

Detergent phosphates : a sustainable detergent component

A natural element, essential for human health

Phosphorus (P) is an **essential element for all living organisms**: man, animals and plants. In man, phosphorus is necessary for human health : phosphorus compounds make up the structure of bones and teeth and are fundamental to the transfer of energy within cells, and thus to all body functions, from thought through to motion. Phosphorus is an essential element in DNA (genetic material) and in many proteins.

Phosphorus is naturally present in foods and is taken into the body as phosphates, the minimum intake requirement for adults is approx. 0.8gP/day but the actual dietary uptake is generally closer to 2-3 gP/day.

Phosphates are also added both to animal feeds and to certain baby foods to improve their nutritional value.

In plants, phosphorus plays an essential role in photosynthesis and all energy recovering processes.

Phosphates are also one of the main nutrients in almost all agricultural and garden fertilisers, because they are crucial for plant growth. It is because phosphates contribute to plant growth that, in certain particular circumstances, their release into surface waters (lakes, rivers, coastal waters ...) may result in the environmental problems.

Phosphates are generally a “good thing” for both animals and plants, and their use in detergents certainly poses neither a health nor a toxicity risk : almost uniquely amongst chemicals, because of their natural role in the body, there is safety confidence.



The only potential risk related to the use of phosphates is that of “eutrophication”. This means nutrient enrichment of surface waters: increased inputs of the plant growth enabling fertiliser elements (in particular nitrogen and phosphorus). This can sometimes be “too much of a good thing”, resulting in “eutrophication problems” caused by an excessive development of vegetation (generally of the microscopic floating plants, algae).

To what extent is phosphate use related to eutrophication problems ?

In many cases phosphate inputs to surface water will have no effect : **an increase in one nutrient will not effect plant growth where this is being limited by other factors** (lack of another nutrient such as nitrogen or silicate, temperature, light, water movement ...). Also, there may already be significant concentrations of phosphate in surface waters (for example from agricultural sources or from natural bed-rock), so that the addition of detergent phosphates will have little effect because plants already have available adequate phosphate for their growth.



In other cases, if increased plant growth does occur, it will simply result in **increased fish production** (through feeding on increased vegetation) without upsetting the ecological balance, to the benefit of leisure and industrial fishing. In many North American lakes (eg. recently Lake Erie), reductions of nutrient inputs, resulting mainly from improved sewage treatment, have led to significantly reduced fish catches.

Will P-free detergents improve surface water quality ?

Where increasing nutrient concentrations in surface waters do result in increased plant growth this is often predominately algae (microscopic floating plants). In particular circumstances, this can lead to problems because of **“algal blooms”** which can turn water green or clog drinking water plants. If algae then die, sink and decompose, this can cause depletion of oxygen in the water and in extreme cases lead to fish deaths. Water management to avoid such problems can target

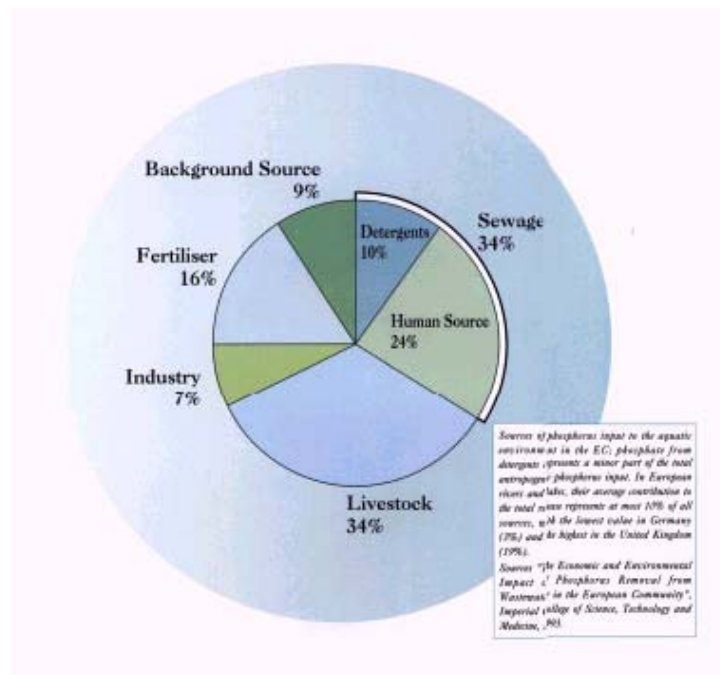
reductions in nutrient inputs, but must also address problems of ecological balance or physical conditions (such as slow water flow caused by dams and weirs). Furthermore, agricultural and natural phosphate sources (soil erosion, animal manure, run-off, natural bed-rock) can be sufficient for algal development irrespective of sewage and detergent phosphates, so that only general restoration of the water body and its water shed can restore ecosystem balance (eg. the recent national [“Phosphorus in the Landscape”](#) report, Australia).

In natural systems, an increase in algal development will often be balanced by grazing by zooplankton (microscopic aquatic animals, which in turn provide a food source for fish). This balance can be upset by **toxins** present in the water affecting the zooplankton (toxins can come from agro-chemicals, industrial discharges or inadequately treated sewage), or by excessive predation of the zooplankton resulting from artificial fish stocking. Restoration programmes can address such problems (eg. Norfolk Broads, UK).

In many cases, a move to P-free detergents may thus not lead to significant improvements of eutrophication problems, because of nutrients from other sources combined with physical factors and ecosystem modifications. This seems to be the case in countries which have moved to phosphate-free detergents, such as the USA, Italy, Japan, where eutrophication problems have not been resolved by this move.

There is no point in using P-free detergents without addressing sewage treatment ...

Detergents only contribute **11% of total phosphate input to European surface waters**, with 23% coming from human wastes in sewage, 49% from agriculture, 7% from industry and 10% from natural bed-rock erosion. (Morse, Imperial College London, 1993)



It is generally estimated that where phosphates are used in detergents, this contributes **less than one third of the total phosphates in sewage**, the remainder coming from human and food wastes and other organic material.

This means that even where sewage phosphate is contributing to eutrophication problems, moving to P-free detergents will not resolve the problems : **irrespective of detergent formulation, it will still be necessary to install phosphate removal in sewage works** (and install adequate sewage collection and treatment, of course) to remove the phosphates in human wastes.

... and in any case, EC legislation makes phosphate removal from sewage obligatory wherever phosphates are a potential problem

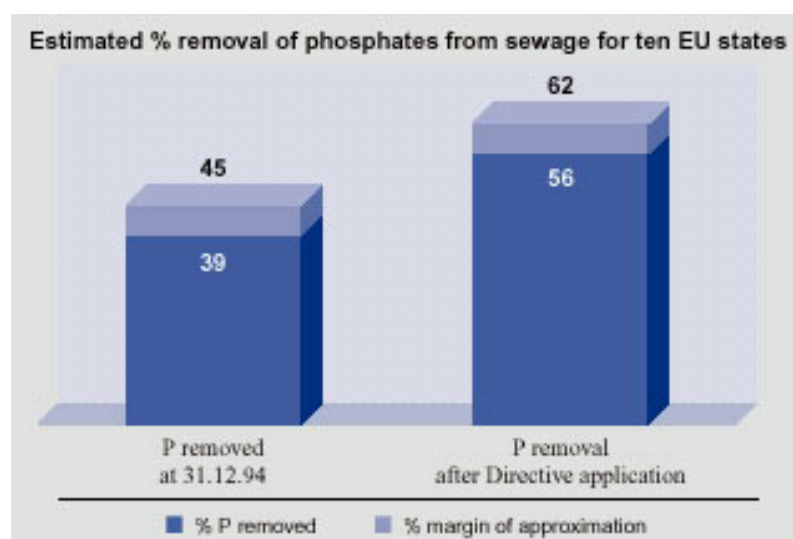
The European Union “**Urban Waste Water Treatment**” **Directive 91/271** renders obligatory the collection of sewage and the removal of phosphate in sewage works for all agglomerations of more than 10,000 “person equivalent” (ie. population of 6 – 8,000) discharging into eutrophication “sensitive areas”, that is “eutrophic or which may in the near future become eutrophic”. The Directive also requires that “appropriate” treatment be installed for smaller agglomerations.

This Directive thus effectively requires that phosphates be removed from sewage wherever they pose, or are susceptible to pose, environmental problems, including for small villages where appropriate.

Phosphate removed in sewage works are transferred to sewage sludge, where they significantly enhance its agricultural value where spreading on farmland is possible. Work is also currently underway to recover phosphates from sewage works elsewhere for recycling – see below.

It should be noted that the small residual discharge of phosphates from sewage works fitted with phosphate removal is not dependent upon phosphate inflow concentrations, but on operating parameters, so that the use or not of detergent phosphates will not modify the discharge quantities.

The general deadline for application of phosphate removal was 31st December 1998. This deadline is far from having been respected in certain member states. Roughly 30% of the phosphate removal capacity which will result from full implementation of the Directive is still outstanding ([IEEP, 1999](#)).



However, the European Commission has confirmed its intention to enforce implementation of the Urban Waste Water Treatment Directive (1998) and its obligations are maintained in the proposed Water Framework Directive.

Thus, in the relatively near future with implementation of the EU Directive, detergent phosphates will be removed from sewage before discharge into surface waters in all situations where they would be susceptible to contribute to eutrophication problems : the question of the environmental impact of detergent phosphates will thus be resolved.

Why add phosphates to detergents then remove them in sewage works ?

It is pertinent to compare the overall environmental implications ([life cycle analysis](#)) of detergent phosphates with those of P-free detergents, and in particular to compare the cost of removing an extra quantity of phosphates (detergent phosphates in addition to human sources) in sewage works with that of removing substitutes.

Life cycle analyses have been carried out for both phosphates and P-free detergents, (Landbank, EMPA) and conclude differing areas of environmental impact, but do not conclude that one product is identifiably better.

Regarding removal in sewage works, phosphates can be removed either by chemical precipitation or by biological techniques (which also allow nitrogen removal).

Chemical precipitation is very easy to operate and involves little investment, but there is a cost for purchasing precipitant chemicals (often iron) and the sewage sludge volumes are increased. Biological systems can also be used to remove phosphates, often at the same time as dissolved nitrogen, but these systems require a higher initial investment and more complex operating know-how. Where phosphate removal in sewage works is not necessary, because the installation discharges into surface waters which are not sensitive to nutrient enrichment, there is no cost or sludge increase. Where P-free detergents are used, 0.7g of phosphates (STPP) is equivalent to approximately 0.9g zeolite plus 0.2 g polycarboxylates. **Both these products will be transferred in sewage treatment to the sewage sludge in all sewage works, implying a significant increase in sludge volumes** (approx. 135,000 tonnes/year dry matter or roughly 4.5 million litres or raw sludge) if France were to move to exclusively P-free detergents, for example).

Sewage sludge disposal is now the biggest single operating expense for most European water companies, with costs usually averaging 150 Euros/tonne dry matter, and rising. Sludge volumes will become an even more important sewage works management issue with application of the recent (July 1999) EU Landfill Directive which imposes over a 15-19 year horizon a 65% reduction in biodegradable waste going to landfill.

The overall economic balance between sewage operating costs for P-based or P-free detergents will thus depend on sludge generation, on the choice between biological or chemical phosphorus removal and on the proportion of sewage works in which P-removal is not necessary (but where substitutes, on the other hand, will nonetheless be transferred to sludge).

Sludge volumes in Switzerland are estimated to have increased significantly by around 15,000 tonnes/year dry matter when the country moved to P-free detergents (source: EWAG, July 1997).

The cost and environmental balance of phosphate removal from sewage may be significantly improved in the future with the [development of phosphate recovery for recycling](#), which will effectively convert sludge production into a valuable re-

usable resource. The substitutes used in P-free detergents are not feasibly recyclable.

Phosphates : the only recyclable detergent ingredient

CEEP, the European detergent phosphate industry, the fertiliser industry and major water companies from a number of EU countries have submitted a proposal to the European Commission for research and development of processes to recover phosphates from sewage for recycling and reduce the use of imported mined mineral phosphate rock. Phosphates can not only be recovered from sewage works operating phosphate removal, but also from animal manures. They can be recycled back into industrial products, detergents and fertilisers. **Phosphate recovery for recycling is certainly feasible.** A recent study by the water treatment engineering consultants CH2M Hill (published in "Environmental Technology") suggests that the resulting reductions in sewage sludge volumes and the value of the recovered phosphate product for recycling could cover related sewage works operating and investment costs (depending on sludge disposal options and costs). **A number of full scale or pilot recovery installations are already operational in sewage works in several countries and the industrial use of recovered phosphates has been successfully tested** (sewage phosphates are currently recycled into industrial products at Vlissingen, Holland and in Japan). The research now being launched aims to develop pathways to achieve recovery for recycling under economic conditions compatible with widespread development by the water industry.

The European detergent industry has fixed an objective that 25% of detergent phosphates should come from recycling within a decade. This places phosphates in a unique position as a potentially sustainable detergent component.

For the consumer, phosphates wash better, wash cheaper, use less detergent

It is quite possible to formulate P-free detergents which wash just as well as P-based ones. However, because phosphates offer a number of different functions in detergents (neutralising hard water, preventing redeposition, buffering, physical properties ...see attached), P-free detergents "on average" tend to offer a less effective wash or imply the consumption of greater quantities of other ingredients, in particular surfactants (generally estimated at +5 to +15%). This is confirmed by the performance tests of a range of European detergents carried out by independent laboratories for CEEP.

It is also confirmed by the definition of criteria for **laundry detergent "green labels"**. Both the Scandinavian "White Swan" ecolabel, the Thailand green label scheme, and the recently updated European Union Ecolabel for laundry detergents (Commission Decision 1999/476/EC) authorise the inclusion of phosphates in eligible detergents (both up to approx. 27% phosphates).

Phosphates are the optimal builder component not only for traditional laundry detergent powders, but also for "compacts", and particularly for the **new "tablet" formulations**. Phosphates offer rapid solubility and dispersion properties which mean they make an effective basis for tablets, whereas P-free tablets are difficult

