PHOSPHATES IN DETERGENTS – Cleaning up our act

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Can removing phosphate from laundry detergents make a meaningful difference to nutrient enrichment problems? Article by Leo Quayle.

The shockingly green pictures of Hartbeespoort Dam algal blooms have, for a long time, set the visual scene for studies and articles addressing the subject of the excessive amounts of nutrients we are pouring into our rivers and dams. Although almost synonymous with it, algal blooms and nutrient enrichment problems are not unique to Hartbeespoort, and managers of impoundments around the country are noticing rising levels of chlorophyll *a* in their water quality samples.

A related subject that has also often been discussed is the contribution that powdered laundry detergents make to this problem. In fact, in South Africa, about 23% of a laundry detergent's mass is made up of sodium tripolyphosphate (STPP). This ingredient's jobs is to act as a water softener and to bind up ions which reduce the effectiveness of the detergent.

However, when it is mixed with water, STPP quickly hydrolyses to ortho-phospate (or soluble reactive phosphate – SRP), a nutrient which is important to the growth and survival of all living organisms. In simple terms, adding additional SRP to water bodies allows aquatic plants and algae, in particular, to grow significantly quicker and in greater abundance than they would be able to without it, hence the green hues of Hartbeespoort Dam.

FINDING A SUBSTITUTE

This fact has not been overlooked by several countries around the world, where the banning or limitation of this ingredient from detergent production has reportedly resulted in some reductions in nutrient-related water problems. A variety of substitute ingredients has been identified, and has been in use for quite some time now.

The most commonly used is a combination of anhydrous zeolite-A (a crystalline alumnosillicate) and soda ash. In a study funded by the Water Research Commission (WRC), a team of water quality scientists from Pietermaritzburg, in association with Unilever, have investigated the effect that removing phosphates from detergents and substituting them with alternative builders would have on the problem of eutrophication in a number of important South African dams.

THE PHOSPHATE IN OUR WATERS

Although people washing their clothes in or alongside rivers make a highly visible contribution to the phosphate loading of these water resources, the largest source of

Table 1: Proportional contribution made by detergent phosphates to total SRP loading at sewage treatment facilities

Sewerage works	SRP proportion (%)
Darvill (KwaZulu-Natal)	40,30
Bushkoppies (Gauteng)	17,75
Goudkoppies (Gauteng)	15,40
Driefontein (Gauteng)	15,10
Ennerdale (Gauteng)	58,82
Olifantsvlei (Gauteng)	28,12
Northern (Gauteng)	28,53

detergent phosphate entering South African rivers are urban sewage treatment works. These facilities, and their efficiency in removing phosphate from their effluent, are central to the issue of water resource nutrient enrichment.

Several studies have shown that the majority of these facilities are currently unable to achieve the legislated effluent SRP concentration of less than 1 mg/ℓ. Significantly, it has been shown that even if all treatment works were to adhere to this limit, loading would still be sufficiently high through sheer volume of wastewater to render several important dams permanently eutrophic suggesting that this limit is not sufficiently strict. It is proposed that removing phosphate from powdered laundry detergents can provide an avenue to reduce the phosphate loading arriving at treatment facilities and hence reduce the knock-on effect of nutrient overloading on our water resources.

CRUNCHING THE NUMBERS

Using Unilever detergent consumption data, the team showed that approximately 22% of the total phosphorus (TP) arriving at the Darvill sewage treatment facility in Pietermaritzburg originated from detergents' phosphate builders. This is equivalent to about 40% of the SRP loading. The study also showed that detergents' proportional contribution varied considerably according to the nature of the wastewater intake as facilities such as Goudkoppies and Driefontein in Gauteng, which service industrial areas, showed a much lower proportional contribution.

The total phosphorus export in a catchment was estimated using phosphorus export co-efficients for different land cover types gleaned from several different studies. The area of each land cover type in each catchment was used to determine a total export co-efficient per catchment. Urban phosphorus export was determined using a value calculated from Darvill effluent and a generic surface runoff co-efficient. Around 22% of this figure was deemed to have originated from detergents.

It should be pointed out that in comparison to some treatment facilities around the country, Darvill is an efficient facility, which means that this value is probably an underestimate, which would be carried through all the results of the study.

Based on the figures calculated, it is suggested that the total phosphorus loading at important dams could be reduced significantly by eliminating detergent phosphorus. This is assuming that sewage treatment works continue to operate in the same manner as before and that effluent loading is reduced by an amount equivalent to the reduction in influent loading.

Guy Stubbs

In South Africa, about 23% of laundry detergent mass is made up of sodium tripolyphosphate (STPP)

NO MAGIC BULLET

Dams with a high degree of urban settlement in their catchment are expected to experience the greatest reduction in TP loading, with dams such as Hartbeespoort, Klipvoor, Roodeplaat, Inanda and Laing all expected to experience a reduction in TP loading at inflow of more than 25%. Of course these reductions all become irrelevant if sewage treatment plants reduce their phosphate removal efficiency in response to a decrease in loading in order to enjoy the benefits of reducing their costs while achieving the

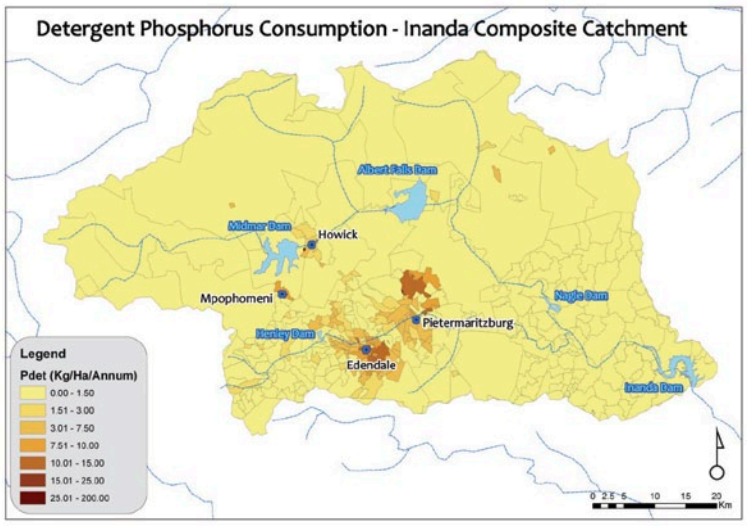

Figure 1: *Detergent consumption intensity in the Inanda composite catchment, including Midmar, Albert Falls, Nagle, Henley and Inanda dams*

same results. If benefits are to be passed on to the aquatic environment, treatment plants will, in the least, need to continue to operate as if nothing has changed.

A reduction in inflow phosphorus does not translate into a reduction in TP and chlorophyll concentration in the dam in a 1:1 ratio. A complex range of processes sees some of the phosphorus being bound up in sediments and also being biologically removed from the water. Modelling enables one to estimate the concentration of both phosphorus and chlorophyll in the dam based on estimated concentrations of phosphorus in its inflow, and dam specific parameters.

The team modelled the in-dam conditions (both TP and chlorophyll) using the OECD and Walker reservoir models. Based on the estimated reductions in inflow concentrations, results were encouraging, with several of the 24 dams showing significant (greater than 20%) decreases in TP and chlorophyll concentrations. A summer TP reduction for all 24 dams was approximately 12%.

Although this level of reduction would not be sufficient to significantly reduce the time some of the worst affected dams spend in an eutrophic state, it reduces the SRP overload margin and makes any reduction targets that are set so much more attainable.

The environmental benefits of a lower nutrient load have been shown to be significant enough to support the proposal to remove phosphates from detergents. However, when looking at the economics of the problem, previous studies of this nature have come to the conclusion that although the elimination of detergent phosphate was desirable, it would not be cost-effective to implement a ban.

Table 2: The estimated reductions in inflow TP loading to be achieved by eliminating detergent phosphates

Catchment	TP production (%)
Albert Falls	17,5
Allemanskraal	3,5
Bloemhof	15,2
Bronkhorstspruit	5,3
Erfenis	4,5
Grootdraai	7,5
Hartbeespoort	28,0
Hazelmere	22,0
Henley	9,0
Inanda	28,0
Klipfontein	18,7
Klipvoor	26,8
Koppies	3,2
Laing	28,3
Lindleyspoort	9,9
Midmar	3,3
Misverstand	6,7
Nagle	7,8
Roodekoppies	8,5
Roodeplaat	29,3
Shongweni	21,0
Vaal	8,6
Welbedacht	13,7
Witbank	8,5

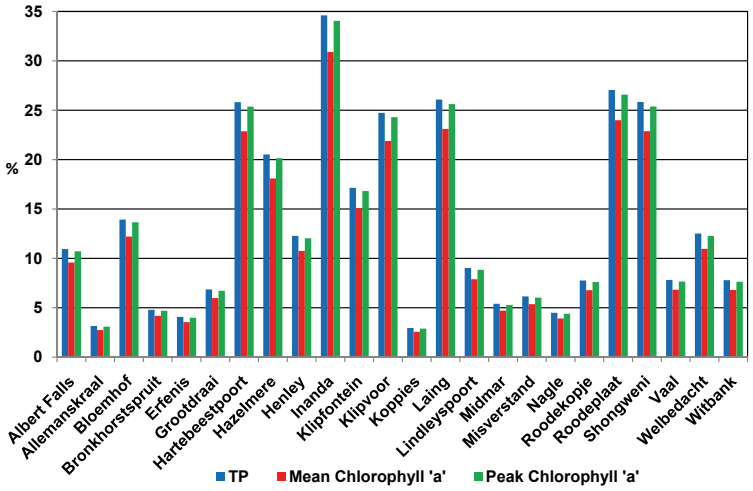

***Figure 2:** Graphical representation of potential reductions in TP and Chlorophyll a*

WEIGHING THE OPTIONS

In these studies, it was calculated that overall, it would be cheaper to retain the phosphate builders in detergents and to continue to extract the phosphate at sewage treatment works than to inflict the costs of introducing a substitute builder on consumers and producers. The suggested costs associated with substitution includes damage to washing machines and fabrics, and the fact that potential substitute materials are generally more expensive than phosphates, increasing the cost of manufacture and pushing the price of detergents up.

As part of this study, a qualitative cost benefit analysis revealed that the costs previously attributed to phosphate substitutes which rendered their implementation as not cost-effective, are today in fact negligible. This conclusion is based largely on the experiences of several countries around the world where phosphate substitutes have now been introduced.

The investigation also concluded that the benefits to be gained by switching to these substitutes will not only accrue to the environment, but to producers and consumers as well. Producers of detergents have seen the cost of phosphate rising rapidly recently due to a global shortage of the resource. This cost escalation makes the suggestion of replacing them with a cheaper substitute product a sensible economic choice. Consumers will therefore also see a benefit in that the cost of detergents in the supermarket will not be escalated by the rising resource price.

A further situation which was unforeseen by previous studies

Although people washing their clothes in or alongside rivers make a highly visible contribution to the phosphate loading of these water resources, the largest source of detergent phosphate entering South African rivers are urban sewage treatment works.

which advocates the elimination of detergent phosphates is the inefficiency of many sewage treatment facilities in removing phosphate from wastewater, and the fact that many of these facilities are overloaded and simply cannot cope with the volume of wastewater currently being produced.

This situation means that the previously adopted approach of leaving the job of removing the detergent phosphate to the wastewater treatment facilities has become untenable. Elimination of detergent phosphates will undoubtedly assist many facilities in achieving better effluent SRP concentrations. This will theoretically constitute a financial saving for these facilities when the Wastewater Discharge Charge System is implemented, reducing the amount each facility will be required to pay for releasing phosphate rich effluent.

Some of the minor market share producers have already begun producing products using zeolite and soda ash builders, and the larger producers have indicated a willingness to adapt their production processes. In essence, the time is right for a shift to phosphate-free detergents in South Africa.

Environmentally, this has long been the case, but economically, the situation has only recently reached a tipping point where consumers, producers and other involved parties will see a direct benefit in switching to alternative builders. Although on its own it does not constitute a 'silver bullet', a move to phosphate-free detergents is undoubtedly an important step in cleaning up our water resources.

This final report, *Investigation of the positive and negative consequences associated with the introduction of zero-phosphate detergents into South Africa* (**Report No: TT 446/10**) is now available from the WRC. ❑

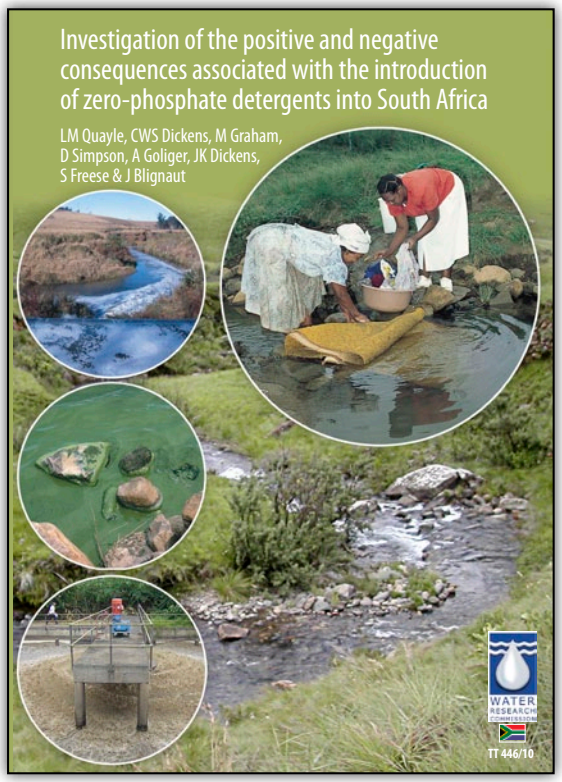

Table 3: Summary of modelled reductions of in-dam TP and Chlorophyll a in the top six dams

Dam	Reductions in TP concentrations	Reductions in Chlorophyll *a*
Inanda	35%	30%
Roodeplaat	27%	23%
Laing	26%	23%
Hartbeespoort	26%	22%
Shongweni	26%	22%
Klipvoor	25%	21%
Total all dams	12%	12%