotheses:

- *"algal growth is limited by nutrient availability".*
- *"the light climate in the Darling River is usually inadequate for algal photosynthesis and hence light availability controls algal growth".*

In the first hypothesis, TN:TP ratios were at first determined - some of the 8 samples were found to be N limited, whilst others were P limited.

However, use of TN:TP ratios in Australian conditions is limited, as not all N or P is bioavailable. Often a very small amount of total P is in the nominally dissolved fraction ($<0.003\mu\text{m}$). This is known as filterable reactive phosphorus (FRP) and is assumed to be the most readily bioavailable. Total N is

also divided into readily bioavailable DIN (dissolved inorganic nitrogen), the less assimilable organic nitrogen compounds, and particulate-bound N.

A study of the readily bioavailable nutrients (DIN:FRP) showed that (as later confirmed in a bioassays experiment in a field laboratory) all 6 samples tested suggested nitrogen limitation.

However, these methods do not determine possible limitation at the time of sampling. *In situ* measurements to determine the instantaneous physiological response in the algal cell to nutrient spike using Nutrient Induced Fluorescence Transient ("NIFT") assays showed that 2 of 8 samples were nutrient limited and both of these demonstrated N deficiency. The authors conclude that these conditions can provide a competitive advantage to cyanobacteria, which can fix atmospheric nitrogen and are not dependent on water-born DIN.

In the case of the second hypothesis, it was found that turbidity at Bourke was clearly related to flow regime during the study period (median turbidity 250 NTU). The analysis of the 2 longest "no water flow" periods since 1945 in '94 and '95 demonstrated that it is a combination of water column stratification and increased light penetration due to decreased turbidity that provides a dramatically improved light climate for algal photosynthesis. However, even if turbidity was normally less than 40 NTU during the large *A. Circinalis* bloom in 1991, it was found that extended periods of low turbidity were not the only influencing factor in excessive algal growth for turbidities have often been ≤ 40 NTU without the development of large blooms.

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To conclude, if there is indeed sufficient bioavailable phosphorus in the Darling River for an algal bloom to occur at any time, it is the imbalance between the consumption of the FRP by the algae and the slow rate of its resupply stemming from the sediments, that actually limit eventual algal biomass. This resupply can be further retarded by manipulating river flows to prevent stratification.

M.R.Grace, Mraci, B.T.Hart, Fraci, R.L.Oliver & C.M.Rees. Chemistry in Australia, August 1997, Vol. 64, N°7, pp 2-5

AUSTRALIA

THE CATCHMENT MANAGEMENT SUPPORT SYSTEM (CMSS) - A PILOT STUDY IN THE MURRUMBIDGEE

CMSS, a decision support system, was developed for the Murrumbidgee Catchment, an area of 81 948km², within the Murray Darling Basin. The simple computer program does not need a technical or computing background to set-up. This pilot study demonstrated the application of the system to a specific area as an initial phase prior to its application to major catchments in New South Wales.

The area covers several large population centres and much of the intensive farming involves irrigated agriculture.

The system needs carefully collected and accurate information. Four key sets of data are required:

- land use data
- mapped land attributes
- expert assessment of nutrient generation rates
- land use and land management practices.

CMSS can thus be used to assess the impact of nutrient loading from changes in land use and management practices. The system stores the quality of the information and can indicate any gaps in the information as well as reliability of outputs.

Although data demands are minimal, collection of the data was time consuming due to the size of the area. 53 subcatchments, each with 20-99 mapping units, were identified. Shortcomings included the absence of an instream nutrient assimilation component and nutrient bio-availability factors.

CMSS includes a policy module - it accepts and analyses land use and management "policy" statements. It also includes a predictive model component involving a simple nutrient balance model - thus it can calculate likely nutrient loads given a particular land use pattern and set of generation rates.

Land use data was extended to register point sources - sewage treatment plants, piggeries and fish farms.

Nutrient loads were calculated using '93 conditions - 3 400±595 tonnes total P and 26 000±4 500 tonnes total N. Overall, average total P and N generated is 0.4±0.1 kg ha⁻¹ year⁻¹ and 3.2±0.5 kg ha⁻¹ year⁻¹ respectively. The land use contributions showed that 95% of nutrients are generated by diffuse source and only 5% by point sources. Dry land cropping, unimproved and improved pasture generate 80% of all nutrient loads; sewage treatment plants generate only 4%.

These results highlight the need to focus on certain parts of the catchment and consider the use of buffer strips etc. to reduce diffuse nutrient source inputs. CMSS has been incorporated into the NSW Algal Management Strategy and implemented in many NSW catchments. The Murrumbidgee CMSS is now being revisited to prepare its catchment nutrient management plan.

S.Cuddy, B.Young, R.Davis & Trevor Farley. Managing Algal Blooms, Ch.9, pp. 103-113, 1997 ISBN 0 643 060499.

IRELAND

PHOSPHORUS LOSS FROM SOIL TO WATER

This book, published following an international workshop held at Teagasc, Wexford, Ireland in September 1995. It provides a valuable reference resource on the state of knowledge of both pathways and mechanisms associated with phosphorus losses from field and catchment.

Participants from over 20 countries established a new and more detailed understanding of the fate of P in agriculture and its contribution to the aquatic load. There is a growing appreciation that sewage works point source control alone will not resolve the P input issue and that agriculture has a major role to play. Diffuse farmland pathways and mechanisms were explored and, where data was available, qualified and quantified.

In addition to an 18 chapter comprehensive review, 45 posters are presented in the text.

This publication should form the basis for the development of workable strategies for controlling agricultural P losses and reducing or completely preventing this potential contribution to eutrophication.

H.Tunney O.T.Carton, P.C.Brookes & A.E. Johnston. 468p., CAN International Publishing, 1997, ISBN 0 85199 156 4.

UNITED KINGDOM

PRECISION FARMING FOR FERTILISER APPLICATION POLICIES

This paper reviews the utilisation of fertilisers in precision farming as part of an integrated management system. Calculation of standard fertiliser recommendations for a particular crop is based on factors such as soil type, crop yield, fate of crop residue etc. Guidance is given on a field by field basis. The distinguishing factor in precision farming is the acknowledgement that significant variability exists not only between fields but also within them.

Precision farming has been made possible through the use of new technologies. Automated techniques, using soil sampling and yield maps, have been developed allowing only the necessary amount of fertiliser to be placed on the land,. A series of experiments has been used to establish sampling procedures providing results with an acceptably low level of variance.

At such a level of precision critical levels of nutrients can be defined to limit runoff and leaching.

The Differential Global Positioning System (DGPS) is the US developed location system,

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adopted from the Global Positioning System (24 earth satellites) and used for precision farming. DGPS receivers can be mounted on harvesters, sprayers or spreaders, or used as hand held units and give positions in real time.

Different types of fertiliser spreaders are available. These already have the facility for automatic rate control and several can be controlled by the combined use of a predetermined application map/plan and the GPS receiver.

The yield map is essential to a fertiliser plan which needs to relate the real inputs of phosphate, potash and magnesium to the quantities removed in the harvested crop. The key to precision farming is the generation of a within-the-field yield map.

The paper concludes that precision farming relies on measurement and that the current lack of collected reliable data, due to the degree of manual input required, is a major constraint. The development of suitable sensors will lead to the development of more robust models for fertiliser recommendations. In future, variation in quality will become as important as variation in yield. Finally, environmental benefits will ultimately play an important role but will need to be quantified in order to give the needed impetus to this new technique.

C.J.Dawson. The Fertiliser Society, Proceedings N°391, December 1996 ISBN 0 85310 024 1.

ITALY

ALTERNATING AEROBIC AND ANAEROBIC CONDITIONS TO INCREASE PHOSPHATE REMOVAL FROM WASTEWATER

Traditional wastewater treatment plants do not exceed P efficiencies of 30%. The Phostrip, Bardenpho and A/O processes, recently developed and implemented in sewage plants have substantially improved this P recovery. This paper, focusing on A/O, describes the optimisation of this process in a laboratory-scaled single basin, by alternating sequences of aerobic and anaerobic phases.

Generally phosphorus is removed through thickened sludge, with an efficiency of ~30%. The remaining phosphorus is then removed using chemical additives, thereby adding to costs. High phosphorus content in the sludge makes it more suitable as fertiliser when agricultural spreading is permitted.

In this study anaerobic conditions lasting 15h were alternated with aerobic conditions of 9h duration. A synthetic wastewater was used following inoculation of an activated sludge (enriched with *Acinetobacter spp*) from the municipal treatment plant in Puntavagno, Genoa.

Results incorporated a residence time in order to allow biomass to adapt to high phosphorus levels. The process studied reduced the start-up time from 30 to 20 days, stabilised removal yield to 90% and prevented wash-out of suspended solids. It was concluded that the biomass fraction, which was unable to adapt to high phosphorus levels, becomes progressively eliminated. Results of continuous

phosphorus removal runs at 4 different feed phosphate concentrations (i.e. 18, 36, 68 & 100mg/l) show that P-accumulating microflora are able to completely metabolise phosphate as polyphosphate up to an influent phosphorus concentration of ~50mg/l. For P influent >50mg/l, phosphate removal yield eventually decreases up to 85%. Over 90mg/l the system tolerates phosphorus overload for no more than 10 days, after which the yield falls to zero.

The paper concludes that fixed and operational costs appear substantially lower due to the elimination of the separate aerobic vessel and by limiting aeration to only 40% of process time.

C.Sommariva, A.Converti & M.Del Borghi. Ref. Desalination, 108, (1996) pp255-260.

NETHERLANDS

HIGH NUTRIENT REMOVAL IN THE THREE-SLUDGE SEWAGE TREATMENT

This three stage concept combined a high-loaded activated sludge plant plus a settler for the biological removal of P, with two biofilm reactors for nitrification and denitrification. A pilot unit (2-3p.e.) showed that sufficient residence time for bacteria activity was critical in P removal (to 1mg/l) but that N reactors were relatively flow insensitive. A patent is pending.

The aim of this research carried out at Wageningen Agricultural University was to:

- determine maximum hydraulic load
- determine the effect of hydraulic peak loads
- evaluate economic prospects of the system

The pilot plant, for 2 to 3 p.e., was fed with raw domestic sewage. The hydraulic load of the plant was increased regularly and thus the hydraulic residence time (HRT) decreased. Real-life conditions were duplicated. Both the influent and effluent of each bioreactor were continuously sampled and, twice a week, on every third and fourth day, composite samples were analysed. The experiment was divided into 2 periods, each of 14 weeks.

Increasing hydraulic load, and thus decreasing HRT decreased the removal efficiency of the dephosphatating stage, although removal efficiencies remained stable in the second and third reactors. This implied that the first stage could be a limiting factor in this new concept.

The required effluent standards for N total and P total were easily achieved (respectively 10mgN/l and 1mgP/l). It was surprising to note that the concentration of suspended solids remained low (3mg/l), probably due to the filtration capacity of the carrier materials in the biofilm reactors. Total HRT was 10.4hrs, compared to 20hrs in conventional WWTPs.

Rainfall and day/night effects led to dramatic changes in the influent flow rate - during rainfall removal efficiency was satisfactory in the first period (2.5 times dry-weather flow) but in the second (3 times dry-weather flow) it decreased with the final mean preceding effluent concentration P-total at 1.8mg/l. However, high concentrations of P input (up to 25mg/l) were removed to a level lower than 2mg/l after passing through the 3 reactors, even during rainfall. This proves the system's good removal capacities. The system was also found to be very flexible since the biomass easily recovered from peak loads.

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Investment costs are lower or comparable to those of an ultra-low-loaded activated sludge plant. Operating costs are comparable and, moreover, this new technology could be a very interesting alternative if required space is considered (only about a third of the size of a conventional system for 100 000 p.e.). Costs of controlling odour problems were relatively low.

The next phase of the research is to scale up the system to a semi-technical scale (500 p.e.), focusing on removal efficiency and stability at full scale conditions. The final goal would be fully-sized operating plant in the near future.

*E.H.Marsman, P.J.Roeleveld & J.H.Rensink
Ref. Wat. Sci. Tech. Vol. 35, N°10, pp129-136,
1997.*

INTERNATIONAL

SECONDARY SETTLING TANKS (SSTs) THEORY, MODELLING, DESIGN AND OPERATION

Over the last 25 years the adverse effect of wastewater discharges on the aquatic environment has led to stringent legislation controlling treatment plant outputs. This International Association on Water Quality (IAWQ) report concentrates on improved activated sludge systems and the need to back this treatment stage with a well designed SST thereby ensuring effluent quality under fluctuating influent quality and quantity conditions.

This up-to-date manual covers international developments in SST design, practice and research since the 1970's. The targeted audience are principally engineers and

scientists involved in the design and operation of activated sludge WWTPs.

Activated sludge systems have been extended from organic carbon removal, to include N removal by nitrification and denitrification, as well as the removal of phosphates. The configuration of the system has, as a consequence, increased in complexity and the number of physical, biological and chemical processes and substances influencing effluent quality has expanded.

The SST plays a major role in achieving the increasingly demanding quality standards for ensuring the efficient "capture" of SS. At many WWTPs, improvements in effluent COD (BOD₅), total N and total P can only be achieved by reducing effluent SS concentrations. This can often be accomplished without the additional cost of effluent filtration through the simple improvement of SST design and operation in general and, in particular, by incorporating improved flocculation features.

*G.A.Ekama, J.L.Barnard, F.W.Günthert,
P.Krebs, J.A.McCorquodale, D.S.Parker &
E.J.Wahlberg. Scientific Technical Report (STR)
N°6, IAWQ, ISBN 1 900222 03 5, ISSN 1025-
0913, 1997.*

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The SCOPE Newsletter seeks to promote a better understanding of the sustainable use of phosphate and the rôle of phosphate in the Environment

The SCOPE Newsletter is open to input from its readers and we welcome all comments or information. Contributions from readers are invited on all subjects concerning phosphates, detergents, sewage treatment and the environment. You are invited to submit scientific papers for resume or full publication, to send comments on the studies mentioned in this Newsletter or other scientific or technical views:

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THE NETHERLANDS p.2

THE METABOLISM OF MICRO-ORGANISMS RESPONSIBLE FOR PHOSPHORUS REMOVAL

Micro-organisms, which are able to accumulate phosphorus as polyphosphate inside the cell, are widely used in enhanced biological phosphorus removal from wastewater. No pure culture, having the same characteristics, has yet been isolated. This paper shows that it is possible to use enrichment, as opposed to pure cultures, to understand, on a metabolic level, the complex dynamic stoichiometric and kinetic microbial mechanisms.

SWEDEN p.3

HUMAN WASTE RECYCLING

Human urine alone contains over 80% of the nitrogen and 60% of the phosphorus in household wastewater; furthermore it has very low levels of heavy metals. This report studies the practicalities of a urine collection system in a Swedish eco-village in order to recycle the urine for agricultural purposes, as a fertiliser; thus human waste can become a resource rather than a pollutant.

UNITED KINGDOM p.3

EVALUATION OF METHODS USED TO DETERMINE TDP IN SOIL SOLUTIONS

Due to a growing awareness of the significance of phosphorus transfer to water across soil boundaries, a simple, high quality method to monitor the movement of total dissolved phosphorus (TDP) is necessary. Analysis can be problematic due to trace concentrations of P in the presence of higher concentrations of a number of organic and colloidal fractions. This paper evaluates a number of methods used to determine TDP using leachate water from lysimeters with 10 different UK soil types. A final recommendation is made.

AUSTRALIA p.4

THE FILTER TECHNIQUE FOR SEWAGE EFFLUENT TREATMENT - PART 2

This report covers the planned trial application of the FILTER (Filtration & Irrigated cropping for Land Treatment & Effluent Reuse) technique in the Murray River Basin - first referred to in Newsletter 20. A 16 hectare pilot trial area is being leveled into irrigation bays to receive effluent from the Griffith Sewage Works.

DENMARK p.5

ALGAL BIOMASS REGULATION IN A SMALL LOWLAND STREAM

The role of invertebrate grazing, phosphorus concentration and irradiance in the regulation of benthic algal biomass on stones (some of which were treated with insecticide) were studied in a 3 year field experiment in a small Danish lowland stream.

GERMANY p.6

DAMMING OF THE DANUBE - EFFECTS ON BLACK SEA BIOGEOCHEMISTRY

Although damming is known to affect riverbourne nutrient loads and their ecosystems, effects in open coastal waters are less certain. In this report long term water and nutrient data from the River Danube to the Black Sea is presented. A decrease of two-thirds in the load of dissolved silicate in the river is revealed, with a corresponding shift in phytoplankton species away from diatoms.

U.S.A. p.7

LONG TERM RECORDS IN LAKE MENDOTA

Mean Secchi disk readings, covering the six seasonal periods for a large part of this century, plus other data, were used to assess the effects of nutrients and herbivory on water clarity in Lake Mendota, (3985ha, 25.3m max. depth).

FINLAND p.7

EFFICIENCY OF PHOSPHATE AND ZEOLITE BASED WASHING POWDERS

This study was undertaken to determine if phosphate and zeolite based detergent powders with differing physical properties were equally efficient at removing dirt under similar washing conditions.

SCOTLAND p.8

PROCEEDINGS FROM EDINBURGH CONFERENCE

The 1995 Edinburgh Conference, organized by the Scottish Environment Protection Agency, brought together agriculturists, scientific advisors, water pollution scientists and focused on issues relating to diffuse pollution from agriculture.- nitrates, phosphorus, pesticides plus the nature and effectiveness of the regulatory regime. A collection of the papers presented has been published.

THE METABOLISM OF MICRO-ORGANISMS RESPONSIBLE FOR PHOSPHORUS REMOVAL

Micro-organisms, which are able to accumulate phosphorus as polyphosphate inside the cell, are widely used in enhanced biological phosphorus removal from wastewater; the competitive advantage being their ability to use polyphosphate as an energy source for the uptake and storage of acetic acid. No pure culture, having these characteristics, has yet been isolated. This paper shows that it is possible to use enrichment, as opposed to pure cultures, to understand, on a metabolic level, the complex dynamic stoichiometric and kinetic microbial mechanisms.

The difficulty in obtaining a pure culture is due to the fact that enrichment procedures used are static. The organisms involved have a strong competitive advantage due to their ability to adapt to highly dynamic conditions. The theory, based around Phosphate Accumulating Organisms (PAO), was sufficient to empirically design and operate processes - but lack of knowledge means trial and error procedures are used in process designs, and causes of disturbance are difficult to detect. No pure culture has yet been reported to have the full range of characteristics equivalent to the behaviour of polyphosphate organisms in activated sludge.

Cultures enriched in the laboratory were used in the most successful studies. Sludge is exposed to anaerobic and aerobic conditions in sequencing batch reactors (SBR), with acetic acid only present during anaerobic periods thereby allowing growth of only those organisms capable of metabolising acetate in the absence of electron acceptors.

Stoichiometric coupling between ortho-phosphate release and acetate uptake under anaerobic conditions was noted in early studies. The organisms do not accumulate phosphate when substrate and electron acceptors are present - this could be the

vital indicator as to why the 'real' phosphorus removal organism has never been enriched.

A metabolic model able to describe conversion rates of all components involved in the process was developed. The main difference between oxygen and nitrate as an electron acceptor is the different efficiency of oxidative phosphorylation. The parameters necessary in a metabolic model are fewer than for a black box model. Model predictions were coherent with experimental results and mass balances over each experiment were closed, indicating that all components of the process are known and that the metabolism of the organisms could be described in terms of stoichiometrics and kinetics.

Storage polymers play an important role in natural ecosystems, which rarely have constant supplies of electron acceptors. There is a need to develop these dynamic selective enrichment techniques in the context of both microbial ecology and new processes in environmental biotechnology. For instance, substrate accumulation by micro-organisms of organic compounds from dilute waste flows could allow for these compounds to be reused (eg: methane gas digestion).

M.C.M. Van Loosdrecht, G.J. Smolders, T. Kuba & J.J. Heijnen. Ref.: Antonie van Leeuwenhoek 71: 109-116, 1997.

HUMAN WASTE RECYCLING

Human urine alone contains over 80% of the nitrogen and 60% of the phosphorus in household wastewater; furthermore it has very low levels of heavy metals. This report studies the practicalities of a urine collection system in a Swedish eco-village in order to recycle the urine to agriculture as a fertiliser; thus human waste can become a resource rather than a pollutant.

The toilets used were equipped with two bowls, for the separate collection of urine and faecal material, and with two separate flushing systems, requiring only a small volume of water to be flushed. The

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urine was piped to a collection tank, followed by a storage tank where it was sanitised and consequently

used as fertiliser for cereal crops. The source separation of urine can be added to any sewage system.

The purpose of the study was to measure the quantities of nutrients per person, daily, separated into the urine fraction, as well as the collection of heavy metals and faecal contamination in the collection system. The urine solution was analysed chemically each time to study how rapidly the urea dissociated to ammonium and carbon dioxide. The experiment was carried out in Understen eco-village on 44 apartments, 160 persons, during two consecutive 14 day periods. Each inhabitant filled in a form relating collection of urine, heavy metals and nutrients to the amount of time they spent at home (average 13.9 hrs per day). They were also asked if they were vegetarians (10%). The proportion of children (2-13 yr.) in this study was higher than in Sweden as a whole.

All factors considered, quantities of nutrients were close to those expected, indicating that 80-100% of the urine generated was correctly separated.. Dissociation of urea in the collection pipes was rapid, activated by the biofilm layer lining the pipes. A high proportion of nitrogen in urine is stored in the form of ammonium/ammonia and the pH-value, due to dissociation was high (9) - thus ventilation of the tank and collection pipes should be restricted to avoid ammonia emissions and losses. The urine contained 3.2 mg cadmium/kg phosphorus, a very low level compared to chemical fertilisers (~26 mg Cd/kg P) and sewage sludge (~55 mg Cd/kg P). Contamination with faecal material was low (~1mg faecal material/l urine solution) and flush water usage was diminished by 50 %. Source urine was thus considered to compare favourably with mineral fertilisers and other organic fertilisers of urban origin (eg. compost).

H.Jönsson, T.A.Stenström, J.Svensson and A.Sundin. Ref. Wat. Sci. Tech. Vol.35, N°9 pp, 145-152, 1997.

EVALUATION OF METHODS USED TO DETERMINE TDP IN SOIL SOLUTIONS

Due to a growing awareness of the significance of phosphorus transfer to water across soil boundaries, a simple, high quality method to monitor the movement of total dissolved phosphorus (TDP) is necessary. Analysis can be problematic due to trace concentrations of P in the presence of higher concentrations of a number of organic and colloidal fractions. This paper evaluates a number of methods used to determine TDP using leachate water from lysimeters with 10 different UK soil types. A final recommendation is made.

The study focused on the determination of TDP, passing through the 0.45 μm filter, including inorganic, organic and P attached to colloidal material. This determination allowed the difference between TDP and molybdate reactive P (MRP) to quantify dissolved, unreactive P in its various forms. Dissolved P in soil solution may also be important, contributing to eutrophication if mobilised to surface waters.

Soil was collected 7 days prior to analysis, from free-draining lysimeters at experimental sites, covering a range of different soil types, notably at: Great Dun Fell, Aber and North Wyke. Three methods were employed which used different digests with standard molybdate blue colorimetric determination: mild digestion (persulfate), peroxide-Kjeldahl and nitric sulphuric acid. In a fourth method inductively coupled plasma-optical emission spectrometry (ICP-OES) was utilised. Aqueous solutions were prepared containing nominal concentrations (100 mg PL⁻¹), and cooled to 4°C. On the day of analysis samples were prepared by 1000 fold to obtain a nominal concentration of 100 $\mu\text{g PL}^{-1}$. Each of the soil and synthetic solutions were replicated (n = 5).

Soil solution concentrations of TDP were significantly different ($P < 0.001$) between methods. Eight of the ten soils contained MRP concentrations below 100 $\mu\text{g L}^{-1}\text{P}$. AQUACHECK

(an interlaboratory sample exchange scheme) samples showed that data obtained by the ICP-OES method and persulfate methods were the most precise (%rsd=3%) but ICP-OES was not sensitive enough to use below 100 $\mu\text{g L}^{-1}$ P.

The nitric acid-sulphuric acid digestion method was slow and required constant attention. Recoveries for model compounds were erratic; soil solution was subject to high blank values and cross-contamination; poor reproducibility at trace concentrations was also a problem. These disadvantages highlighted the need for an alternative procedure for routine analysis.

In the peroxide-sulphuric acid digestion experiment AQUACHECK samples indicated that the method was not completely effective in recovering P. Overall the method was considered to be reasonably robust, although it was difficult to control the final stages to avoid superheating and volatilisation.

The persulphate digestion procedure, using sealed reaction vessels, was the mildest wet oxidation method evaluated. Advantages included control simplification plus reduced contamination compared with other methods, which use open vessels. The acidified conditions are less oxidising than the alkaline alternative, thus potential oxidation and interference from Mn^{2+} are avoided.

To summarize, the most important factors in obtaining accurate and precise estimates of TDP were the sensitivity of the procedure, simplicity of oxidation conditions, plus the ability to control the reaction, thus avoiding contamination. On this basis the persulfate digestion method was recommended.

A.P.Rowland & P.M.Haygarth. Jour. Environ. Qual. Vol. 26, N°2 pp.410-415, March-April 1997.

THE FILTER TECHNIQUE FOR SEWAGE EFFLUENT TREATMENT - PART 2

This report covers the planned trial application of the FILTER (Filtration & Irrigated cropping for Land Treatment & Effluent Reuse) technique in the Murray River Basin in Australia - first referred to in Newsletter 20. A 16 hectare pilot trial area is being leveled into irrigation bays to receive effluent from the Griffith Sewage Works.

The system was designed to reach EPA treated effluent targets by reducing phosphorus from 2-8 mg/L to less than 1mg/L and nitrogen from 20mg/L to less than 15mg/L by 1999 in a sustainable, efficient way. Although systems using artificial wetlands, cropping and woodlots are gaining popularity, they are expensive in large urban centres, due to costs involved in storing excess effluent during periods when crop and pasture growth is low. In addition, on slowly permeable soils, such as those in Eastern Australia, waterlogging and salinisation often occur.

A system was proposed whereby crops are grown over a network of sub-surface drains, thus combining irrigated cropping with filtration of effluent through the soil to a drainage system when cropping activity is low. The rate of sub-surface drainage could be regulated, ensuring sufficient nutrient removal and reaching target criteria.

Trials took place in 1994 (for details refer to Newsletter 20). Mean P concentrations fell by 98% to >0.5mg/L and N by 85% to >5mg/L. The applied effluent contained blue-green algae (Mycrocystis), whilst drainage waters were colourless and free of blue-green algae due to the increase in N:P ratio (as N:P falls below 12 so the risk of blue-green algae increases). Occurrence of downstream blooms was much less likely.

Other trials indicate the potential usage of the system to clean pesticide-contaminated run-off. Adapted versions of the system could be used to treat industrial and commercial effluent containing

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chemicals and heavy metals, or management of salinity problems in irrigation regions.

Encouraged by the success of the trials to date, a year-long commercial scale trial is planned. The pilot system will cover 16 ha of farmland, and, if successful, will be extended to 130 ha. This would be sufficient to handle Griffith's (18 000 pop) sewage effluent in time to meet the EPA's 1999 deadline, whilst generating 1000T/yr of high quality grain and hay.

B. Bennett. Ref.: Ecos, Winter 1997, pp 30-33.

ALGAL BIOMASS REGULATION IN A SMALL LOWLAND STREAM

The role of invertebrate grazing, phosphorus concentration and irradiance in the regulation of benthic algal biomass on stones (some of which were treated with insecticide) were studied in a three year field experiment in a small Danish lowland stream: Gelbaek stream in Jutland. Three experiments were carried out between March and August.

Inter-annual differences in peak-algal biomass were presumed to be due to differences in grazing pressure, with growth being further limited by a reduction in light from leaf vegetation proliferation on the banks in the summer. Three experiments were designed to determine:

- if invertebrate grazing in early spring could regulate algal biomass development
- if algal growth was phosphorus limited in spring
- if a fall in light due to leaf proliferation could limit algal growth thus determining the timing of peak biomass.

The invertebrate grazing experiment, conducted over 44 days in spring '92, used an aluminium frame, consisting of 4 troughs stocked with stones originating 20m upstream. Stones from two of the troughs were treated with an insecticide (Permethin). Nutrient concentrations were high (orthophosphate 33-117 $\mu\text{g l}^{-1}$). Algal biomass was

found to be regulated by invertebrate grazing. It was found that invertebrate scrapers could regulate algal biomass accretion and suggested that *A. fluviatilis* was largely responsible for invertebrate grazing pressure. The density of this snail on untreated stones and stones treated with insecticide varied by 50 %. Algo-biomass increased significantly on the insecticide-treated stones.

The phosphorus enrichment experiment was conducted over 35 days in spring '91: an inorganic phosphorus solution, from a butt on the bank, was continuously added to 3 troughs, whilst 3 others served as controls. Algal biomass development on stones was not found to be phosphorus limited during the spring algal bloom, and thus could not be controlled by nutrient limitation.

The irradiance experiment was carried out over 70 days in summer '91: two reaches, one shaded and one not, were used, and stocked with non-colonised stones; 10 from each reach were sampled biweekly to monitor algal biomass and scraper density. A very low biomass accumulation occurred in the shaded reach, whilst a peak of 800mg chlorophyll m^{-2} occurred after 6 weeks in the non-shaded reach.

It was concluded that invertebrate grazing can prevent significant increases in algal biomass despite a surplus supply of nutrients. Reduced light conditions, either from an overhead canopy or self shading, also play a part in limiting algal biomass increase. Insecticides, it was shown, may have the reverse effect of permitting algal growth due to reduced grazing input. Algal biomass regulation can be considered as a complex interaction of top-down and bottom-up mechanisms.

K. Kjeldsen Ref.: Freshwater Biology (1996) 36, 535-546.

DAMMING OF THE DANUBE - EFFECTS ON BLACK SEA BIOGEOCHEMISTRY

Although damming is known to affect riverbourne nutrient loads and their ecosystems, effects in open coastal waters are less certain. In this report long term water and nutrient data from the River Danube to the Black Sea is presented. A decrease of two-thirds in the load of dissolved silicate in the river, was revealed, with a corresponding shift in phytoplankton species away from diatoms, since dam constructions in the early '70s. Results show that the biogeochemistry of the entire Black Sea basin has been altered.

Dams can reduce nutrient loads due to the removal of nutrients to reservoir sediments ('the artificial-lake effect'). Although this removal could be compensated for by anthropogenic nitrogen and phosphorus inputs downstream, no such compensation has been observed for silicate. Median silicate concentration ($58\mu\text{M}$) in the Danube for the period 1979-92 is considerably lower than for the pre-construction period 1959- 60 ($140\mu\text{M}$). In winter, concentrations of silicate in coastal waters 1960-92 fell from $55\mu\text{M}$ to $20\mu\text{M}$, after the dam was built. Nutrient concentrations on the coast were also influenced by the Danube - though nitrogen and phosphorus were only slightly affected by coastal sources. The dramatic fall in the Si:N ratio (42 to 2.8) can be accounted for by the increase in dissolved organic nitrogen from increased inputs from the Danube. This change in nutrient inputs has led to a dramatic shift away from diatoms to coccolithophores and flagellates (non-silica based): increases of a factor of 2.5 and 6 were noted respectively. It can be assumed that a large part of the increase in nitrogen loads after damming of the Danube are being, and will be, removed by non-diatom species. The effect of the decrease in silica was also observed in the Black Sea.

The occurrence of toxic flagellate blooms may become more widespread - to the central Black Sea - as observed in other coastal areas. Effects of altered

silicate inputs, overfishing plus the introduction of alien species, have yet to be studied.

Similar dam constructions world-wide (more than 36 000) should now be examined for their possible influence on food web structure in closed seas, lakes and rivers since these effects could be of global consequence.

C.Humborg, V.Ittekkot, A.Cociasu & B.V.Bodungen.
Ref.: Nature, Vol. 386, 27 March 1997, pp. 385-388.

LONG TERM RECORDS IN LAKE MENDOTA

Mean Secchi disk readings, covering the six seasonal periods for a large part of this century, plus other data, were used to assess the effects of nutrients and herbivory on water clarity in Lake Mendota, Wisconsin, (3985 ha, 25.3 m max. depth).

The control of phytoplankton blooms and the role nutrients and zooplankton play is not fully understood. This study seeks to understand if, in the long term, grazing can improve water clarity in a large eutrophic lake, at varying nutrient levels. The lake has a history of algal blooms since at least the late 1800s. It has been subject to increased phosphorus loading rates during this century.

Readings were divided into 6 seasonal periods distinguished by a number of precisely defined criteria. It was found that despite different nutrient-herbivory interactions the summer algal blooms had not increased since 1900. Water clarity was at its greatest from spring turnover through to autumn destratification, corresponding to the time when herbivory levels were high. Indications are that lake size and trophic status do not prevent lakes from achieving increased water clarity from biomanipulation that increases herbivory. Grazer effects on water clarity can be seen over a long period, and, in principle, there may be no time restriction on grazers' capacity to control phytoplankton. In practical terms, however, sustained biomanipulation may be problematic. The

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authors conclude that management programmes involving P reduction and biomanipulation may be more effective than if only one technique is used on its own.

R.C.Lathrop, S.R.Carpenter and L.G.Rudstram. Ref.: Can. J. Fish. Aquat. Sci 53:2250-2261. 1996.

EFFICIENCY OF PHOSPHATE AND ZEOLITE BASED WASHING POWDERS

This study was undertaken to determine if phosphate and zeolite based detergent powders with differing physical properties were equally efficient at removing dirt under similar washing conditions.

Results were correlated in terms of whiteness, redness and blueness, as well as detergent residues in the materials and the washing machines.

Smaller particle zeolites-based detergents did not wash as well as larger particle detergents and the former left more residue. New clothes with coarse fibres had the most residues.

It was found that phosphate based detergents left significantly less residue and increasing the number of washes did not have any effect on the amount of phosphate residues left. This discrepancy was all the more apparent when energy saving washing machines using less water and mechanical input were used.

Residues imply possible irritation and sensitivity for the user, which could be minimised by using phosphate-based detergent powders.

H.Aino. Ref.: Master's Thesis, University of Helsinki, Faculty of Agriculture and Forestry, May 1997.

PROCEEDINGS FROM EDINBURGH CONFERENCE

The 1995 Edinburgh Conference, "Diffuse Pollution and Agriculture", organised by the Scottish Environment Protection Agency, brought together agriculturists, scientific advisors, water pollution scientists and focused on issues relating to diffuse pollution from agriculture - nitrates, phosphorus, pesticides plus the nature and effectiveness of the regulatory regime. A collection of the papers presented has now been published.

These conference papers provide an up-to-date account, and a perceptive insight, into a growing environmental problem in agriculture.

The presentation of the papers led to a good debate and the establishment of a strong rapport amongst participants. Emphasis was on future actions and it was agreed that research into practical solutions, co-operation at all levels and the formation of partnerships were the only way to bring about lasting change and improvement. Evidence of strong commitment to the debate has been witnessed since, through both follow-up research on nitrates, and the establishment of partnerships aimed at the application of new farming methods.

A follow-up regional conference is planned in 1997 ensuring that the original impact of this first conference was sustained.

Edited by T.Petchey, B.D'Arcy and A.Frost, The Scottish Agricultural College, 1996, ISBN 1 85482 575 5.

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The SCOPE Newsletter seeks to promote a better understanding of the sustainable use of phosphate and the role of phosphate in the Environment

The SCOPE Newsletter is open to input from its readers and we welcome all comments or information. Contributions from readers are invited on all subjects concerning phosphates, detergents, sewage treatment and the environment. You are invited to submit scientific papers for resume or full publication, to send comments on the studies mentioned in this Newsletter or other scientific or technical views:

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SELECTIVE REMOVAL AND RECOVERY OF PHOSPHATE USING A NEW CLASS OF SORBENTS - II - PROCESS OPTIMISATION

The main processes concerning the precipitation of calcium phosphate in a fluidized bed were established (see Newsletter 22). An optimisation of the phosphate removal efficiency was attempted, in this second paper, by focusing on the aggregation process.

THE NETHERLANDS

p.2

ENVIRONMENTAL IMPACTS OF NUTRIENT REMOVAL PROCESSES

The influence of primary clarification of sewage on nitrogen and phosphorus removal was studied, in a modified University of Cape Town type wastewater treatment plant (WWTP), using batch tests, on a full scale, before and after the introduction of raw sewage. Both the effect on the activated sludge population and the overall environmental impacts were studied.

THE NETHERLANDS

p.3

EFFECTS OF ANIMAL WASTE APPLICATION TO SANDY SOILS ON DOP LEACHING

A substantial part of total P in soil solution and leachates can exist as dissolved organic phosphorus (DOP), which may be more mobile than inorganic orthophosphate and so be an important P source for surface water eutrophication. The analysis of DOP has not been included in many field studies, nor included in models developed to predict the movement of P through the soil. This paper focuses on four experiments to investigate the effects of pig waste application to sandy soil on DOP leaching.

INDIA

p.4

RECLAMATION OF EUTROPHIC WATERS: NUTRIENT REMOVAL BY WATERHYACINTH

A vast number of tropical pond wetlands are no longer suitable for fish culture in India. Sophisticated ecotechnological models used for control of eutrophication in advanced countries are not suitable in the small, shallow ponds used for fish farming in developing countries. The use of biological agents is ecologically significant due to their ease of handling and as component members they may cause less perturbation. Nutrient removal capacity of waterhyacinth was studied.

FRANCE

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DIFFERING EUTROPHICATION GRADIENTS IN COASTAL LAGOONS

Eutrophication conditions are described in three lagoon systems, differing in structure, catchment and connection with the sea: the Bassin d'Arcachon on the Atlantic coast, SW France, the semi-artificial fish ponds of the Bassin d'Arcachon and the Etang du Prévost on the Mediterranean coast.

AUSTRIA

p.5

PHYSIOLOGICAL ADAPTATION PROCESSES TO CHANGES IN THE ENVIRONMENT

The properties of the phosphate uptake system of the cyanobacterium *Anacystis nidulans* were studied during the transition from a phosphate-deficient non-growing state to a non-deficient growing state. The paper is a detailed scientific study of the various physiological adaptation processes by which organisms react to changes in their environment.

POLAND

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SUBSTITUTION OF POLYPHOSPHATES IN POPULAR POLISH DETERGENTS

This paper describes the possible impact of certain substitutes of polyphosphates (NTA, EDTA) in detergents, on the environment. EDTA is reported as non-biodegradable, this, coupled with a high chelating capacity may cause mobilisation of heavy metals from sediments. NTA is essentially biodegradable though there is evidence of non-biodegradable complex carry over.

UNITED KINGDOM

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CLEANING UP THE THAMES ESTUARY

A 69 page report "The Water Quality of the Tidal Thames", published by the Environmental Agency covers in detail the recovery of the Thames Estuary, from a heavily polluted catchment to one of the cleanest metropolitan estuaries in the world. No phosphate restrictions were required.

PLUS...

p.7

THE PHOSPHATE FILE :

An informative booklet covering phosphate source, use and fate in the environment.

**SELECTIVE REMOVAL AND RECOVERY OF
PHOSPHATE USING A NEW CLASS OF
SORBENTS - II - PROCESS OPTIMISATION.**

The main processes concerning the precipitation of calcium phosphate in a fluidized bed were established (see Newsletter 22). It was suggested that an improvement in the phosphate removal efficiency from 60% to 80% may be achieved if process conditions are found favouring aggregation, molecular growth, or preferably both. Thus an optimisation of the phosphate removal efficiency was attempted, in this second paper, by focusing on the aggregation process.

Experiments with a fluidized bed preceded by a pre-mixing reactor as well as without pre-mixing were carried out.

In the first case the aggregation of the fines with the grains in a fluidized bed was studied. A set-up was designed to isolate the aggregation from other processes and mathematically modeled to take into account two competing mechanisms: orthokinetic aggregation and breakage. In the second case (i.e. normal operation of a fluidized bed) experiments with a spread type dosage were also performed. Both experiments are described in the paper. In the fluidized bed preceded by a pre-mixing reactor it was found that the aggregation model gives a fairly accurate prediction of the measured efficiency for both types of grains (fine and coarse sand) over the complete range of the total flow despite the spread in experimental data, it also showed that small grains and a low throughput favour a high aggregation efficiency.

In the fluidized bed with the base dosage at the bottom, reactants were mixed with NaOH dosage and a high local supersaturation was obtained. Predicted efficiencies were too low suggesting processes other than aggregation. Most of the phosphate removal occurred at the bottom of the bed. Phosphate removal efficiencies due to aggregation were equal to ~ 60% and to molecular growth of ~ 40%.

By spreading the base dosage between at least two additional points a non-negligible supersaturation is sustained for a longer period of time, improving phosphate removal efficiency by increasing both net aggregation and molecular growth. Deviations in the model predictions were thought to be due to the contribution of the inlet stream kinetic energy to the total energy dissipation rate, suggesting that a high energy dissipation rate is detrimental to phosphate removal.

In conclusion, optimisation was achieved by selecting sand grains of small sizes (0.1-0.3 mm), a low superficial velocity (7×10^{-3} m/s) and by spreading the base addition over two locations. The highest phosphate removal efficiency was found to be 0.8 for a conversion of 0.25 after the first base dosage. The phosphate removal efficiency can be further improved by lowering the mixing intensity at the bottom of the reactor.

*Wat. Res. Vol.30. N°7 pp.1589-1596, 1996.
M.M.Seckler, M.J.L. Van Leeuwen, O.S.L.Bruinsma
and G.M.Van Rosmalen.*

**ENVIRONMENTAL IMPACTS OF NUTRIENT
REMOVAL PROCESSES**

The influence of primary clarification of sewage on nitrogen and phosphorus removal in a modified University of Cape Town type wastewater treatment plant (WWTP) was studied, using batch tests, on a full scale before and after the introduction of raw sewage. The effect on the activated sludge population and the overall environmental impacts were studied.

A WWTP in Holten, The Netherlands, is designed as a modified University of Cape Town type treatment plant, operated with presettled sewage. The primary sludge (including precipitated phosphorus) and the secondary sludge is digested. The treatment plant consists of anaerobic, anoxic, and aerobic zones, and primary and secondary clarifiers. Presettled wastewater is introduced into the anaerobic zone. Return sludge from the secondary clarifier is recirculated to the start of the anoxic zone. Mixed liquor in the anoxic zone is

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recirculated to the start of the anaerobic zone. The WWTP is operated at a long sludge retention time (SRT) of 45 days, and the following batch tests were carried out:

- Anaerobic phosphorus release tests
- Aerobic phosphorus uptake tests
- Anoxic phosphorus uptake tests
- Anoxic phosphorus release tests

Before the introduction of raw sewage the maximum released phosphorus was approx. 30 mg P/g volatile suspended solids (VSS): this figure fell to 14 mg P/g VSS after the introduction. The proportion of phosphorus-removing organisms in total biomass decreased from approx. 30-50% to 15-20%. Before and after the introduction of the raw sewage the contribution of denitrifying dephosphatation was similar, approx. 40-45% of total activity - indicating that denitrifying dephosphatation still contributed significantly to phosphorus removal after the introduction. The phosphorus release rate was, however, much lower under anoxic conditions than under anaerobic conditions. The nitrification efficiency fell from 84% to 73%, probably due to a decrease of SRT. Less nitrate was formed in the effluent, although the nitrogen balance indicated that the improvement was due to extra nitrogen assimilation because of extra sludge production. Net energy consumption rose (+75%) mainly because of the sludge handling but also in view of the decrease (-45%) in methane production in the digester.

It is questionable whether the improved effluent quality imposed by government regulations obtained by changing to raw sewage feeding had an overall positive effect on the environment. This work shows that evaluating treatment processes only on effluent quality can lead to overall adverse effects on the environment.

Journal of Environmental Engineering Vol. 13, N°1, Jan. 1997 pp 33-40. M.C.M. Van Loosdrecht, T.Kuba, H.M. Vn Veldhuizen, F.A.Brandse, J.J.Heijnen.

THE EFFECTS OF ANIMAL WASTE APPLICATION TO SANDY SOILS ON DOP LEACHING

A substantial part of total P in soil solution and leachates can exist as dissolved organic phosphorus (DOP), which may be more mobile than inorganic orthophosphate and so be an important P source for surface water eutrophication. The analysis of DOP has not been included in many field studies, nor included in models developed to predict the movement of P through the soil. This paper focuses on four experiments to investigate the effects of pig waste application to sandy soil on DOP leaching.

- **Exp. 1** examined the effect of storing pig slurry on DOP fractionation using gel permeation chromatography.
- **Exp. 2 & 3** studied immediate and long term effects of animal waste application to soil in both laboratory columns and outdoor maize-grown lysimeters (four treatments in triplicate for 7 yr.).
- **Exp. 4** examined concentrations of DOP and total P (TP) in soil solutions at various depths in a long term field experiment, between 1971 and 1982.

The following hypotheses were tested:

1. DOP is a significant fraction of TP in leachates and in the soil solution, and this fraction increases with increasing soil depth.
2. DOP is a larger fraction of TP in soils heavily supplied with slurry than soils only receiving mineral fertilisers.

A large amount of molybdate reactive P (MRP) was found in high molecular weight (MW) material from pig slurry liquid. The MRP probably originated from acid hydrolysis during the analysis. This can cause an underestimation of DOP content in fresh pig slurry.

In a manured sandy soil column more than 90% of P leached was present in the organic form. Results of the field experiment showed that DOP fraction makes up the largest part of TP in soil solutions below 50cm depth. Thus the first hypothesis was found to be correct. However the second hypothesis was rejected.

SUBSTITUTION OF POLYPHOSPHATES IN POPULAR POLISH DETERGENTS - ENVIRONMENTAL IMPLICATIONS

This paper describes the possible impact of certain substitutes of polyphosphates (NTA, EDTA) in popular Polish detergents on the environment. EDTA is reported as non-biodegradable - this coupled with a high chelating capacity may cause mobilisation of heavy metals from sediments. NTA is essentially biodegradable though there is evidence of non-biodegradable complex carry over.

The contribution of phosphorus from detergents to total phosphorus load in wastewater is approx. 30-50%. Substitutes are proposed by the producers of commercial washing powders/liquid detergents: i.e. zeolites and organic chelating ligands - ethylenediaminetetraacetic acid (EDTA) and nitylotriamineacetic acid (NTA). Studies show that none of them are as efficient as tripolyphosphates, nor are they neutral for the environment.

Levels of EDTA and NTA in raw domestic sewage were measured at each step of the treatment process in Hajdów (near Lublin) in Poland in 1994. The contents of EDTA and NTA in popular washing powders and liquid washing-up detergents (both Polish and imported) were verified. Hajdów is a mechanical-biological treatment plant, with no chemical stage, typical of municipal sewage treatment plants in Poland. It caters for the Lublin (400 000 inhabitants) and Swidnik (20 000 inhabitants) communities.

Studies show that no polyphosphates are found in the raw sewage thus only data for EDTA and NTA was presented. NTA was not found in the raw sewage although the most common powder and the least common (due to its high price) concentrate powder contain large amounts of NTA. Waste from industry may dilute the stream at the entrance to the plant so NTA was not detected. Results for EDTA were very different : almost all washing-up liquids contained EDTA, except a liquid produced in Western Europe, advertised as "environmentally friendly". Results for powders varied, the concentrate powder contained highest levels of phosphates and chelates and was the only product containing EDTA and NTA. The powder

advertised as "phosphate free" contained 2.55g/kg of phosphates in the orthophosphate form and high levels of EDTA. EDTA was found in the raw sewage - the level did not decrease as it passed through the treatment plant.

EDTA is a strong complexing agent for divalent and polyvalent metals. In Poland, industrial wastewater is often mixed with municipal wastewater after primary pre-treatment. Naturally heavy metals forming strong complexes with EDTA ligands are found at low concentrations. Higher concentrations of Ca and Mg may occur but Ca-EDTA and Mg-EDTA have stability constants a few orders of magnitude lower.

The paper concludes that "phosphate free" (i.e. free from polyphosphate but not from inorganic phosphorus) detergents are not neutral for the environment. Stable chelating ligands may cause mobilisation of heavy metals from sediments. To prevent unexpected effects in the water environment, limitations of non-degradable chelates is necessary. The EDTA/NTA complex interaction with heavy metals in soil and water environments merits further careful study.

Chemistry for the Protection of the Environment 2 edited by Pawlowski et al, Plenum Press, New York, 1996. M.R.Dudzinska & A.Montusiewicz.

CLEANING UP THE THAMES ESTUARY

A 69 page report entitled "The Water Quality of the Tidal Thames" has been published by the Environment Agency. It covers in detail the recovery of the Thames Estuary, from a heavily polluted catchment to one of the cleanest metropolitan estuaries in the world. No phosphate restrictions were required to manage the 14 000 km² area with 12 million population.

The recovery was achieved by the restoration of water quality. The most important factor in water quality control in the Thames is dissolved oxygen and improved sewage treatment standards, particularly under summer conditions in order to ensure adequate oxygen reserves i.e. 30% saturation..

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Eutrophication was not considered to be a problem in the main body of the estuary due to strong tidal flows, salinity variations and high turbidity, precluding the development of significant algal blooms, although algal blooms have occurred in some enclosed waters, e.g. London Docks. Phytoplankton were considered to be important in their capacity to convert inorganic material to organic matter, oxygenate water through photosynthesis and deoxygenate through respiration and decomposition. This remarkable recovery has supported over 115 species of fish and nearly 300 000 seasonal water birds.

The challenge now is to ensure that this achievement is maintained and built upon. As the Thames Estuary Environment Management Plan recognises "nowhere in the country are environmental pressures and competing demands for space and resources greater than on Thameside". To achieve "an Estuary which is valued as a place to live, work and relax: an environmental asset and a focus for economic growth" it is vital that resources are managed in a sustainable way.

"The Water Quality of the Tidal Thames", Environment Agency Report 1997, ISBN 0 11 31025 2.

**THE PHOSPHATE FILE :AN INFORMATIVE
BOOKLET COVERING PHOSPHATE SOURCE,
USE AND FATE IN THE ENVIRONMENT**

The Centre Européen d'Etudes des Polyphosphates (CEEP), a CEFIC sector group representing the European Phosphate producers, have recently published a 14 page booklet entitled « Phosphate-File ».

Both clear and concise, this booklet was prepared as an informative study of phosphate and the environment. From its geographical extraction sites, its nutritional impact, its uses in agriculture through to an in-depth study of phosphate in the environment, the « Phosphate File » covers all aspects related to this valuable resource. Moreover with global development, the need for phosphorus is expected to increase in agriculture and industry thereby placing constraints on this valuable finite resource.

Analysing the interactions between phosphates and water quality, the « Phosphate-File » lays out the need for improved sewage recovery as a means not only to retain phosphorus but to recover and reuse both directly as a rich fertiliser or, utilising new extraction techniques, return it as a raw material for detergent and other product applications. Clearly this element which is not replaceable and essentially rare lends itself ideally to the principle of sustainable development. Thus, what is already considered the most effective builders in detergents would also become the most environmentally adaptable.

« Phosphate File » 14p. 1997, order directly from SCOPE Newsletter or CEEP, Avenue Van Nieuwenhuysse 4. Bte 2-b- 1160 Brussels, Belgium.

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IN EUROPE

NUMBER TWENTY TWO

JULY 1997

U.S.A **p.2**

SELECTIVE REMOVAL AND RECOVERY OF PHOSPHATE USING A NEW CLASS OF SORBENTS

A new class of sorbents - polymeric ligand exchangers (PLE) - have been tested in a fixed bed column allowing the selective removals of phosphate through ligand type interaction. The sorbent is also amenable to efficient regeneration and phosphate can be recovered as magnesium ammonium phosphate (struvite), a high value fertiliser.

THE NETHERLANDS **p.2**

CALCIUM PHOSPHATE PRECIPITATION IN A FLUIDIZED BED : A BLACK BOX APPROACH.

This paper studies the precipitation features of calcium phosphate in a fluidised bed reactor in a concentration range between 5 and 10 mg P/l and establishes the conditions for optimum phosphate removal efficiency. A method is presented to select process conditions where co-precipitation of unwanted phases is avoided.

UNITED KINGDOM **p.3**

MONITORING OF SOIL DERIVED PHOSPHORUS IN SURFACE RUNOFF

This paper examines the rates of P transfer from soil to waters from intensively managed grazed grassland by surface runoff plus interflow to 30 cm depth, in a poorly drained soil, in relation to rainfall inputs during 12 months. It concludes that grasslands are a significant source of diffuse P inputs to surface and estuarine waters and may cause eutrophication.

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PHOSPHATE & NITROGEN INFLUENCE FISH STOCKS

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DRAMATIC CHANGES IN SURFACE WATERS DUE TO IRON ENRICHMENT EXPERIMENT

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FOOD WEB INTERACTIONS AND BIOMANIPULATION

The control of phytoplankton biomass in several Australian reservoirs was studied. Food web interaction of Australian biota were explored at different levels. In order to manipulate fish communities to reduce phytoplankton biomass a thorough understanding of the process in the plankton-associated food web is needed.

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ENVIRONMENTAL FACTORS AND NUTRIENT REGULATION IN NATURAL WATERS

This review seeks to identify the key areas in aquatic science required for future management of algal problems in freshwaters.

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SUCCESSFUL WATER PROTECTION MANAGEMENT

Lake Zurich, Lake Walenstadt and the Zurichobersee make up a connected system of lakes with differing population densities, geographical and meteorological conditions making them suitable for studying the effectiveness of water protection measures.

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**RECENTLY PUBLISHED REPORT -
"PHOSPHORUS REMOVAL AND RECOVERY TECHNOLOGIES"**

NORDIC ECO-LABELLING SCHEME OPEN FOR PHOSPHATE BASED DISHWASHING DETERGENTS

**IAWQ VIDEO "NATURE'S WAY"
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NEW WEBSITE FOR ENVIRONMENTAL INFORMATION

SCOPE is a non-commercial, non-profit making European association based in Brussels.

Its aim is to provide a platform for objective and scientific information on the effects of phosphate-containing and phosphate-free detergents on the environment.

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produced by European Communications Unit - 20, rue de l'Arcade - 75008 PARIS - FRANCE - Tel. + 33 1 44 94 80 70

SCOPE : Scientific Committee on Phosphates in Europe - Association Sans But Lucratif sise à Bruxelles et soumise à la Loi du 27 juin 1921

SELECTIVE REMOVAL AND RECOVERY OF PHOSPHATE USING A NEW CLASS OF SORBENTS

The presence of various competing anions make the selective removal of low concentrations of phosphate after secondary treatment particularly difficult. In this research a new class of sorbents - polymeric ligand exchangers (PLE) - have been tested in a fixed bed column allowing the selective removal of phosphate through ligand type interaction. The sorbent is also amenable to efficient regeneration and phosphate can be recovered as magnesium ammonium phosphate (struvite), a high value slow-release fertiliser.

Phosphorus can be removed through either chemical precipitation or biological nutrient removal (BNR), and transferred to the sludge phase.

4 successive column runs were carried out in the laboratory using treated wastewater from the Bethlehem Sewage Treatment Plant in Pennsylvania, U.S.A. The objective was to validate:

- * PLE's high affinity with phosphate compared to sulphate
- * extended column runs with complete phosphate removal with synthesised wastewater and secondary effluent
- * regeneration of the exhausted column for phosphate recovery.

A specially chelating polymer containing only nitrogen donor atoms (DOW N2) was used as PLE after loading with copper (II) and 2 other commercially available resins - IRA-958 (a strong base anion exchanger) and IRC-718 (a copper loaded chelating exchanger). were used for comparison. The resins were conditioned following the standard procedure of cyclic exhaustion, and the following chemical analyses were carried out: sulphide, chloride, phosphate, bicarbonate, copper and TOC analyses.

The breakthrough histories were measured and the influent compositions, pH and operating hydrodynamic conditions - empty bed contact time (EBCT) and superficial liquid velocity (SLV) were identical for each of the 3 sorbents. The phosphate breakthrough for DOW 2N-Cu occurred much later than for the other sorbents, in spite of high concentrations of competing bicarbonate, sulphide and chloride. DOW 2N-Cu also offered much higher phosphate uptake capacity than IRA-958. Total anion exchange capacity was found to be equal to the copper (II) loading capacity of DOW 2N, suggesting that fixed copper (II) anions in the polymer provide the primary sorption site for anions.

Following exhaustion of PLE after phosphate breakthrough more than 90% phosphate was recovered in less than 10 bed volumes - both electroselectivity reversal at high ionic strength and lower affinity of $H_2PO_4^-$ - compared to HPO_4^{2-} provide the reasons for efficient phosphate regeneration.

Phosphate is an anionic ligand and its sorption onto DOW 2N-Cu involves electrostatic interaction due to fixed positive charges in the polymer phase and accompanying lewis acid-base interaction with immobilised copper ions.

It has been demonstrated that a new fixed-bed sorption process is capable not only of removing phosphate selectively from municipal and industrial wastewater but is also amenable to efficient regeneration leading to phosphate recovery. With the current concern over nutrient removal from wastewater and water reuse, the process is expected to be an economically viable one in the near future. *Water Science Tech. Vol. 33 1996 Department of Civil and Environmental Engineering 13E Packer Avenue, Lehigh University, Bethlehem, PA 18015, U.S.A. Dongye Zhao and Arup K. Sengupta.*

CALCIUM PHOSPHATE PRECIPITATION IN A FLUIDIZED BED : A BLACK BOX APPROACH

Emphasis in recent years has been focused on improving processes which lead to enhanced phosphate recovery - this paper studies the precipitation features of calcium phosphate in a fluidised bed reactor in a concentration range between 5 and 10 mg P/l and establishes the conditions for optimum phosphate removal efficiency. The feasibility of a process based on the precipitation of magnesium phosphate was shown for waters with a low calcium content. A method is presented to select process conditions where co-precipitation of unwanted phases is avoided.

Currently several processes for phosphate removal based on the precipitation of phosphate salts are used - conventionally a reagent is added to precipitate phosphorus salt, which becomes incorporated in the sludge by-product.

A screening study of a fluidised bed process with high inlet phosphate concentrations was carried out, by varying conditions such as the inlet concentrations of calcium and phosphate and the outlet. Phosphate removal efficiency, mechanical stability of the phosphate grains and the effects of carbon and magnesium ions (which can interfere in the process) were determined.

The process is based on a precipitation of calcium phosphate obtained by mixing a phosphate solution with calcium ions and a base. The fluidised bed

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reactors (of 2 different sizes, which did not appear to affect the process) were filled with sand grains and then fed continuously with aqueous solutions containing phosphate ions, calcium ions and a base. Phosphate covered grains were removed from the bottom of the bed and replaced regularly with fresh sand grains. At the same time two unwanted processes occurred leaving small particles ("fines"): primary nucleation in the liquid phase and abrasion of the mineral layer in the bed. The fines leave the bed with the remaining phosphate not recovered in the reactor. However aggregation with the fines and the grains can contribute to phosphate recovery. The concentrations of P, Ca, Mg and Na were measured - total carbonate concentration was measured by acid-base filtration, fine and grains by X-ray diffraction, the grains were also analysed by optical microscopy and scanning electron microscopy (SEM). The grains and fines produced appeared to be amorphous calcium phosphate (ACP) except for one experiment at the highest P concentration where DCPD (dicalcium phosphate dihydrate) was formed.

Optimum conversion is the one corresponding to maximum efficiency - if water does not contain magnesium or carbonate ions the supply of the base should promote conversion of 50-60% of the incoming phosphate: the presence of these ions increased these values to 80-95% - most wastewaters are in this latter category. Low conversion values are desirable as they imply low base consumption (an important element when considering operating costs). The amount of base needed to obtain the required conversion can be calculated if the composition of the water to be treated is known. Corresponding outlet pH values were 7.5-9.

It was concluded that phosphate removal efficiency in a fluidised bed reactor depends on composition of the water treated: a maximum efficiency of 50% was achieved. This corresponded with a low phosphate input. *Wat. Res. Vol.30, N°7, pp 1677-1685 Laboratory for Process Equipment, Delft University of Technology, Leeghwaterstraat 44, 2628 CA, Delft, The Netherlands & IPA P.O.Box 7141, Cidade Universitária, 01064-970, São Paulo S.P. Brazil. M.M.Seckler, O.S.L. Bruinsma & G.M. Van Rosmalen, January 1996.*

MONITORING OF SOIL DERIVED PHOSPHORUS IN SURFACE RUNOFF

This paper examines the rates of P transfer from soil to waters from intensively managed grazed grassland via surface runoff plus interflow to 30 cm depth, in a poorly drained soil, in relation to rainfall inputs during 12 months. In order to gain an understanding of the mechanisms involved total phosphorus (TP) and molybdate reactive phosphorus (MRP) are considered with temporal differences in runoff discharge. It concludes that

grasslands are a significant source of diffuse P inputs to surface and estuarine waters and may contribute to eutrophication.

Seven 1 ha grazed lysimeter plots managed for the past 12 years as intensive grassland at North Wyke, Devon were monitored. The existing sward is dominated by *Lolium perenne* L and other grass species. The soil is a clayey non-calcareous pelostagnogley of the Hallsworth Series. Before analysis water was collected from each plot lysimeter and channelled through a continuous level recording reservoir and then through V-notch weirs. The plots were managed for N studies, but this involved inputs of triple super phosphate (TSP) fertiliser. An observational/empirical approach was used, involving both routine and storm monitoring. Modelling the data was difficult as they were skewed by the occurrence of low frequency, high intensity events.

Higher discharge was associated with higher TP concentration although this was not the case for MRP, implying that unreactive P and particulates > 0.45 µm in size play a major role in the export of TP. Thus mechanisms such as hydrolysis and mineralisation of organic P and erosion of particulate P may be important processes for releasing P from these soils. Patterns of TP concentration and loading and suspended sediment throughout the period of hydrograph were more complex. The delayed peak in TP concentration was associated with the second peak in the suspended sediment, suggesting that sediment transfer rather than water movement, as such, was important. More research is needed to understand the dynamics of P runoff, particularly when it is transferred from the soil surface into surface drainage systems.

Release of high concentrations of TP and MRP (exceeding 1000 µg l⁻¹) are thought to relate to pasture conditions at that time. It was suggested that 3 factors were responsible:-

* short term management history - excreta are a direct source of P and have long term effects on the EPC in soils, but the design of the drainage/sampling system did not reflect localised nutrient concentration from excreta. Introduction of cattle may also have resulted in "poaching" - both dung deposits and poaching were prevalent around drink troughs and gateways in the plot lysimeters - slurry application and grazing during periods when the soil was close to saturation lead to much higher losses of P than during dry periods. The release of P may have been exacerbated by the wetting and drying cycle.

* rainfall intensity - high intensity rainfall may have caused erosion of particulate P and contributed to high losses of TP compared to MRP.

* estimated P loads in grassland soil - a total annual loss of c. 3kg of TP ha⁻¹ was estimated.

Minimal loss strategies have previously been suggested. If P is added as basic slag rather than TSP a slow release of P would occur when it was ploughed and incorporated into the soil matrix. Direct injection methods of slurry and sludge additions have been suggested to minimise losses, the use of buffer zones has also been discussed. Most loss strategies have focused on arable systems and more research is required to assess the importance of managing grassland. However in sensitive catchments it is advisable to avoid spreading fertiliser and manure at times when runoff is likely to occur. Impacts of re-seeding pasture, grazing and pasture differences may also be important management considerations affecting P loss and are important areas for future research. *P.M. Haygarth & S.C. Jarvis, ref. Wat.Res. Vol. 31, N° 1 pp 140-148, 1997.*

PHOSPHATE AND NITROGEN INFLUENCE FISH STOCKS

This report is an inventory of current knowledge, carried out at the request of the Dutch Commodity Board for Fish, in response to the debate on the connection between depleted stocks of flatfish and the considerable reduction in the quantity of phosphate in coastal waters.

From 1950-80 amounts of phosphate and nitrogen in these coastal waters rose considerably, and when levels then fell phosphate suffered a greater decrease than nitrogen, leading to an excess in nitrogen.

It is probable that plant growth increased with the increase in nutrients, leading to a larger number of Seabed organisms (copepods and decapods) which are an important source of nutrition for fish. There appears to be a connection between the increase in nutrients and the survival and increased growth rate of the larvae of plaice and sole - with important positive consequences for fish catches.

The decrease in phosphate has led to disequilibrium over the past 15 years - the nitrogen excess has caused an increase in marine phosphorescence, undesirable toxic species of algae (unsuitable for consumption) and thus negative effects on the food chain;

Restoration of the equilibrium is desirable for both water and fish management, although no decrease in nitrogen levels can be expected in the near future and restoration at the current level is undesirable (leading to an excess of algae). The only remaining option is to allow the concentration of phosphate to increase. A policy involving a reduction of nitrogen discharges and an increase in phosphate discharges would thus be the most appropriate and would benefit the fishing sector. *Marine Biology Research Group, University of Groningen, W.J. Wolff, Dr H.J. Nanninga & Dr R. Boddeke 1997.*

DRAMATIC BIOLOGICAL AND BIOCHEMICAL CHANGES IN SURFACE WATERS DUE TO IRON ENRICHMENT EXPERIMENT

An *in-situ* iron fertiliser experiment has been carried out twice, in 1993 and 1995, in the eastern Pacific Ocean in order to observe the effect on phytoplankton abundance. Despite high concentrations of the major nutrients, nitrate and phosphate, phytoplankton abundance remains low in this area. These features characterise the 3 "high nitrate, low chlorophyll" (HNLC) regions - including the eastern equatorial Pacific, the ice-free Southern Ocean and the Sub Arctic North Pacific Ocean.

Papers report that it is the extraordinarily low availability of iron which limits phytoplankton growth in these HNLC areas: although iron is almost insoluble in sea water, it is an essential trace nutrient required by phytoplankton for many biochemical processes - e.g. chlorophyll synthesis and biochemical processes.

Iron ExI, carried out in 1993, reported that a single dose of iron raising the dissolved iron concentration to 4nm, over 64km² resulted in significant increased phytoplankton abundance and production rate, but had limited effect on nitrate concentration or partial pressure of CO₂. Unfortunately the experiment ended abruptly when the fertilised patch sank beneath a layer of less dense water. Although the experiment verified the iron hypothesis, the issue of whether iron fertilisation could relieve the HNLC condition was left unresolved.

In Iron ExII, carried out in 1995, the same amount of dissolved iron was added from a ship into the surface layer of a square patch of ocean in the eastern equatorial Pacific, in three sequential infusions over a week, to sustain the increase of dissolved iron in the surface layer over 72km². The fertilised patch, tagged with a drogued buoy and a biologically inert tracer (SF₆), whilst drifting 1500 km. Untreated water outside the patch served a control.

The effect of the fertilisation was immediate and dramatic - phytoplankton photosynthetic capacity growth rate and abundance increased, whilst nitrate concentration declined by half. As the phytoplankton bloomed its species composition changed radically - diatoms became dominant and accounted for most of the increased use of nitrate. As the bloom developed the partial pressure of CO₂ in the middle of the patch decreased rapidly, reducing the ocean-to-atmosphere CO₂ flux by 60%. There was also an increase of dimethyl sulphide (DMS) in the bloom which may have a role in global warming.

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However, the stimulated production was short lived - within a week of the final infusion, indicators of the last phytoplankton physiological condition returned to the same levels as before, phytoplankton bloom waned (presumably due to grazing and sinking) - and contrary to expectations there was no indication that the iron was retained and efficiently recycled within the biota of the surface layer. The consequences of larger scale, longer term inputs of iron are uncertain.

Iron ExII reinforced the notion that availability of iron limits cell division rates, abundance and production rate in phytoplankton. Although zooplankton increased in abundance and grazing rate, the response was insufficient to prevent the diatom bloom. It also showed that, along with grazing, iron limitation determines the composition of natural assemblages of phytoplankton. Iron fertilisation did little to disrupt the natural grazing balance of the small species. The larger-sized phytoplankton are probably under the most stress in HNCL regions, and division rates should be low, although evidence is contradictory. *Nature Vol.383 10 October 1996 p.475 Bruce W. Frost.*

FOOD WEB INTERACTIONS AND BIOMANIPULATION

The control of phytoplankton biomass in several Australian reservoirs was studied. Food web interaction of Australian biota were explored at different levels: laboratory trials, in mesocosms, by analysing the time series of plankton and fish biomass in reservoirs. In order to manipulate fish communities to reduce phytoplankton biomass a thorough understanding of the process in the plankton-associated food web is needed. The aim of biomanipulation is the establishment and maintenance of a ratio of planktivores/piscivores sufficient for water quality requirements.

In Lake Hume (surface area 202.5km², 41m depth) and Lake Dartmouth (63km², 170m depth) *Daphnia* biomass accounted for more than 50% of the observed variance in total phytoplankton biovolume (TPB) in spring/summer '94/95. When zooplankton biomass and nutrients were manipulated in water from the lakes, total chlorophyll-*a* was significantly affected by grazers in 8 out of 12 experiments and by added nutrients in 9 out of 12 experiments - the relative importance of the 2 effects changed seasonally. Acoustic biomass of pelagic fish (echo integration above 90dB) also varied seasonally - peaking in autumn and having minima in spring. Acoustic fish biomass was highest in eutrophic (Queensland) lakes and lowest in oligotrophic (Snowy Mountains) lakes.

In contrast to other continents, Australian reservoirs contain established populations of fish in the pelagic zone. It has been demonstrated that a strong negative

correlation between mean crustacea body length and TPB exists, although maximum mean length is much higher (more than 2mm) than elsewhere, suggesting that the potential for biomanipulation will be higher. This larger mean value is due to the presence of the zooplankter *Daphnia Carinata*, a species widespread in Australia.

The planktivorous fish of Australian reservoirs are relatively small and they may deplete small zooplankters, resulting in the promotion of this *Daphnia*.

In Lake Dartmouth small flat headed gudgeon, *Philypnoden grandiceps*, were co-existing with *Daphnia Carinata* in the pelagic zone, and a positive correlation between crustacean body length and fish acoustic biomass was found. Such interactions suggest that biomanipulation may involve creating conditions to protect some planktivorous fish. It was also suggested that some planktivores stimulate algal growth by excreting nutrients.

Final control will depend on which force prevails: zooplankton grazing or nutrient supply from fish and other sources. Such complex interactions show the necessity of analysing a lakes' food web before applying biomanipulation as a management option - further development of the food web theory under Australian conditions is needed. *CRCFE Murray-Darling Research Centre, P.O.Box 921, Albury 2640, Australia. Dr V.F. Matveev & L.K. Mateeva 1996.*

ENVIRONMENTAL FACTORS AND NUTRIENT REGULATION IN NATURAL WATERS

This review seeks to identify the key areas in aquatic science required for future management of algal problems in freshwater. The short term management of problems related to toxic cyanobacterial blooms in the U.K. has been met by raising the general public's awareness, defining the role of public bodies in the matter and introducing monitoring programmes.

Agricultural fertilisers play a major role in eutrophication - the change in English lakes in the 1950's was abrupt and coincided with the increased usage of fertilisers for grass production, a population increase, an increase in the influx of tourists, the introduction of piped water, sewerage and secondary wastewater treatment - it is impossible to separate these effects. The diffuse and point source of inputs of nutrients from agricultural practices are still ill defined and the effects of nutrient regulation difficult to predict.

The author deduces that if the export of nitrogen and, particularly phosphorus is increased there is some *pro rata* increase in the capacity of water to support

primary production. Production is also subject to other constraints, e.g. the availability of light and temperature - different phytoplankton species differentiated selectively by the interplay of these factors. Although the development of blooms have been associated with eutrophication and phosphorus concentration, it is not apparent that cyanobacterial biomass requires any mass specific contribution of phosphorus.

It is imperative to understand that it is a question of dynamics - bloom forming cyanobacteria are one of the slowest and most light sensitive phytoplankton species. This is the main link between cyanobacterial blooms and eutrophication: the avoidance of cyanobacterial production is not a question of eliminating all phosphorus inputs, but ensuring optimal physical and chemical conditions.

There is a wide range of different forms of phosphorus which differ in their availability for uptake by algae. The main agricultural export is in particulate form - clay, fine sand and detritus. Its role in eutrophication is considered to be subordinate to secondary sewage treatment - demonstrated by the rapid improvement in the condition of lakes benefiting from tertiary wastewater treatment.

As most biological material produced is destined for the permanent sediment, it must be considered how often components can be reused in biomass formulation before being buried. Much of the flux of phosphorus is held in iron (III) hydroxide and reuse depends on reduction of the metal to the iron (II) form.

The released phosphorus is biologically available to the organisms in contact with it, thus the significance given to solution events is understandable. However, it is unclear how well this phosphorus is used, as it generally remains isolated from production sites in surface waters. Deep lakes do not tend to recycle phosphorus, whilst shallow lakes do so almost continuously - in shallow lakes containing macrophytes, the macrophytes take up and accumulate nutrients from the water and sediment.

A combination of various factors acting serially drives the seasonal changes in mass and species composition in the planktonic community, offering a choice of solutions to combat eutrophication. The extent of the influence of any one mechanism must be considered when selecting a control method. Techniques may be categorised accordingly:

* Nutrient removal - the most important point sources of phosphorus are those from wastewater treatment plants, thus control of phosphorus loading is achieved by precipitation of phosphorus with iron salts or by biological removal.

* Catchment management - This is a longer term approach although methods to reduce diffuse sources of nitrogen have already been adapted for the

protection of drinking water rather than eutrophication - methods include crop zonation and reduced fertiliser application. These techniques are developing rapidly but their nutrient removal efficiency has yet to be quantified. Entry of nutrients to lakes can also be reduced using pre-lake techniques, including the installation of treatment plants to remove phosphorus. Most eutrophied lakes have large amounts of phosphorus isolated in their sediments as iron salts or calcite - this is a particularly effective solution in smaller, shallower lakes.

* Physical controls - these are really only applicable in lakes, since the effects of river morphology on eutrophication is not well enough understood - the most commonly used method for long term eutrophication control is artificial destratification, which aims at breaking down lake stratification in summer months. Work in the Lund Tubes in Blelham Tarn suggests that intermittent destratification enhances this method by creating instability in the alga-community resulting in no dominant species.

Although this method is attractive in cost terms there is controversy over its efficacy and few lakes in the U.K. are deep enough for it to be used.

* Bioremediation - recently much work on the understanding of biological process in lakes has been done, leading to the development of "ecotechnical methods", manipulating the trophic status; Biomanipulation is essential in the restoration of shallow lakes with high rates of phosphorus sediment recycling.

However, since concentrations of available phosphorus required to control primary production are very low ($5-10 \mu\text{g l}^{-1}$ total dissolved phosphorus) the reduction of nutrients from any one source will be ineffective. The National Rivers Authority has developed a framework for gathering and presenting scientific evidence including the publication of "Action Plans" on a case by case basis. This should then be subjected to a cost-benefit analysis to achieve agreement of all those involved before the plan is implemented. *Excerpt from the RC Publication "Agricultural Chemicals and the Environment" 1996 ISBN 0-85404-220-2 pp27-41. A.J.D. Ferguson, M.J. Pearson & C.S. Reynolds.*

SUCCESSFUL WATER PROTECTION MANAGEMENT

Lake Zurich, Lake Walenstadt and the Zurichobersee constitute a connected system of lakes with differing population densities, geographical and meteorological conditions thereby making them suitable for studying the effectiveness of water protection measures.

Although there is little research on the lakes before 1950, it is known that the eutrophication of Lake Zurich began around 1890. Stepwise wastewater

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treatment, with both mechanical and biological stages, was introduced in the 1950's and 1960's, which greatly reduced amounts of DOC, TOC and BOD. In the 1970's phosphate precipitation by chemical means was introduced, leading to a lower phosphorus input, reflecting a decrease in phosphorus concentration. However a significant reduction in algal biomass is only observed when phosphorus concentration sinks below $5 \mu\text{g l}^{-1}$, and even then a delayed reaction of the phytoplankton biomass over several years must be expected (as in the case of Lake Walenstadt). Between $5 - 60 \mu\text{g l}^{-1}$ no sporadic mass development occurs, but neither is there any marked reduction of the average algal biomass of 1 to 2 mg/l. When phosphorus concentration is above $60 \mu\text{g l}^{-1}$ short periods of moderate mass development can occur, although they have little negative effect on the lake (as in the case of Lake Zurich). Currently there is no information on the biomass development at higher phosphorus concentrations, since the influx of phosphorus into the lake is limited by protection measures resulting in a maximum concentration of $130 \mu\text{g l}^{-1}$.

Between $5-60 \mu\text{g l}^{-1}$ phosphorus, changes in phytoplankton composition are observed e.g. as phosphate levels fell blue-green algae, particularly the genus *Oscillatoria*, reappeared in Lake Zurich. The biomass of zooplankton is dependent on the supply of phytoplankton, as a consequence the decrease of certain algal groups of phytoplankton was followed by a decrease in zooplankton.

The ban on phosphates in detergents (1986) has had no additional effect on the phosphate content of the lakes investigated. The residual concentration of phosphate in the outflow from wastewater treatment plants is largely independent of phosphate concentration in untreated wastewater.

As far as drinking water processing from lake water is concerned further reduction of phosphate is unnecessary. The effect of phosphate fluctuations between $5-60 \mu\text{g l}^{-1}$ on biomass is small, thus replacing phosphate in detergents with other chemicals is questionable, particularly as their effects and degradation in lakes and drinking water are not yet known. The flocculation filtration stage now in place in the waste-water treatment process has been found to be effective in removing both phosphate and organic substances from wastewater.

The costs relative to waste-water pollution and eutrophication problems are enormous and include waste-water treatment, lake water protection and continuing drinking water processing. Capital costs are a continuing burden to water supply authorities - the depreciation period for the plants is 40 years. Users in

Zurich pay 3.06 SFr/m^3 for both drinking water and wastewater treatment.

Overall water protection measures in the area are effective, leading to better quality lake water, which in turn is processing to excellent drinking water. *1996 Water Supply, Vol. 14, N°s 3/4, 415-437. Zurich Water Supply Authority, Quality Control, Hardhof 9 P.O.Box, CH Zurich, Switzerland. H.P. Klein & U. Zimmermann.*

RECENTLY PUBLISHED REPORT- "PHOSPHORUS REMOVAL AND RECOVERY TECHNOLOGIES"

The Imperial College of Science and Medicine has carried out a world-wide review of the scientific and technical possibilities for the recovery and recycling of phosphorus in sewage. The report was sponsored by the phosphate industry's research foundation, with the aim of stimulating discussion and subsequent research-development into the recovery of this essential resource. SCOPE subscribers will be receiving a copy of this report. If you wish to obtain a five page synopsis please contact E.C.U who publish this newsletter for SCOPE (see back cover for details). *S. Brett, G.K. Morse & J.N. Lester. Environmental and Water Resource Engineering Section, Imperial College of Science, Technology and Medicine, 1997. ISBN 0 948411 10 0*

THE NORDIC ECOLABELLING SCHEME OPEN FOR PHOSPHATE BASED DISHWASHING DETERGENTS

Since 1989 a voluntary, positive ecolabelling scheme has been operating in Finland, Norway, Sweden and Iceland with the aim of informing consumers in the selection of products which are least harmful to the environment. The criteria for the ecolabel, the Swan, are based on a product's environmental impact throughout its lifecycle. A recent criteria document covering dishwasher detergents has been published by the Nordic Ecolabelling board. The document states that "phosphate and other phosphorus compounds may be included". - and the Swedish Institute of Standards (SIS) has decided that products containing up to 53% STPP are eligible for the Swan label. This decision of the Nordic Ecolabelling Board recognises STTP as an environmentally acceptable builder for detergents.

**IAWQ VIDEO "NATURE'S WAY"
BEST MANAGEMENT PRACTICES (BMPs)
THE CONTROL OF WATER DIFFUSION**

This new video has been produced to introduce a range of Best Management Practices (BMPs) and stimulate interest in these control approaches to diffuse pollution. The video illustrates the principles developed from research, working into practice and seeks to encourage techniques of source control and treatment train approaches. The video is designed for a wide audience including water agencies, land users, developers, urban/agricultural engineers, regulators...

Particular attention is given to :

- grass swales and buffer zones/strips
- infiltration systems
- wet ponds
- stormwater wetlands

This 26 min. video is available for a processing charge of £9.50 from:
International Association of Water Quality (IAWQ)
Duchess House, 20 Mason's Yard
Duke Street St James's
London, SW1Y 6BU
ENGLAND

**NEW WEBSITE FOR ENVIRONMENTAL
INFORMATION**

Drs. G. Fred Lee and Anne Jones Lee who have been active for many years in the field of eutrophication-related water quality have now begun to publish their papers and reports on their web site - <http://members.aol.com/gfredlee/gfl.htm>. Further information on the site and the publications can be obtained from Dr. G. Fred Lee at gfredlll@aol.com.

The SCOPE Newsletter is produced by the SCIENTIFIC COMMITTEE ON PHOSPHATES IN EUROPE, a non commercial, non profit-making association (Association Sans But Lucratif) based in Brussels.

The association includes international groups headquartered in Belgium, France, Spain, Sweden and the UK, producers of a wide variety of detergent ingredients including phosphates. Its aim is to provide a platform for objective and scientific information on the effects of phosphate-containing and phosphate-free detergents on the environment.

The SCOPE Newsletter is open to input from its readers across Europe and we welcome all comments or information. Contributions from readers are invited on all subjects concerning phosphates, detergents, sewage treatment and the environment. You are invited to submit scientific papers for summary to send comments on the studies mentioned in this Newsletter or other scientific or technical news.

For more information, please contact :

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PHOSPHORUS LEACHING INVESTIGATED IN THE BROADBALK EXPERIMENT

Movement of P vertically through and out of soil is generally considered to be of little importance, unless soils become P saturated (following heavy manure applications), due to high P fixation capacity of soils. Factors controlling these losses are generally considered to be related to soil type, pH and weather rather than fertiliser use. These findings have been questioned by data from the Broadbalk Continuous Wheat Experiment at Rothampsted.

UNITED KINGDOM p.3

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EUROPE p.4

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SWEDEN p.4

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AUSTRALIA p.5

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PUBLIC PERCEPTION AND WATER QUALITY MANAGEMENT

This paper examines the factors which have the greatest impact upon the general public's assessment of environmental quality, and most particularly their perception of water quality. It shows that those responsible for the management of surface water quality must recognise the need to apply a range of management strategies including a consideration of the public's perception of water quality and the impact of this upon their use of rivers and beaches for recreation and amenity.

SCOPE is a non-commercial, non-profit making European association based in Brussels.

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PHOSPHORUS LEACHING INVESTIGATED IN THE BROADBALK EXPERIMENT

Movement of P vertically through and out of soil is generally considered to be of little importance, unless soils become P saturated (following heavy manure applications), due to high P fixation capacity of soils. Factors controlling these losses are generally considered to be related to soil type, pH and weather rather than fertiliser use. These findings have been questioned by data from the Broadbalk Continuous Wheat Experiment at Rothamsted.

For more than 100 years plots in the experiment have annually received, either no P, P in farmyard manure (FYM) or in inorganic fertiliser (superphosphate), and now contain a wide range of sodium bicarbonate-extractable P (Olsen-P) concentrations in the plow layer (0 to 23cm). This is, in part, due to differences in P offtakes by wheat given different rates of N fertilisers and grown on soils given the standard rate of fertilisers. The aim of the measurement was to see if significant quantities of P were lost through drainage and the relationship to P concentrations in the plow layer.

It has previously been demonstrated that about 35% of P inputs to natural waters now come from agriculture in the U.K., 70% in Denmark and 38% in Germany: these percentages but not necessarily the amounts could rise with the increasing control of industrial and municipal discharge.

Drainage water analyses were made on 20 plots on each of five occasions between October 1992 and in February 1994, before and after the installation of a new drainage system (September 1993). Drainage water samples were collected from 20 different plots on 5 occasions, after the drains (at 65cm depth) had been running freely, each time. The drainage water was then filtered. Total particulate P (TPP) was calculated from the difference between TP (total P) and TDP (Total dissolved P). Dissolved organic P (DOP) was calculated from the difference between TDP and DPR. Average Olsen P concentrations in soil were also obtained.

The lowest Olsen-P concentration occurred in the plot which had never received any form of phosphate fertiliser (the nil plot). The next lowest concentrations were found in the plots receiving half the annual standard rate of superphosphate. Plots treated with FYM and the standard rate of superphosphate had more Olsen P ranging from 72mg P kg⁻¹ to 90mg P kg⁻¹. A general trend for plots with higher N rates to have lower Olsen-P concentrations was noted, since the

crop P offtakes were generally greater at the higher rates of applied N.

There was a large variation in both total P concentration and the relative contribution of the P-fractions between the 5 events and the 5 plots. Soils with similar Olsen-P concentrations had comparable P concentrations in the drainage water. DRP was the largest fraction in the drainage water and remained low (<0.15mg L⁻¹) from plots below 60mg Olsen-P kg⁻¹, when there was then a rapid increase in DRP up to the maximum Olsen-P concentration

These findings, shown on a simple Split Line model, imply that below the change point the small losses were not related to Olsen-P concentrations. Beyond this point P losses in drainage water were more closely related to Olsen-P concentrations.

The P leaving the plow layer could have passed to the drains by preferential flow in large cracks through the subsoil or, less likely, rapid transport of P in forms less susceptible to sorption but finally measured as DRP. These processes will be investigated further.

If soil P concentrations continue to increase in the future there could be an enhanced risk of P leaching. This may happen particularly in areas of high livestock density. Further research is necessary in order to better predict P dynamics, with regard to both fertiliser efficiency and better environmental protection.

This research has been cited in the ENDS report 263 December 1996, page 10.

Quote « In a study sponsored by the Ministry of Agriculture and the European Commission, Dr Philip Brookes and colleagues have found that excessively fertilised cultivated soils can also leach soluble phosphate. The result was surprising 'Leading experts in the world said it couldn't happen' Dr Brookes told ENDS. »G.Heckrath, P.C. Brookes, P.R. Poulton, and K.W.T. Goulding. The Journal of Environmental Quality. Vol 24, no 5, Sept/Oct 1995

ACID LAKES TREATED WITH PHOSPHATE SOLUTION

Lakes acidified by airborne pollutants typically have low biological productivity and support an impoverished flora and fauna. Although they can be neutralised by adding base (lime), the resulting calcium rich water supports animal and plant communities unlike those in natural softwater lakes. This paper examines the results of a 3 year experiment, a pretreatment year, followed by 2 years of fertilisation, in the Lake District.

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It demonstrates that the modest addition of phosphate to stimulate primary production allows the highly efficient generation of a sufficient base, by nitrogen assimilation to raise the pH of acid lake waters. The phytoplankton growth required to bring about this change was modest and did not cause any unacceptable changes in the qualitative composition of the lake's community.

The quantity of base generated depends on many factors, including the flushing rate of the basin, the rate of incorporation into the sediment and gaseous transfers to the atmosphere. Seathwaite Tarn, an upland reservoir, was chosen due to its moderate acidity (pH 5) one main inflow and a gauged outflow.

Most of the phosphorus added was rapidly assimilated by growing phytoplankton, particularly 'nanoplankton', which were consumed in large numbers by filter feeding crustacea, accelerating the rate at which the fixed carbon is deposited in the deep sediment.

The treatment will work best for lakes with a residence time in excess of a year. A modest initial acidity and a sustained loading of nitrogen from the atmosphere or catchment is also desirable. Inducing small increases pH (0.5 in this case) is worthwhile, since it may markedly reduce the metal content of polluted waters. Poor productivity in acid waters is usually associated with poor supplies of phosphorus. In addition to the increase in zooplankton in Seathwaite Tarn there have already been signs of an improved growth rate of the scant brown-trout population.

In practical terms it is difficult to dissolve calcium carbonate, whilst phosphate can be easily added in a concentrated form. In this experiment 5.9m³ of phosphate solution was added, whereas it would have taken 34 tonnes of calcium to obtain similar results. Moreover the phosphorus solution does not result in an unnatural chemistry and the pH is restored to pre-acidification levels rather than to unnaturally high levels. The addition of phosphate can clearly be cost effective, particularly if there is ultimately considerable recycling of phosphorus.

This study shows that it is possible for phosphate to have beneficial environmental effects and that eliminating phosphate may increase problems of low productivity and acidity.

*Institute of Environmental and Biological Sciences,
Lancaster University. Institute of Freshwater Ecology,
Ambleside. W.Davidson, D.G.George &
N.J.A.Edwards. Nature vol 377 12 Oct 1995*

A TOOL FOR RESTORATION : BIO-MANIPULATION IN SHALLOW LAKES -THE FISH-ZOOPLANKTON INTERACTION

This paper questions the traditional 'bottom -up approach' and thus traditional restoration methods focused on reducing nutrient levels, most particularly phosphate levels. The lake restoration programme in the Norfolk Broads began in 1980, with the removal of phosphorus from sewage effluents. Despite a 90% reduction in phosphorus to Barton Broad, the lake remained dominated by phytoplankton. In contrast, this research focuses on top-down processes such as fish- zooplankton - phytoplankton interactions and their importance in the restoration of eutrophic lakes.

Grazing by zooplankton can reduce chlorophyll a concentrations. However predation by planktivorous fish during the summer prevents such populations from developing in most of the lakes studied (in the Norfolk Broads).

It has been shown by artificially reducing these fish populations from some of these lakes, the resulting increase in zooplankton grazing has reduced the chlorophyll a concentration creating clear water and allowing the establishment of aquatic vegetation in the lakes.

This biomanipulation provides a good tool which could be used by lake managers (see also the following article on best management practices) in the planning of the restoration of lakes which are plankton dominated instead of nutrient removal. This method is more effective in shallow lakes as the zooplankton may be able to switch to sediments as an alternative food source when the phytoplankton population is reduced.

It has also been demonstrated that in unmanipulated broads there is a significant positive correlation between large grazing zooplankton and macrophyte biomass. In addition the least number of fish were found associated with dense macrophytes, corresponding with extremely low predation pressure. It is clear that macrophytes provide a refuge for grazing zooplankton and thus a long term accumulation of nutrients may assist in the maintenance of low algal standing crops. These macrophyte dominated lakes have a greater proportion of pike to prey species than plankton dominated lakes.

Water for chemical analysis and zooplankton samples from 3 lakes (Upton Broad, Hoverton Litte Broad and a fish enclosure in a nearby isolated bay) were collected regularly during 1992/3. Fish removals

were carried out using non destructive techniques, mainly electrofishing. Fish removal was thought to have reduced the fish population by at least 90%.

Hoveton Little and Upton Broads provide good examples of the contrasts seen in the plankton of the Broads. In Hoveton Little Broad *D.hyalina* only occurs for a short period associated with a spring clear water phase. Clearly planktivorous fish in this kind of environment rapidly reduce the populations of these larger cladocerans, leaving the zooplankton dominated by smaller species such as *B.longirostris* in the summer.

In Upton Broad moderate populations of *D.hyalina* occur Jan - July, when macrophytes become well established in the lake, and weed associated cladoceran species are found. In the absence of planktivorous fish in this lake and in the fish enclosure, large cladoceran species are predominant throughout the year.

When planktivorous fish were removed from these lakes, such as in the fish enclosure, it is clear that despite zooplankton population cycles low chlorophyll concentrations could be maintained. This form of biomanipulation seems to be a practical way of creating clear water conditions provided the control of the fish population continued.

In many other European lakes biomanipulation carried out on only once or twice has led to a shift in community structure of the lake, maintained over many years. This was almost always in association with the rapid development of aquatic vegetation. The mechanism is still unclear although vegetation uptake and the physical nature of the plants are thought to play a major role. The role of piscivorous fish in determining lake structure is also unclear. Initial observations support the view that high pike biomass in relation to planktivorous fish is linked to macrophyte dominated lakes and restructuring of the fish community is likely to be an essential final step in the permanent restoration of these lakes.

It has been shown in published relationships that as far as biomass and nutrient supply are concerned all lakes tend to follow the same general curve. Concerning summer chlorophyll a and total phosphorous the data can be divided into two categories : those lakes dominated by phytoplankton, and those by macrophyte. Biomanipulated lakes fall between these two groups, and suggest that within a range of phosphorous concentrations either plankton or macrophyte states can form stable communities without any further artificial intervention.

A simple nutrient supply reduction to a lake will not necessarily result in the desired reduction in algal growth, except if the food webs are able to restructure. Biomanipulation can be considered as a

way to assist in this process, and it may be an essential step in the restoration of shallow lake

G.L.Phillips, M.R.Perrow & J.Stansfield. Aquatic predators and their Prey Chapter 22 - 1996.

BEST MANAGEMENT PRACTICES LAKE RESTORATION GUIDE LAUNCH

A Guide to the Restoration of Nutrient Enriched Shallow Lakes, jointly produced by the Broads Authority and the Environment Agency, is supported by the European Commission through its LIFE programme.

The first comprehensive handbook linking up-to-date science with practical techniques to solve one of the environment's most pressing problems has been launched.

The guide outlines how to deal with eutrophication. It is aimed at lake managers across Europe, and includes a step-by-step strategy for restoration based on a sound ecological approach. The Environment Agency is developing a strategy for handling eutrophication and will be consulting organisations with a particular interest. *A Guide to the Restoration of Nutrient Enriched Shallow Lakes. Brian Moss, University of Liverpool, Jane Madgwick, the Broads Authority, Geoffrey Philips, the Environment Agency. Jan 1997. ISBN 0-948119-29-2*

BUILDERS IN DETERGENTS : CITRATES, PHOSPHATES AND ZEOLITES

Over the last few years the laundry detergent market has seen the development of alternative builder systems, moving away from conventional laundry detergents. Numerous studies have shown that the impact on the natural environment of builders is insignificant.

Citrates, phosphates and zeolites were studied : none were found to have toxic effects, and no negative effects on the environment were found. It is to be noted that phosphate free detergents contain many more surfactants which may have a higher rate of toxicity.

Phosphates are most efficiently removed during advanced waste water treatment, thus allowing more scope for recycling. Citrates decay biologically in the waste water treatment implying no burden to the recipient.

VATTEN 52 :197-203. Lund Andreas Björklund, Stefan Mattsson and Gunnar Karlsson.

THE FILTER TECHNIQUE FOR SEWAGE EFFLUENT TREATMENT

A filter technique for sewage effluent treatment has been developed in the Murray River Basin in Australia, as a cheaper and more sustainable alternative to existing land treatment systems. It aims to provide a sustainable and economically viable land treatment system. Nutrient rich effluent for intensive cropping was used, with filtration through the soil to a subsurface drainage system.

The Environment Protection Agency (EPA) promotes sewage effluent treatment by land application to reduce nutrient and other pollution of water bodies and to minimise waste generation. However in certain areas of Australia land treatment effluent is often less economical than other treatment techniques due to the cost of winter and wet weather effluent storage on high value urban lands. The low permeable clay soils dominating the urban areas of eastern Australia are also prone to waterlogging and salinisation which may reduce the long term sustainability and economic viability of the effluent application sites. A need was identified to develop a technique adapted to overcome these problems.

FILTER (Filtration and Irrigated cropping for Land Treatment and Effluent Reuse) combines the usage of nutrient-rich effluent for intensive cropping with filtration through the soil to a sub-surface drainage system. This is carried out during periods of low growth activity and high rainfall, thus eliminating the need for effluent storage.

The system is regulated to ensure adequate nutrient removal and so produces low-nutrient drainage waters. This filtration phase could be followed by a cropping phase to remove any nutrients stored in the soil, if necessary, thereby ensuring a sustainable system. Specific combinations of filtration and cropping phases used depend on site conditions.

Total phosphorus and total nitrogen concentrations in the drainage waters were reduced well below EPA target limits of 1.0mgL^{-1} and 15mgL^{-1} respectively. Total phosphorus and total nitrogen loads were reduced by 96% and 85% respectively.

The effluent showed presence of blue-green algae whilst the drainage water did not, thanks to the increase in the N:P ratio (from 3 to 23), coherent with previous research which has showed the threshold to be approx. 12.

The crops selected for the plots were relatively waterlogging and moderately salinity tolerant, so crop yields and nutrient removal rates during the filtration

phase were comparable to those obtained overseas in well managed land treatment systems.

Another potential use for the system has been identified in a separate trial involving spiking the effluent with the full range of pesticides used in agricultural enterprises in the area. Pesticide loads were reduced by more than 98%. Modified FILTER systems may be used to treat commercial and industrial effluents containing heavy metals and chemicals, feedlots, piggeries and dairies.

*Water November/December 1996 pp18-21.
N.S.Jayawardane & J.Blackwell*

PUBLIC PERCEPTION AND WATER QUALITY MANAGEMENT

This paper examines the factors which have the greatest impact upon the general public's assessment of environmental quality, and most particularly their perception of water quality. It shows that those responsible for the management of surface water quality must recognise the need to apply a range of management strategies including a consideration of the public's perception of water quality and the impact of this upon their use of rivers and beaches for recreation and amenity.

The general public's initial perception of river and coastal environmental quality is often based solely upon visual and odorous characteristics. These factors bear very little relation to actual physico-chemical or biological water quality.

In recognition of the importance of these factors to the general public the National Rivers Authority (NRA), the principal regulator of water quality in England and Wales, has developed a new General Quality Assessment (GQA) scheme, which includes consideration of the aesthetic impact of pollution parameters for the first time.

Research was carried out 1992-1994 to evaluate the importance of individual water quality impairment parameters; foaming, litter, coloured effluents, and sewage derived waste products to perceived water quality and the use of rivers and beaches for recreation and amenity.

In theory the presence of sewage derived contaminants should have the greatest negative impact on the enjoyment of a visit to a river or beach. However people failed to recognise sewage derived products, either because they are not familiar with them or because of an unwillingness to mention specific products. Solid waste contaminants were

more disturbing in the water than on the beach or the banks of a river. Single items of derived sewage waste seemed to have a greater impact than a conglomeration of items. A large proportion of the public did not identify these products as coming from the water.

In conclusion it can be seen that there is a gap between the « real » versus « apparent » effect in

water quality. This highlights the importance of a well thought out strategy in any public discussion of factors such as phosphate in the environment.

*Public Perception and Water Quality Management.
Margaret A. House : Middlesex University,
Queensway, Enfield , U.K.*

The SCOPE Newsletter is produced by the SCIENTIFIC COMMITTEE ON PHOSPHATES IN EUROPE, a non commercial, non profit-making association (Association Sans But Lucratif) based in Brussels. The association includes international groups headquartered in Belgium, France, Spain, Sweden and the UK, producers of a wide variety of detergent ingredients including phosphates. Its aim is to provide a platform for objective and scientific information on the effects of phosphate-containing and phosphate-free detergents on the environment. The SCOPE Newsletter is open to input from its readers across Europe and we welcome all comments or information. Contributions from readers are invited on all subjects concerning phosphates, detergents, sewage treatment and the environment. You are invited to submit scientific papers for summary to send comments on the studies mentioned in this Newsletter or other scientific or technical news.

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NORWAY

p.2

NORWEGIAN RESEARCH PROGRAMME BASED ON NUTRIENT INPUT INTO THE SEA

The state owned conglomerate Norsk Hydro has launched a five year research programme called Maricult (funded in part by the European Commission) designed to consider the cultivation of marine ecosystems. It will study the opportunities and constraints for a more comprehensive use of the oceans in order to improve our prospects for a larger, yet sustainable harvest of marine resources in the future in an environmentally acceptable way involving the addition of nutrients.

SPAIN

p.2

A REAL LIFE STUDY ON THE CONSUMER'S SHOPPING BASKET

An interesting study was carried out on nine different conventional and compact detergents, bought in a supermarket in Spain, containing STPP or other builders, used for washing textiles. 5 were conventional, of which 3 contained STPP; and 4 were compact, of which 2 contained STPP.

GERMANY

p.3

BIOREMEDIATION OF AN OLD FUEL OIL-CONTAMINATED SITE USING HEXAMETAPHOSPHATE

Groundwater is often found to be contaminated with various organic chemicals whereby heterotrophic bacteria dominate. Phosphate is a required electron acceptor, an essential nutrient, and an important limiting factor of hydrocarbon degradation in bioremediation.

This case concerns contamination, 40-50 years ago, by a leaking pipeline, of 15 000-17 000 L. Most of the oil floating on the groundwater was removed in the 70's; the pollution now lies 4-9m below ground level.

AUSTRALIA

p.3

ANALYSIS ON THE TOXICITY OF COMMERCIAL AVAILABLE LAUNDRY DETERGENTS ON NATIVE FRESHWATER *CERIODAPHNIA DUBIA* RICHARD

Tests were carried out on 20 Australian, and 4 British laundry detergents, purchased in Sydney during June 1994, to determine the relative impact of phosphate containing and phosphate free formulations in view of the lack of knowledge on their toxicological effects on the Australian environment

NORWAY

p.3

INPUTS TO THE OCEAN AND RESULTING POLITICAL DEMAND FROM THE SCIENTIFIC COMMUNITY LEADS TO DESIGN OF A 3D MODEL

This paper describes a model to calculate mass and volume transport and primary production throughout the North Sea. This was the first time such a 3D baroclinic hydrodynamical model had been coupled to a chemical biological model in order to better understand these parameters. In response to political pressure to understand the impact of a 50% reduction of nutrient input, Morten D. Skogen et Al. ran the model for the year 1985 with specified time series of riverine and atmospheric inputs and they reran it with a 40% reduction. The authors conclude it would be a useful tool for political and environmental planning.

U.K.

p.4

CLASSIFICATION AND ASSESSEMENT OF WATER QUALITY IN LAKES

This paper studies the way water quality can be assessed in standing waters; a subject which has, until recently, with the introduction of European legal requirements, attracted very little attention. A scheme is described to assess, classify and monitor water and ecological quality in standing waters greater than 1ha in area in England and Wales, though is normally applicable to North West Europe.

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produced by European Communications Unit - 20, rue de l'Arcade - 75008 PARIS - FRANCE - Tel. + 33 1 44 94 80 70

SCOPE : Scientific Committee on Phosphates in Europe - Association Sans But Lucratif sise à Bruxelles et soumise à la Loi du 27 juin 1921

NORWAY

NORWEGIAN RESEARCH PROGRAMME BASED ON NUTRIENT INPUT INTO THE SEA

The state owned conglomerate Norsk Hydro has launched a five year research programme called Maricult (funded in part by the European Commission) designed to consider the cultivation of marine ecosystems. It will study the opportunities and constraints for a more comprehensive use of the oceans in order to improve our prospects for a larger, yet sustainable harvest of marine resources in the future in an environmentally acceptable way involving the addition of nutrients.

Overfishing has resulted in reduced global harvests of major fish stocks in the recent past. The problems associated with managing these stocks has been put on the national agenda.

The richest fishing grounds are found where there is a continuous flow of nutrient rich deep water to the surface resulting in short, efficient food webs. Typical areas can be found off the coast of Chile and Namibia. These « upwelling areas » comprising only 0.1% of the ocean surface, produce 50% of global fish production. This clearly indicates a potential for increased production in marine ecosystems.

Maricult raises the question : « Can we learn how nature creates these areas of high biological productivity, and are we able to imitate this artificially in other coastal areas ? » The research programme emphasises studies of the effects of dosages of plant nutrients, namely nitrogen and phosphorus, at concentrations found naturally in upwelling areas.

The experiments are to be conducted in areas of limited size in marine food webs and seaweed areas and involve the supply of nutrients in controlled conditions : their aim being the definition of the conditions leading to a useful productivity that can be harvested

Preliminary studies show that although introducing desired species on a large scale, plus other biological aimed initiatives, was not enough, the introduction of fry would increase the chances of success if the fry's food supply increased correspondingly, particularly at the youngest stages. This is only possible if an adequate amount of nutrients is supplied by artificial upwelling or direct application of mineral fertilisers

Nutrients will only be added where an increased productivity of plankton is desired. The composition and the amounts must match both the fluxes which occur in naturally high productive areas and the natural requirements, in order to prevent the growth of harmful and undesirable algae.

A large nutrient supply may increase both fish production and sediment rate, leading to an advanced an accelerated carbon accumulation rate on the seabed. Even if at present it is difficult to imagine artificial fertilisation of the sea as a viable prospect for removing CO₂ from the atmosphere, it may well become a future option.

The results of this project will contribute significantly to highlight and clarify important aspects of the environmental impact of nutrient discharge into marine systems and thus increase our knowledge on the effects of nutrient dosage and biological indicators of eutrophication.

The Maricult Research Programme. Hydro Porsgrunn Industrial Park P.O. Box 110, 3901 PORSGRUNN.

SPAIN

A REAL LIFE STUDY ON THE CONSUMER'S SHOPPING BASKET

An interesting study was carried out on nine different conventional and compact detergents, bought in a supermarket in Spain, containing STPP or other builders, used for washing textiles. 5 were conventional, of which 3 contained STPP ; and 4 were compact, of which 2 contained STPP.

All samples were subjected to a treatment reproducing a typical European textile-washing process after which the following parameters were measured

- (i) total suspended solids (TSS)
- (ii) dissolved organic carbon (DOC)
- (iii) chemical oxygen demand (COD)

The three main aims of the study were :-

- (i) the experimental determination of chemical parameters related to the aquatic environment : it was found that the P-based formulations (both conventional and compact) contain less TSS, and have lower COD and DOC than P-free formulations. Only P-based washing powders improved washing performance in compact form ; moreover, a smaller amount of detergent was needed for equivalent soil removal, implying a smaller release of the detergent into the aquatic environment.
- (ii) experimental determination of detergency for each detergent category : common maximum soil removal was 40% on cotton and 48% on polyester/cotton. Detergency on cotton fabric of 40% the calculated dose was 8.8, 10, 4.4, and 10.6g/L, for P-based conventional, P-free conventional, P-based compact, and P-free compact respectively. Similarly the dose was 11.9, 10, 4.2 and 10.6g/L, respectively on polyester/cotton.

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(iii) evaluation of the environmental impact at equivalent detergency performance : as far as results of chemical loading to the environment is concerned, assuming an equal detergency performance for a typical wash (20L), detergent load, surfactant load, COD, DOC and particularly TSS are much smaller for P-based than P-free detergents, especially P-based compacts.

After examining these three points it was concluded that the use of compact detergents containing STPP implies a lower environmental impact than other detergents tested, in terms of both a reduced generation of sludge residues and a reduced organic load in sewage works.

Comparative Study of Conventional & Compact detergents. J.Sanchez Leal, L.Perez, I.Ribosa, M.T.Garcia & J.J.Gonzalez. Centro de Investigación y Desarrollo (CISC) Barcelona, Spain.

JAOCS, Vol.73, 27-30 no 1 (1996)

GERMANY

BIOREMEDIATION OF AN OLD FUEL OIL-CONTAMINATED SITE USING HEXAMETAPHOSPHATE

Groundwater is often found to be contaminated with various organic chemicals whereby heterotrophic bacteria dominate. Phosphate is a required electron acceptor, an essential nutrient, and an important limiting factor of hydrocarbon degradation in bioremediation.

This case concerns contamination, 40-50 years ago, by a leaking pipeline, of 15 000-17 000 L. Most of the oil floating on the groundwater was removed in the 70's ; the pollution now lies 4-9m below ground level.

The in situ remediation design consists of 2 infiltration wells, production wells, plus a groundwater processing plant. Before infiltration, hydrogen peroxide and nitrate were added to the reinfiltreated water to meet the electron acceptor demand, plus phosphate to meet nutrient demand.

Initial results suggested that phosphorus was the limiting factor for heterotrophic bacterial activity. It is probable that the phosphate stopped the limitation and oxygen was used in and next to the infiltration wells. However, during the use of diphosphate, problems occurred with the precipitation of insoluble phosphate salts and thus plugging of the infiltration wells and the surrounding aquifer occurred.

After 2 months the phosphorus source was stopped, the wells regenerated with H₂O₂ and acid, then 6 weeks later was replaced by sodium hexametaphosphate. This

eliminated problems of precipitation and plugging in the infiltration wells. For the first time a phosphorus supply for the whole contaminated area was observed.

Although all the work to date on polyphosphates in bioremediation has concentrated on tripolyphosphates, this study showed the superiority of polyphosphate over orthophosphate on a field scale. It was also found that sodium hexametaphosphate is superior over commonly used phosphates in transporting phosphorus over long aquifer distances.

Martin Steiof/Wolfgang Dutt. Applied Bioremediation of Petroleum Hydrocarbons (301-309)

AUSTRALIA

ANALYSIS ON THE TOXICITY OF COMMERCIAL AVAILABLE LAUNDRY DETERGENTS ON NATIVE FRESHWATER CERIODAPHNIA DUBIA RICHARD

Tests were carried out on 20 Australian, and 4 British laundry detergents, purchased in Sydney during June 1994, to determine the relative impact of phosphate containing and phosphate free formulations in view of the lack of knowledge on their toxicological effects on the Australian environment.

The detergents were classified according to their chemical composition using a 2 way classification system, whereby each product belonged to 2 categories :-

(i) high phosphate (HP), containing more than 5% phosphorous on a weight to weight basis (w/w)
(ii) low phosphate (LP) containing 1-5% phosphorous (w/w)

(iii) phosphate free (PF) containing less than 1% phosphorous (w/w)

these categories were further subdivided into :-

(iv) containing neither enzymes nor zeolites (NoE & NoZ)

(v) containing enzymes (E)

(vi) containing zeolites (Z)

(vii) containing enzymes & zeolites (E & Z)

Australian cladocera *Ceriodaphnia dubia* was chosen as the test species since it is representative of the zooplankton which graze on algae and help prevent the development of toxic algal blooms. Cladocerans were exposed to 5 concentrations of each detergent, plus a control, which were randomly placed in each test vessel and covered with cling film. Each treatment in each test was triplicated and each test repeated 3 times. The tests were terminated after 48 hours. A further quality control measure was taken using the Environment Canada methodology (1990) to determine if detergent toxicity data

was accepted or rejected. Only data passing this test was used.

As far as the results are concerned it must be borne in mind that the percentage of the recommended dose (%RD) toxicity data were likely to contain greater error than the concentration toxicity (mg/L) data since recommended doses were often vague and it is questionable if consumers actually use these doses.

It was found that the most toxic Australian detergent was approx. 35 & 25 (mg/L & %RD respectively) times more toxic than the least toxic. The toxicity values obtained were similar to those determined by Ankley et al (1990) for U.S. detergents and individual surfactants tested on a U.S. cladoceran.

All 4 U.K. detergents were found to have medium toxicity (1 mg/L < EC50 < 10mg/L), 15 of the Australian detergents were classed as having low toxicity (EC50 < 10mg/L) and 5 were of medium toxicity (1mg/L < EC50 < 10mg/L). These differences were not statistically significant.

The contingency analysis showed that toxicity class is independent of phosphate concentration, the presence or absence of enzymes, the presence or absence of enzymes and zeolites combined and various combinations of these. The authors concluded that not only phosphates, but also other detergent components could contribute to toxicity, including surfactants (one of the most toxic, *Canton & Slooff 1982*), chelates and enzymes.

The results of all the analyses underlined that it is not possible to generalise about the toxicity of detergents based on the criteria used to classify the detergents in this study, since there is a large variability in the toxicity of detergents belonging to each class.

It was concluded that the explanation of the differences in toxicity was likely to lie in the chemical composition of individual detergents. The important components contributing to toxicity could include surfactants, enzymes and chelates. The second stage of this research project will consider which of these components are predominantly responsible for the toxicity of Australian detergents.

Michael St. J. Warne. Australasian Journal of Exotoxicity Vol 1, pp 127-135, 1995

NORWAY

INPUTS TO THE OCEAN AND RESULTING POLITICAL DEMAND FROM THE SCIENTIFIC COMMUNITY LEADS TO DESIGN OF A 3D MODEL

This paper describes a model to calculate mass and volume transport and primary production throughout the North Sea. This was the first time such a 3D baroclinic hydrodynamical model had been coupled to a chemical biological model in order to better understand these parameters. In response to political pressure to understand the impact of a 50% reduction of nutrient input, Morten D. Skogen et Al. Ran the model for the year 1985 with specified time series of riverine and atmospheric inputs and they reran it with a 40% reduction. The authors conclude it would be a useful tool for political and environmental planning.

The NORWECOM (NORwegian ECOlogical Model System) presented in this paper focuses on the 1995 modelling of mass and volume transport and primary production throughout the North Sea.

Two factors contributed to the development of this : inputs to the ocean and the resulting political demand to the scientific community to clarify the situation; and the importance of understanding the primary production process because of its importance as a possible regulating mechanism for the fish production.

In order to obtain realistic biological results, the coupled chemical biological model system was based on a sophisticated 3 dimensional physical model that was able to represent the vertical exchanges realistically.

This model is discretized in a 20 x 20 km grid with 11 vertical layers which follow the bottom topography. The model calculates all the P.C.B. prognostic variables every 15 minutes. It is strongly dependant on two physical constants :

a minimum value for the vertical eddy viscosity/diffusion coefficient

a dimensionless horizontal diffusion constant

The 7 chemical biological prognostic variables are :

- inorganic nitrogen (such as nitrate and ammonia)
- inorganic phosphorus (phosphate)
- inorganic silicon (silicate)
- detritus (dead organic matter)

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- diatoms
- flagellates
- light/turbidity

The compiling involves 4 physical variables :-

- subsurface light
- hydrography
- the horizontal movement of water masses
- the vertical movement of water masses

The model is based on the following hypotheses

- nutrients are added to the system from the many rivers and from the atmosphere (only nitrate)
- nitrogen and phosphate are also reglemented from the dead algae, detritus at a constant rate
- no zooplankton eating the algae and no «particle» bottom settlement and resuspension are incorporated.

The analysis of the data demonstrates a strong coherence between model results and existing literature (with some discrepancies in the North) as well as a strong seasonal variation in production of diatom and flagellate blooms. The balance between diatoms and flagellates is clearly linked to silicate as a limiting seasonal factor.

For the flagellate bloom the authors also observed a strong correlation between the plankton correlation and the available phosphorous, nitrogen being a nutrient.

Blooms of toxic algae have dramatically increased over the past few years. The model was thus rerun based on political decisions to reduce nutrient input by 50% around the North Sea, with the hypothesis of reducing initial conditions by the same percentage.

This reduction only affected, as predicted (see above) the flagellates, with more than a 25% reduction in local regions, and an overall 5-10% reduction annually (with some uncertainties in the model due to lack of resolution in the coastal region).

However, the model can not be considered to be 100% accurate since various phenomenon can generate discrepancy in the simulation, eg. sensitivity of the model to initial conditions, annual calculation conception of the model, the importance of the recycling of nutrients, lack of sedimentation/resuspension process as a component of the model.

Despite these limitations the potential of using this kind of model, to study, for example, reduced deposition of

nutrients to the North Sea, makes them a useful tool in political and environmental planning.

Skogen, Svendsen, Bernstsen, Aksnes & Ulvestad. Estuarine, Coastal and Shelf Science (1995) 41, pp. 545-565.

U.K.

CLASSIFICATION AND ASSESSEMENT OF WATER QUALITY IN LAKES

This paper studies the way water quality can be assessed in standing waters ; a subject which has, until recently, with the introduction of European legal requirements, attracted very little attention. A scheme is described to assess, classify and monitor water and ecological quality in standing waters greater than 1ha in area in England and Wales, though is normally applicable to North West Europe.

Thirteen hydrological, chemical and biological variables are used to characterise the water body, these variables being the key indicators of the state of eutrophication, acidification, salinisation, and infilling of a water body :-

- lake volume
- maximum depth
- conductivity
- Secchi disc transparency
- pH
- total alkalinity
- calcium ion concentration
- total N concentration
- winter total oxidised inorganic nitrogen (effectively nitrate) concentration
- total P concentration
- potential maximum chlorophyll *a* concentration
- a score based on the nature of the submerged and emergent plant community
- the presence or absence of a fish community

The scheme is not, however, a closed one and other variables could be included when necessary, and when appropriate reference data becomes available (eg. oxygen profile, benthic invertebrate community, phytoplankton community and fish community).

Standing waters are classified within the scheme in a value-or-state change system in which the contemporary values of the variables are compared with a reference baseline state and then classified according to percentage change from this baseline. A mean percentage change in all variables can be calculated or the variables can be sub-grouped to indicate change in the directions of eutrophication, acidification, infilling or potentially any other factor if the relevant variables are included and can be determined in the baseline. The baseline state also provides an objective reference for determining water quality objectives for given water bodies.

The baseline state is the one which reflects a sustainable agricultural land-use of the catchment and thus a consequent quality of the water body, determined by the catchment's natural topography, climate and geology but in the absence of sewage effluent untreated to remove phosphorous. Since the Second World War land-use has been increasingly determined by economic and technological factors, with natural features taking second place.

The Annual Agricultural Censuses allow reconstruction of aspects of the water chemistry of appropriate baseline states for individual lakes or lakes grouped in uniform regions. Appropriate nutrient variables (total N and total P concentrations) can be predicted to within a few percent, as can retention time and conductivity and from these variables the others listed can be calculated. Comparisons of change can then be made for any contemporary data set.

The scheme, incorporating a ranking scheme for aquatic plants, has been designed for use on lakes greater than 2ha in England and Wales and for others of significant amenity or conservation interest. It has been pre-tested on 90 lakes, the results showing a high degree of change in British standing waters. Results are consistent with studies carried out with other methods. The system will be easy to computerise, allowing automatic baseline calculations and comparisons.

*By Brian MOSS, Penny JOHNES and Geoffrey PHILLIPS.
Bio Rev. (1996) 71, pp 301-339*

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The association includes international groups headquartered in Belgium, France, Spain, Sweden and the UK, producers of a wide variety of detergent ingredients including phosphates. Its aim is to provide a platform for objective and scientific information on the effects of phosphate-containing and phosphate-free detergents on the environment.
The SCOPE Newsletter is open to input from its readers across Europe and we welcome all comments or information. Contributions from readers are invited on all subjects concerning phosphates, detergents, sewage treatment and the environment. You are invited to submit scientific papers for résumé, to send comments on the studies mentioned in this Newsletter or other scientific or technical news.
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THE NETHERLANDS p. 2

The effect of pollution on phytoplankton dynamics in the River Meuse

The correlation between phytoplankton development, and chemical and physical characteristics of water extracted from the River Meuse has been examined. The River Meuse is described as highly eutrophic and carrying a persistent load of toxic compounds. Results of the study show that the phytoplankton growth rate may be related to a high toxicity. An approach including both functional and structural parameters is recommended for rehabilitation programmes.

FRANCE p. 2

Evaluation of phosphorus from point sources on a catchment area scale

Researchers from the Savoie region in France, have proposed a new model for evaluating phosphorus from point sources in a catchment area. The model distinguishes phosphorus coming from the area itself, sources coming from upstream, and diffuse sources. The information collected from the application of the model should contribute to developing and adjusting eutrophication control strategies in sensitive areas.

NEW BOOK p. 3

Phosphorus in the global environment

The Scientific Committee on Problems of the Environment (not to be confused with the organisation SCOPE which edits this newsletter) publishes a compilation of articles on transfers, cycles and management of phosphorus in the environment.

SWEDEN p. 4

Impact of fish farming on lakes' phosphorus concentration

An extensive research project has been conducted in Sweden to evaluate the impact of fish farms on eutrophication phenomenon in lakes (see also our previous Newsletter). One of the study's objectives was to see whether phosphorus emissions from rainbow trout farms could be used to reduce mercury and radiocaesium levels in the lakes' fish.

However, no result on this issue could be obtained since no increase in P-concentration had appeared due to fish farming activities. The authors concluded that fish production could be multiplied by 200 without affecting the lakes' trophic condition.

GERMANY p. 4

Opportunities and constraints in the recycling of nutrients

This article addresses the question of nutrient recycling. Dr. Joachim Lamel, from the Centre for Plant Nutrition and Environmental Research in Hanninghof, Germany, studies the different components of the recycling nutrients issue (historical, sociological, economical and technical).

AUSTRALIA p. 5

A new process reduces the amount and cost of chemicals used for phosphorus removal from waste water.

Alum sludge might contribute to lowering both cost and amount of chemicals used for removing phosphorus from waste water. If the trials conducted by the Centre for Wastewater Treatment at the University of New South Wales at Bowral are successful, this technique could be used throughout Australia.

NORWAY p. 6

Assessment of cost efficiency and sustainability of wastewater treatment processes at the University of Trondheim.

Cost efficiency and sustainability of different commonly used wastewater treatment techniques were evaluated. Results show that among the methods assessed, chemical treatment alone and advanced treatment with chemical pre-treatment rank first with respect to both criteria. However, the author notes that municipal wastewater treatment equipment is often chosen according to national or international treatment standards rather than the quality and self purification capacity of the local receiving water.

SCOPE is a non-commercial, non-profit making European association based in Brussels.

Its aim is to provide a platform for objective and scientific information on the effects of phosphate-containing and phosphate-free detergents on the environment.

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THE NETHERLANDS

THE EFFECT OF POLLUTION ON PHYTOPLANKTON DYNAMICS IN THE RIVER MEUSE

The correlation between phytoplankton development, and chemical and physical characteristics of water extracted from the River Meuse has been examined. The River Meuse is described as highly eutrophic and carrying a persistent load of toxic compounds. Results of the study show that the phytoplankton growth rate may be related to a high toxicity. An approach including both functional and structural parameters is recommended for rehabilitation programmes.

The River Meuse is described as a typical nutrient rich lowland river with relatively high plankton productivity. Previous studies have shown a strong relationship between the presence of toxicants and the decline of species in the river.

Twenty litre water samples were collected at 8 points along the river in February, April, June, August, October and December 1993. The samples were taken to a laboratory where they were maintained at their original temperature. The following parameters were measured :

- Biological parameters:
 - Chlorophyll A concentration
 - Contribution of functional groups to Chlorophyll A
 - Rate of carbon fixation by phytoplankton
 - Bacterial growth
- Physical and chemical parameters:
 - Dry weight of suspended matter
 - Dissolved reactive phosphate
 - Ammonium ions
 - Nitrate
 - Nitrite
 - Dissolved reactive silicate
- Toxicity of polar organic compounds concentrated by XAD resin and measured with the Microtox test system.

The study revealed a relatively low Chlorophyll A concentration in the River Meuse in comparison with other large rivers. This observation cannot be explained by nutrient depletion. Phosphate and

ammonium concentrations are very high and cannot therefore be limiting in any part of the river. The hypothesis of a regulation by zooplankton grazing has also been considered. High zooplankton densities were correlated with declining phytoplankton concentration in April, June and August.

In water samples collected in locations with a high content of organic substances, the low phytoplankton growth rate supported the idea of a strong correlation between the presence of toxicants and the inhibition of plankton productivity. The presence in abundance of light and nutrients at these locations also upholds this hypothesis.

Due to uncertainties concerning the efficiency of the XAD-concentration procedure, the authors indicate that the interaction between organisms and pollutants may be under-estimated in the results. A possible impact of the pollutants on the plankton species composition is also suggested.

The authors question the current approach used in remedial policies which focuses on single target groups of pollutants and individual marker substances. Such an approach does not consider the interactions between species and the possible combined effect of chemical, physical and biological parameters affecting aquatic ecosystems.

D.M.J. TUBBING, D. DE ZWART AND T. BURGER-WIERSMA, (1995) Phytoplankton Dynamics in the River Meuse as Affected by Pollution, in The Netherlands Journal of Aquatic Ecology, 29(1), pp.103-116.

FRANCE

EVALUATION OF PHOSPHORUS FROM POINT SOURCES ON A CATCHMENT AREA SCALE

Researchers from the Savoie region in France, have proposed a new model for evaluating phosphorus from point sources in a catchment area. The model distinguishes phosphorus coming from the area itself, sources coming from upstream, and diffuse sources.

The information collected from the application of the model should contribute to developing and adjusting eutrophication control strategies in sensitive areas.

It is difficult, because of the costs involved, to produce a reliable evaluation of point sources of phosphorus for a large area by measuring the flow from each

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source. The rate of transfer of P originating from upstream is also hard to predict since it depends widely on the hydrological and climatic conditions.

Because of these difficulties, a team from INRA (Institut National de Recherche Agronomique) in Thonon, Savoie, France have developed a model which aims at evaluating point sources by measuring the P released during droughts, when point sources are likely to be the predominant input of P into rivers and soluble P represents 90% of total P.

Several conditions are necessary to guarantee the efficacy of the approach, such as a detailed knowledge of the hydrology of the catchment area and of the variability of the P input to the river. In addition, sampling must be done out of flooding periods since phosphorus reaches the sediment, where it forms an important reservoir of P, likely to be released during floods.

During droughts, point sources represent the only significant input of P into the area and their volume is constant, regardless of the hydrological and climatic conditions. In contrast, the volume of diffuse P exported from the area varies with the flow of water. When the water flow increases, the amount of P tends to increase likewise until it reaches a constant value. When this threshold is reached, inputs equal outputs and a reliable measure of P from point sources can be taken.

This method was tested in the Foron catchment areas, a tributary of the Geneva Lake. Weekly figures were considered to be the most reliable since concentrations of P from point sources varies hourly and daily. For an area covering 56, 9 km², the average weekly output of P was estimated at 90 kg.

The authors consider that this approach is applicable to areas with a surface less than 100 km². Any larger than this size, the transfer rate for water becomes too long (more than 24 hours) and the possible error margin is too important for a sampling period of a week.

DORIOZ, J-M. ET ORAND, A. (1996). Evaluation des rejets de pollution ponctuelle de phosphore à l'échelle des bassins versants, in Environnement et Techniques, 153: 61-64 (in French)

NEW BOOK

PHOSPHORUS IN THE GLOBAL ENVIRONMENT
Transfers, Cycles and Management

The Scientific Committee on Problems of the Environment (not to be confused with the organisation SCOPE which edits this newsletter) publishes a compilation of articles on transfers, cycles and management of phosphorus in the environment.

Phosphorus in the Global Environment is the achievement of a major study launched by the Scientific Committee on Problems of the Environment in 1987. Its objective was to improve the understanding of "phosphorus cycles in terrestrial and aquatic ecosystems". Data and research presented during four regional workshops by 240 scientists were summarised during a final workshop held in Hungary in 1993.

We quote below a summary of this highly detailed volume as published by the editor:

"Phosphorus is one of the world's vital but relatively scarce resources, which is a limiting factor in plant (and therefore food and fibre) production. This volume brings together data and concepts on the transfer and transformations of phosphorus.

Although the phrase "biogeochemical cycle" is commonly used to describe the fate of elements of the environment, it has become apparent that for phosphorus, linear transfers from land to rivers to lakes and seas are more typical. In some regions, these transfers are augmented by the addition of mined phosphates and manure, and surplus phosphate needs to be managed with care. Environmental managers need to incorporate an understanding of phosphorus transfers into their decision making.

But the controls on phosphorus transfers through landscapes are complex, and an integrated approach by terrestrial and aquatic scientists is needed to develop such an understanding. The use of water bodies as sensitive and fragile indicators of phosphorus losses from surrounding watersheds is an important step towards a comprehensive scientific approach. Processes which limit plant production are often well understood but socio-economic constraints limit remediation and must form part of a comprehensive approach to phosphorus management."

TIESSEN, H. (1995) Phosphorus in the Global Environment; Transfers, Cycles and Management, in SCOPE n°54, pp460, published by John Wiley & Sons, Chichester.

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SWEDEN

IMPACT OF FISH FARMING ON LAKES' PHOSPHORUS CONCENTRATION

An extensive research project has been conducted in Sweden to evaluate the impact of fish farms on eutrophication phenomena in lakes (see also our previous Newsletter). One of the study's objectives was to see whether phosphorus emissions from rainbow trout farms could be used to reduce mercury and radiocaesium levels in the lakes' fish.

However, no result on this issue could be obtained since no increase in P-concentration had appeared due to fish farming activities. The authors concluded that fish production could be multiplied by 200 without affecting the lakes' trophic condition.

As part of an extensive study on eutrophication phenomenon in Swedish lakes, a group of scientists at the Uppsala University studied the possibility of using phosphorus emissions from fish farms as a way of reducing the high levels of mercury and radiocaesium present in the lakes' wild fish (the theory of "biological dilution.") This hypothesis could not be verified since the expected rise in total P-concentration did not occur.

Conclusions of previous studies had shown that this lack of correlation between fish farming and P-concentration cannot be explained by climate conditions, precipitation or by the hydrology and the chemistry of the lakes. Instead, the reasons likely to explain these results were:

- the uptake of P from trout faeces by wild fish (mainly bream and roach),
- the elimination of phosphorus from the fish feed by bioproduction directly followed by sedimentation, predation through the food chain and transfer downstream.

Data has also shown that no significant primary production resulted from the activities of the fish farms, which seems to indicate that direct uptake of phosphate from the lakes by wild fish was very substantial.

The authors conclude that environmental authorities should review their methods for evaluation of the impact of fish farming on lakes' eutrophication. In addition, they suggested that the tonnage presently allowed by farming permits could be raised from 50 tons/year to 10, 500 tons/year without affecting the lakes.

HÅKANSON, L., CARLSSON, L., JOHANSSON, T. (1995) *Can emissions from fish farms be used as a remedial measure for lakes?* in *Vatten 51*: pp 112-124, Lund (in Swedish.)

GERMANY

OPPORTUNITIES AND CONSTRAINTS IN THE RECYCLING OF NUTRIENTS

This article addresses the question of nutrient recycling. Dr. Joachim Lammel, from the Centre for Plant Nutrition and Environmental Research in Hanninghof, Germany, studies the different components of the recycling nutrients issue (historical, sociological, economical and technical) Several approaches are discussed, particularly:

- Nutrient use and cycling in agriculture
- Demand from society for recycling nutrients
- Recycling of manure
- Recycling of urban waste
- Recycling and the fertiliser industry

With the development of intensive farming the traditional nutrient cycling practices on-farm are no longer appropriate. In Europe the boom of mineral fertilisers means that we can now supply growing urban populations, and has broken down traditional nutrient cycling practices. In order to restore the cycle nutrients need to be used and recycled efficiently. At the same time, in many developing countries, mineral fertilisers are necessary to restore nutrient cycling in depleted soils.

Due to intensive livestock farming, manure is now the main source of nutrients available for recycling, and surpluses are becoming increasingly frequent. The efficient management of this source of nutrients is now the challenge for livestock farmers, particularly in the light of possible proposed legislation limiting the use of mineral fertilisers.

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IN EUROPE

Despite growing public opinion to limit the use of landfill sites the application of urban waste to farmland is not recommended because of the potential content of heavy metals and other harmful substances, unless separate collection of organic waste is implemented. This, however, represents substantial extra costs which may be justified by sustainable arguments such as the saving of landfill space, or recycling of finite resources (eg. phosphate).

The fertiliser industry is the last key element in this process, as it consumes limited resources, such as phosphorus extracted from rock and energy from fossil fuels. Its involvement in the coming debate between farmers and policy makers will finally contribute to closing the nutrient cycle again.

LAMMEL, J. (1995) *Opportunities and Constraint in the Recycling of Nutrients*, paper presented at the International Conference in Cambridge, organised by The Fertiliser Society, Proceedings N°372, Peterborough.

AUSTRALIA

A NEW PROCESS REDUCES THE AMOUNT AND COST OF CHEMICALS USED FOR PHOSPHORUS REMOVAL FROM WASTE WATER.

Alum sludge might contribute to lowering both cost and amount of chemicals used for removing phosphorus from waste water. If the trials conducted by the Centre for Wastewater Treatment at the University of New South Wales at Bowral are successful, this technique could be used throughout Australia.

Alum is normally used as a coagulant in drinking water treatment. This process generates a by-product, alum sludge, which is left to dry in a pond before going to landfill.

The idea promoted by the Department of Land and Water Conservation and the Co-operative Research Centre for Waste Management and Pollution Control consists of reintroducing to waste water the alum sludge from previous treatment.

The main advantage of the *alum re-use process* which uses the same product twice is a reduction of the amount of chemicals used in the chemical recovery processes. This technique is also reported to be more cost-efficient than Biological Nutrient Removal, a

technique considered expensive for small and medium size wastewater works.

Australian Environmental Review (December 95) Vol. 10, n°11:p.13

NORWAY

ASSESSMENT OF COST EFFICIENCY AND SUSTAINABILITY OF WASTE WATER TREATMENT PROCESSES

Cost efficiency and sustainability of different commonly used waste water treatment techniques were evaluated. Results show that among the methods assessed, chemical treatment alone and advanced treatment with chemical pre-treatment rank first with respect to both criteria. The author notes that municipal waste water treatment equipment is often chosen according to national or international treatment standards rather than the quality and self purification capacity of the local receiving water.

The evaluation was based on a treatment plant designed for serving a population of 100 000 people. Five different treatment process were examined:

- Primary (mechanical) treatment
- Secondary (high load biological or chemical) treatment
- Advanced secondary with nitrification (mechanical/biological or chemical/biological)
- Tertiary treatment (mech./biol./chem. or chem./biol.)
- Advanced tertiary treatment including nitrogen removal (mech./biol./chem., chem./biol. or mech./biol.)

The cost of the treatment increases with the sophistication of the technology, which in turn depends on the type of component removed from waste water. Therefore, the cost efficiency was calculated for each single component. For example, secondary treatment and primary precipitation were the most cost efficient techniques with respect to BOD and suspended solids removal respectively. In turn, chemical treatment by primary precipitation was found to have the best ratio for phosphorus removal. Different possible situations were also considered with respect to the impact of sewage water discharge on receiving waters. A cost/impact ratio was calculated using the oxygen consumption potential of each component as well as the likely impact of P and N on

algal growth, under both marine and fresh water conditions.

Two methodologies were used to assess the sustainability of each process:

- the energy and raw material consumption vs each process' potential to reduce oxygen consumption in receiving waters
- the life cycle assessment (LCA) technique, using the SimaPro model.

The results show that direct chemical treatment has a better ratio with respect to cost/efficiency, cost/impact and energy consumption/impact when compared to

biological treatment. The LCA indicator is also favourable to direct chemical treatment. The study also showed that using the biogas resulting from sludge digestion also represents a viable way to increase the treatment sustainability.

The author concludes that water treatment technologies should be selected in the light of cost/benefit criteria. He regrets that "such analyses are rarely carried out and that suitable tools for such evaluations are lacking". Acknowledging the limits of a study presented as an attempt to show a direction for developing evaluation methods", the author recommends that more work be done on developing a reliable model for calculating the impact under different receiving water conditions.

ØDEGAARD, H. (1995) An evaluation of cost efficiency and sustainability of different waste water treatment processes, in Vatten 51:291-299, Lund.

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The SCOPE Newsletter is open to input from its readers across Europe and we welcome all comments or information. Contributions from readers are invited on all subjects concerning phosphates, detergents, sewage treatment and the environment. You are invited to submit scientific papers for résumé, to send comments on the studies mentioned in this Newsletter or other scientific or technical news.

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IN EUROPE

NUMBER SEVENTEEN

APRIL 1996

UNITED KINGDOM p. 2

Carp appear to be a major cause of eutrophication in English sites of special scientific interest

Eutrophic status and symptoms of eutrophication of 102 Sites of Special Scientific Interest in England were examined. Eighty four showed symptoms of eutrophication, a phenomenon attributed primarily to sewage effluent, carp and bream.

SWITZERLAND p. 2

The state of Swiss lakes

The Swiss Federal Office for the Environment, Forests and Landscape published a review of the environmental state of the country's 20 most important lakes.

FINLAND p. 3

Impact of EDTA on toxicity of metals

We publish here below the full text of a letter submitted to SCOPE Newsletter. It presents the results of a study conducted to evaluate the impact of metal complexation by EDTA on toxicity on Photobacterium phosphoreum.

FINLAND p. 4

Factors influencing the service life of home appliances

A study was conducted in Finland for the Consumer Affairs Bureau of the Ministry of Trade and Industry in order to assess the factors influencing the service life of home appliances. As for laundry and dish washing machines, it appears that phosphate free-detergents are responsible for a greater amount of deposit accumulation in the machines than phosphate containing products.

SWEDEN p. 5

Flows and effects of phosphorus in a lake - calibrations and simulations using the LEEDS model

The LEEDS model (Lake Eutrophication, Effect-Dose-Sensitivity model) was used to evaluate the actual impact of fish-farming on Lake Bullaren, Sweden. After calibrating, the multi-criteria model was used to predict the maximum volume of phytoplankton likely to result from the input and circulation of phosphorus. It appears that a significant part of the variability is related to internal dynamic processes and that over-simplistic models such as vollenweider or OECD-type can give totally meaningless predictions.

THE NETHERLANDS p. 6

Selection mechanisms controlling biomass distribution

Water, Science & Technology published a compilation of the papers presented in a conference on Selection Mechanisms Controlling Biomass Distribution between Cyanobacteria, Phytoplankton and Macrophytes Species, held in Noordwijkerhout, The Netherlands, in December 1994.

CANADA p. 6

Autumn leaves gathering in urban areas may contribute to eutrophication

Leaves piled up along roadsides in urban centres may contribute to up to 5 % of the total export of phosphorus from urban catchment. Prompt leaf pickup is recommended in order to prevent aggravation of eutrophication phenomenon.

SCOPE is a non-commercial, non-profit making European association based in Brussels.

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UNITED KINGDOM

CARP APPEAR TO BE A MAJOR CAUSE OF EUTROPHICATION IN ENGLISH SITES OF SPECIAL SCIENTIFIC INTEREST

Eutrophic status and symptoms of eutrophication of 102 Sites of Special Scientific Interest in England were examined. Eighty four showed symptoms of eutrophication, a phenomenon attributed primarily to sewage effluent, carp and bream.

The concept of Site of Special Scientific Interest (SSSI) was initiated by English Nature in order to allow a better understanding and assessment of state and degree of changes of aquatic sites of particular importance. After collecting data from English Nature, the National River Authority, British Waterways, water supply companies and field sampling, the study went on to examine the trophic state and eutrophication symptoms of 102 selected SSSIs.

Of all these sites, 84 % showed symptoms of eutrophication. The occurrence of this phenomenon had changed the conservation interest of the site in 69 cases.

Table 1. Number of SSSIs showing symptoms of eutrophication

OECD Category	Number of SSSIs examined	SSSIs with symptoms of eutrophication
Oligotrophic	2	0
Mesotrophic	13	9
Eutrophic	13	10
Hypertrophic	66	57
Unknown	9	9
Total	102	85

Among the 85 sites affected, untreated sewage effluent discharge was identified as the primary cause of eutrophication in 35 cases, and possibly in 5 additional cases. The second most important cause was the presence of certain fish, mainly common carp and common bream.

These species search for food in the sediment. In so doing, they mobilise nutrients and increase the water body's turbidity. In fifteen cases, external nutrient load appeared unlikely to lead to the symptoms

observed. It is only the presence of large carp (*Cyprinus carpio*) which could explain the appearance of eutrophication problems.

In some sites, the additional presence of bream (*Abramis brama*) also contributed to the phenomenon. Apart from the feeding in the sediment, this last species is known for feeding on zooplankton during the first year of life, which has a direct impact on phytoplankton grazing and regulation.

The symptoms of deterioration were observed mainly among the plant communities. The authors mention, however, that this may simply be due to the fact that plants are more frequently monitored than animal communities.

The authors recommend that :

- sewage effluent be diverted or treated with phosphate removal in at least 30 cases,
- biomanipulative measures including carp removal be implemented in 18 cases,
- systematic monitoring of SSSIs for the effect of eutrophication be carried out.

L. Carvalho, B. Moss, The current status of a sample of English Sites of Special Scientific Interest subject to eutrophication, in Aquatic Conservation: Marine and Freshwater Ecosystems, Vol. 5, 191-204, 1995.

SWITZERLAND

THE STATE OF SWISS LAKES

The Swiss Federal Office for the Environment, Forests and Landscape published a review of the environmental state of the country's 20 most important lakes.

This document is divided into 3 parts, one containing a review of basic limnology principles, one addressing the question of waste water treatment, protection and rehabilitation of lakes and the last one presenting the 20 lakes, with respect to their environmental status.

SCOPE NEWSLETTER

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The chapter on limnology devotes a large part to the question of thermal exchanges, lake stratification and to the role of nutrients. As an illustration of the complexity of these processes, the report describes how excessive consumption of oxygen from deep waters, due to enhanced primary production in surface layers, can trigger chemical reactions in the sediment which, in turn, provokes an important release of phosphorus.

The report discusses protection and remediation measures applied in Switzerland. Phosphorus removal from waste water by simultaneous precipitation was made mandatory in all waste water treatment (WWT) plants of lakes catchment areas in 1971. Some WWT plants located in the most sensitive areas are equipped with flocculation/filtration systems which allow a 90% phosphate recovery efficiency.

The report indicates that the amount of phosphorus in domestic waste water before treatment was reduced by 30% after the introduction of a detergent phosphate ban in 1986.

Despite the measures implemented, it is concluded that, because of the high amounts of P present in the sediment, a return to the "natural" state is often impossible by simply reducing the nutrient input to the lakes, even when conditions are favourable. In most cases, internal measures such as deep water recirculation, introduction of low nutrient containing water and oxygenation are necessary to prevent P release from the lake beds.

The Swiss lakes are divided into 3 groups:

- Oligotrophic lakes with a phosphorus concentration between 3 and 30 $\mu\text{gP/l}$. At these concentrations, the oxygen present in deep waters and sediment is abundant enough to effectively transfer P from water to the sediment.
- Lakes with a medium to heavy P load, with a concentration between 30 and 60 $\mu\text{gP/l}$. P concentrations in these lakes have been decreasing due to remedial measures in their catchment areas.

Lake Lemman and Zurich belong to this group. Their upper layer of water, where primary production occurs, is low in phosphorus content when compared to the lowest layer. Although a

complete mixing of the lake water is very unlikely to happen due to the lakes' morphology, major climatic change could provoke this mixing and increase the presence of nutrients in the phototrophic layer.

- Very heavily loaded lakes with a phosphorus concentration between 90 to 140 $\mu\text{gP/l}$. They belong to areas with a very high population concentration or intensive farming. In this last case, it is very unlikely that the lakes will rapidly move towards the second group.

As a conclusion, the authors consider that the environmental status of the Swiss lakes has greatly improved since the seventies but acknowledge that P reduction measures did not always reach the set objectives. Agriculture is now considered the major source of pollution. They also warn about the likely adverse consequences of a long term warming of the lakes' temperatures.

Office Fédéral de l'Environnement, des Forêts et du Paysage, L'Etat des Lacs Suisses, Cahier de l'Environnement n° 237, Berne, 1994.

FINLAND

IMPACT OF EDTA ON TOXICITY OF METALS

We publish here below the full text of a letter submitted to SCOPE Newsletter. It presents the results of a study conducted to evaluate the impact of metal complexation by EDTA on toxicity on *Photobacterium phosphoreum*.

Among a number of industrial applications, Ethylenedimineacetic acid (EDTA) is used as an additive to substitute for polyphosphate in cleaning formulations. In external waste treatment, it is known for having a low reduction capacity and for increasing heavy metal concentration in waste water effluents by forming cyclic, water-soluble chelates with metal ions. Thus, a high percentage of EDTA is released into natural waters.

As a nitrogen containing compound, EDTA might constitute a source of nutrient for aquatic algae under certain circumstances. EDTA also increases general permeability, releasing calcium ions from cell membranes.

The presence of EDTA was monitored in pristine waters of Central Europe. Concentrations between 1-80 µg/l were found, which are not likely to cause acute toxic effects. On the other hand very little is known of the long-term toxicity of EDTA.

In this study, the toxicity of several heavy metals was investigated after complexation by EDTA. Microtox bioassay, based on measuring the bioluminescence of *Photobacterium phosphoreum*, was used as an indication of toxicity. The reproducibility of data revealed correlation coefficients between 0.983-1.000.

The results suggest that complexation by this chelating agent increases the toxicity of iron, has very low or no influence on the toxicity of Cu, Cd and Hg, and reduces noticeably the toxicity of Zn and Pb. The slopes of the dose-response curves were steeper for metal complexes than for metals, suggesting that toxicity mechanisms change during complexation.

The inhibitory effect of EDTA on metal toxicity is explained by the binding of the reactive sites of heavy metal ions, thus preventing their normal action.

Mika Sillanpää, Letter submitted to SCOPE NEWSLETTER, Laboratory of Inorganic and Analytical Chemistry, Helsinki University of Technology, January 1996.

FINLAND

FACTORS INFLUENCING THE SERVICE LIFE OF HOME APPLIANCES

A study was conducted in Finland for the Consumer Affair Bureau of the Ministry of Trade and Industry in order to assess the factors influencing the service life of home appliances.

As for laundry and dish washing machines, it appears that phosphate free-detergents are responsible for a greater amount of deposit accumulation in the machines than phosphate containing products.

The trial involving the comparison of phosphate-containing and phosphate-free detergent started after a questionnaire distributed to appliance repairmen revealed that faults in washing machines had increased after the introduction of phosphate-free products.

The tests were conducted in 4 separate districts corresponding to water hardnesses ranging from 2°dH to 7°dH. Two hundred washes were done, which corresponds to a year's use. The assessment of the impact on washing machines was performed by a service expert group, in the presence of representatives of detergent companies.

The trials showed that the use of P-free detergents increases the level of encrustation on both dish and laundry washing machines.

Furthermore, with dishwashers, a film was formed on the surface of the dishes when P-free detergents were used. This did not occur with phosphate containing brands.

As for laundry washing machines, tests showed a slightly higher in-machine deposition with P-free products but the difference with P-containing ones was not as marked as for dishwashers. The most obvious precipitation appeared in the drain hose.

It is stated that more tests are needed to reach a final conclusion since only one kind of washing machine was used and a limited number of detergents were tested. However, these results clearly suggest that both the type of builder and the water hardness influence the number of problems in washing machines and dishwashers.

A. Reisbacka, A. Rytönen, Factors influencing the service life of home appliances, work carried out by the Working Efficiency Institute (Finland) for the Ministry of Trade and Industry, TTS-Institutes publication 341/1995, ISBN 951-788-3, 245 p., 1995.

SCOPE NEWSLETTER

IN EUROPE

SWEDEN

FLOWS AND EFFECTS OF PHOSPHORUS IN A LAKE - CALIBRATIONS AND SIMULATIONS USING THE LEEDS MODEL

The LEEDS model (Lake Eutrophication, Effect-Dose-Sensitivity model) was used to evaluate the actual impact of fish-farming on Lake Bullaren, Sweden. After calibrating, the multi-criteria model was used to predict the maximum volume of phytoplankton likely to result from the input and circulation of phosphorus. It appears that a significant part of the variability is related to internal dynamic processes and that simplistic models such as Vollenweider or OECD-type can give totally meaningless predictions.

Lake Bullaren is in the middle of a controversy related to the possible impact of fish farming on the trophic status of the lake. The LEEDS model is presented as "time dependent, generic-dynamic model which accounts for all major processes regulating the distribution and effects of phosphorus in lakes.

In order to calibrate the model, data were gathered on amounts, fluxes and concentrations of phosphorus in the lake. From this step on, predictions of the maximum volume of phytoplankton (target effect variable) were made on a monthly basis.

Dissolved and particulate P, stratification, sedimentation, re-suspension/advection, diffusion, bioturbation, predation, fishing, mixing and mineralisation are among the parameters accounted for by the LEEDS model, as well as the different P sources feeding the lake.

The study focused primarily on providing:

- the quantification of internal loading,
- a phosphorus budget (amounts and fluxes),
- indications on the effects of seasonal variations on the input of P,

- a new format for environmental consequences analysis, with special attention to the volume of phytoplankton and extreme climatic conditions,
- a better understanding of the processes regulating recovery after an hypothetical extreme eutrophication.

Among the results of the study, it appears that:

- About 5 % of the P contained in the active surface of the sediment - which accounts for 90% of the P in the lake - is transported each year to the productive surface waters.
- Of the three primary phosphorus inputs, 72% comes from the in-flowing waters (natural P-flow and agriculture), 25% from the fish farm and the remaining 3% from the rain.
- The exchange of phosphorus through sedimentation, resuspension and diffusion is very extensive. The P flow from the sediment corresponds to almost half the total weight of P external input.
- Lake Bullaren could probably tolerate a fish production of 1 000 tons a year, while the present permit allows only 70 t/year.

It is suggested that the controversy surrounding fish farming activities on Lake Bullaren are based on an over-simplistic understanding of phytoplankton regulation phenomenon derived from the application of models such as Vollenweider or OECD-types, qualified as very crude and not adapted to a case like Lake Bullaren.

L. Hakanson, L. Carlsson, Flows and effects of phosphorus - Calibration and simulations using the LEEDS-model in Lake Bullaren, Sweden, Vatten 51, 183-218, Lund 1995.

THE NETHERLANDS

SELECTION MECHANISMS CONTROLLING BIOMASS DISTRIBUTION

Water, Science & Technology published a compilation of the papers presented in a conference on Selection Mechanisms Controlling Biomass Distribution between Cyanobacteria, Phytoplankton and Macrophytes Species, held in Noordwijkerhout, The Netherlands, in December 1994.

This conference paid particular attention to the changes occurring in the phototrophic compartment of aquatic ecosystems. The conference was organised by the International Association for Water Quality and the International Association of Theoretical and Applied Limnology. In total, 82 scientists from 19 countries participated in this conference.

37 papers were presented covering 5 separate fields:

- Light Climate and Hydrodynamics
- Nutrients
- Physical and Chemical Factors
- Biological Interactions
- Physical, Chemical and Biological Interactions.

The conference confirmed that the mechanisms of the major ecological factors influencing competition and succession are well known and that the understanding of the contribution of each factor is rapidly growing.

The conference has also demonstrated that strategies focused on reduction of external nutrient alone are often not sufficient enough to restore eutrophied waters and that an integrated approach is necessary.

In this approach, biological and physicochemical factors must be accounted for in order to enable more balanced water management practices. Stronger co-operation between technologists and biologists is also recommended.

L.R.Mur, P.M. Visser and H. Reith, Selection Mechanisms Controlling Biomass Distribution, introductory paper by C. Reynolds, in Water Science & Technology, Vol. 32, N°4, 1995.

CANADA

AUTUMN LEAVES GATHERING IN URBAN AREAS MAY CONTRIBUTE TO EUTROPHICATION

Leaves piled up along roadsides in urban centres may contribute to up to 5 % of the total export of phosphorus from urban catchment. Prompt leaf pickup is recommended in order to prevent aggravation of eutrophication phenomenon.

Laboratory experiments were conducted by the Department of Biology at McGill University, Montreal, to evaluate the amount of phosphorus exported by water leaching through birch and trembling aspen leaves.

In southern Canada, plant litter represents from 200 to 800g/m², a possibly significant nutrient supply to receiving waters. The amount of P exported to gutters and rivers can be substantial depending on the length of the period between leaf gathering and pickup.

The objective of this study was to assess the amount of total phosphorus released per g of dried and non-dried leaves placed in flasks containing distilled water.

Analysis of samples extracted from the flasks after one week showed a strong linear relation between P release and leaf mass. Based on average litter fall in southern Canada, it is estimated that fallen leaves can contribute 11 to 45 mg of total P per m², which represents up to 5% of the total export of total P from urban areas.

No significant difference was observed between total P concentrations of samples from dried and non-dried leaves.

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H. Culbert, R. France, Laboratory Prediction of Phosphorus Release from Deciduous Leaves to Urban Runoff, Water Quality Res. J. Canada, Vol. 30, N°2, 243-246, 1995.

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November 1995

SCANDINAVIA p.2

Revision Of The Nordic Environmental Label

Three years after the adoption of its first version, the revised *Nordic Swan Label* is more severe on most detergents' components, but reverses its earlier position on phosphates. Completely excluded in the 1992 version, phosphate containing detergents can now apply for and obtain the Nordic environmental label.

SWEDEN p.3

Swedish Water Treatment Experts Compare Phosphate-Based And Phosphate-Free Products

"The use of phosphate based detergents means lower organic loading, lower ecotoxicity to micro organisms, lower concentration of suspended solids and a lower oxygen consumption in municipal sewage treatment plant "

This statement was made in a report published by VA-FORSK, a research programme managed by VAV, the Swedish Water Association. The report is entitled: *Laundry detergents: Effects on waste water treatment and the environment*,

UNITED KINGDOM p.5

Phosphates Used To Restore Acidified Lakes

Tests conducted by researchers at the Institute of Freshwater Ecology and Lancaster University reveal that phosphates can be used to control lake acidity.

FRANCE & SWITZERLAND p.6

Evolution Of Phosphorus And Biomass Concentration In Lake Geneva.

Both phosphorus and biomass concentrations decreased in 1994. Biomass concentration still remains higher than values recorded from 1989 to 1991. The International Commission for the Protection of the Lemman Waters (CIPEL) announces that 87 % of the population of the lake's catchment area is now connected to waste water treatment plants.

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SCANDINAVIA

REVISION OF THE NORDIC ENVIRONMENTAL LABEL

Three years after the adoption of its first version, the revised *Nordic Swan Label* is more severe on most detergents' components, but reverses its earlier position on phosphates. Completely excluded in the 1992 version, phosphate containing detergents can now apply for and obtain the Nordic environmental label.

After the revision of the Nordic environmental label, applicable in the Spring of 1996, only about half the products already labelled will pass the new criteria.

To the Swedish Standards Institution (Standardiseringen i Sverige - SIS), which is responsible for developing the Nordic Swan for household laundry detergents, the idea behind the label, presented as an educational instrument, is to encourage manufacturers to formulate increasingly environmentally sound products. Today, 84 % of the Swedish consumers favour Swan-labelled products.

The two other environmental labels used in Scandinavia also allow a certain amount of phosphate in detergents.

The new criteria for household laundry detergents cover more parameters and all the ingredients are assessed. The volume of zeolites, a phosphate substitute, is now taken into account.

Requirements on dosage and efficiency are also established. The Swedish National Board for Consumer Policies produced a test method for measuring washing efficiency at the recommended dosage.

Phosphates reassessed

"We have reassessed the issue of phosphates", says Magnus Hedenmark, ecotoxicologist at SIS. This assessment led to the decision that "a detergent can have the Swan ecolabel and contain a certain amount of phosphate".

The decision by SIS follows the position adopted by the European Commission, which also allows phosphate containing products to apply for the recently adopted European Ecolabel for household laundry detergents.

The first version of the Nordic label excluded all phosphate containing detergents. Back in 1992, this decision had provoked reactions from water treatment authorities and associations like the Swedish Nature Conservation Society, which disagreed with the exclusion of phosphates.

The Swan label applies to products sold in Finland, Iceland, Norway and Sweden.

Eco-labelling of detergents for textiles, Criteria document 1992/03/94 - 1999/04/04, Version 3, SIS Miljömärkning, SIS-Standardiseringen i Sverige, P.O. Box 3295, S-103 66,, Stockholm., Sweden.

SWEDEN

**SWEDISH WATER TREATMENT
EXPERTS COMPARE PHOSPHATE-
BASED AND PHOSPHATE-FREE
PRODUCTS**

"The use of phosphate based detergents means lower organic loading, lower ecotoxicity to micro organisms, lower concentration of suspended solids and a lower oxygen

consumption in municipal sewage treatment plant "

This statement was made in a report published by VA-FORSK, a research programme managed by VAV, the Swedish Water Association. The report is entitled: *Laundry detergents: Effects on waste water treatment and the environment,*

Water samples from 27 household laundry detergents were tested in order to evaluate the chemical parameters and the toxicity of each product. The detergents were divided into 3 groups, depending on the builder system used :

- phosphate based powder detergents,
- phosphate-free powder detergents,
- liquid detergents without phosphates.

The study comes to the following conclusions:

Suspended solids

The concentration of suspended solids is on average 10 times higher in the effluents of phosphate-free products than in phosphate based detergents (see fig. 1). The use of phosphate substitutes leads to the production of larger amounts of sewage sludge, which

must be disposed of by incineration or in landfill sites.

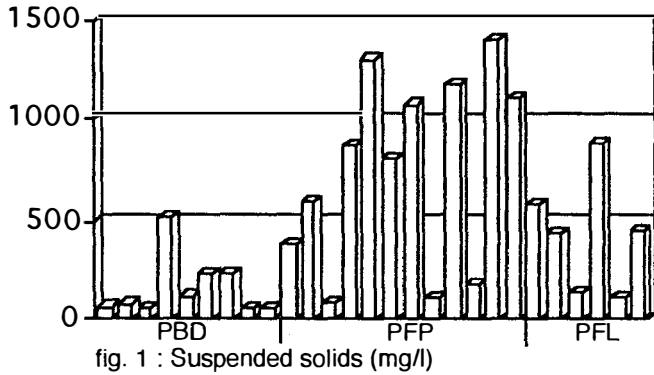


fig. 1 : Suspended solids (mg/l)

In contrast, phosphate is the only detergent builder which can be recovered in sewage plants and recycled, therefore increasing the possible exploitation of this resource. On the other hand, the use of phosphate leads to larger consumption of flocculating agents in sewage treatment, when enhanced biological treatment is not applied.

Concentration of organic material and ecotoxicity

Phosphate based detergents produce the effluent with the lowest concentration of organic material (measured in TOC (see fig. 2) and DOC¹). The release of organic material leads to a consumption of oxygen (BOD) in the effluent from the washing machine three times higher when phosphate-

free powders are used instead of phosphate based powders. The Biological Oxygen Demand (BOD) is six times higher when phosphate-free liquid detergents are used (see fig. 3).

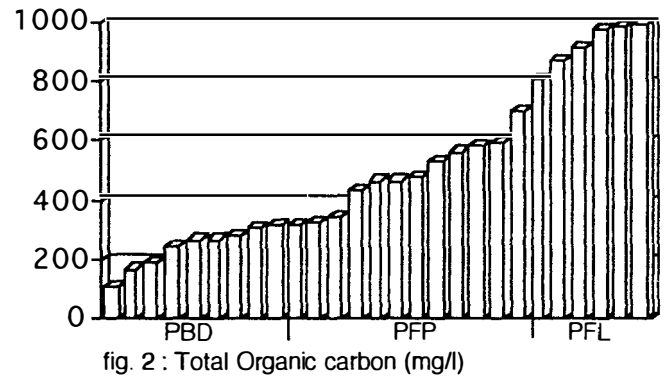


fig. 2 : Total Organic carbon (mg/l)

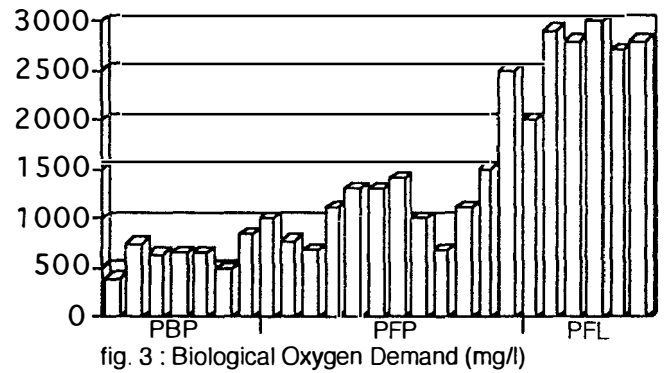


fig. 3 : Biological Oxygen Demand (mg/l)

The ecotoxicity towards micro-organisms generally follows the content of organic carbon (TOC). Therefore, there are large differences between the detergents tested. Liquid detergents without phosphates appear to have the highest potential impact, with respect to this parameter (see fig. 4).

¹ TOC and DOC stand for Total Organic Carbon and Dissolved Organic Carbon.

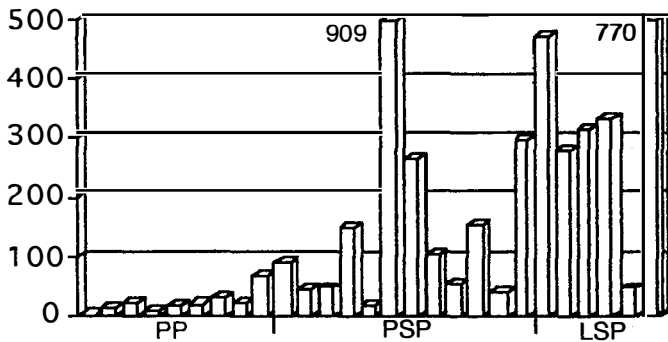


fig. 4 : Ecotoxicity (measured according to the microtox method) LC50 (15 min.)

Cajsa Wahlberg, VAV - VA-Forsk, Tvättmedel - effekter på reningsverk och miljö, Stockholm Vatten, 1995.

UNITED KINGDOM

PHOSPHATES USED TO RESTORE ACIDIFIED LAKES

No long term environmental impact

The report notes "that most ecolabeled products are easily degradable". Among the products tested, none or very little ecotoxicity could be detected after 14 days of degradation, with the exception of one product which is no longer on the market.

The potential ecotoxicity will rapidly disappear as the surfactant degrades, and the risk of any long term environmental effects will be eliminated, says the report.

The study was conducted assuming that advanced waste water treatment is implemented. Therefore, no assessment is made of the possible environmental impact of ecotoxicity, when sewage water is discharged directly into the natural environment.

Tests conducted by researchers at the Institute of Freshwater Ecology and Lancaster University reveal that phosphates can be used to control lake acidity.

A series of tests were conducted from 1992 to 1993 in Seathwaite tarn, in Northern England Lake District, in order to determine the ability of phosphate fertilisation to control lake acidity. Many lakes are dramatically acidified by airborne pollutants generated by combustion from industrial and transportation activities.

The traditional approach to lake acidification consists of adding lime to lower the pH value of the water. This technique, however, tends to provoke a modification of the plant and animal communities naturally present in the lakes. The original species are often unable to

cope with the excessive concentration of calcium and are rapidly replaced by more tolerant species, thus modifying the natural composition of the ecosystems.

The idea of using phosphates to control lake acidity is supported by the fact that phytoplankton productivity can act as an important buffer of soft water. The phytoplankton feeds on nitrate ions which are largely responsible for lake acidity.

The experiment showed that the phosphorus added to the lake in the form of fertiliser is rapidly assimilated by growing phytoplankton. For each mole of phosphate, 16 moles of nitrate nitrogen are consumed. This ratio illustrates that very low quantities of fertiliser are needed to obtain satisfactory results in terms of pH increase without affecting the community structure.

The corresponding increase of phytoplankton chlorophyll was due to " the rapid growth of small species that are commonly referred to as nano-plankton".

In turn, "these species are consumed in large numbers by tiller-feeding crustacean which greatly accelerate the rate at which the fixed carbon is deposited in fixed sediments.

The authors conclude that "phosphate can have beneficial effects within the environment, and that the complete elimination may enhance problems of low productivity and acidity.

W. Davison, D.G. George & N. J. A. Edwards, Controlled reversal of lake acidification by treatment with phosphate fertilizer, in Nature, vol. 317, october 1995.

FRANCE & SWITZERLAND

EVOLUTION OF PHOSPHORUS AND BIOMASS CONCENTRATION IN LAKE GENEVA.

Both phosphorus and biomass concentrations decreased in 1994. Biomass concentration still remains higher than values recorded from 1989 to 1991. The International Commission for the Protection of the Lemman Waters (CIPEL) announces that 87 % of the population of the lake's catchment area is now connected to waste water treatment plants.

SCOPE NEWSLETTER

IN EUROPE

Phosphorus content of the Lake has regularly decreased since 1981, to reach a 45 micrograms per litre concentration. Meanwhile, however, the biomass concentration has not followed a regular decreasing curve.

As of in 1989, the biomass stopped decreasing. Instead, the period from 1989 to 1993 showed an unexpected increase of phytoplankton density. During the latest year

of observations, biomass had decreased again but was still higher than the lowest value reached in 1989.

In the light of this data, it is difficult to define whether the evolution of the biomass during the last year is part of a decreasing trend, or if it must be considered as an exception in a general stabilisation of the Lake's phytoplankton density.

The regular decrease in phosphorus concentration is the result of an extensive phosphorus control programme. This programme includes:

- the installation of waste water treatment for almost the entire population surrounding the lake (85%),
- the control of phosphorus release by industries,

- the closing or modification of pig farms,
- the increase of storage facilities for manure produced by cattle farms.

The changes observed in the lake phytoplankton show that eutrophication and related negative effects are diminishing. This evolution, however is still considered insufficient.

1994 primary productivity is regarded as quite low. The very low value registered during the spring is thought to be due to a very short period of sunshine.

Rapport sur les études et recherches entreprises dans le bassin lémanique, Campagne 1994, Conseil Scientifique de la Commission Internationale pour la Protection des Eaux du Léman, 1995.

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