

# THE 1 mg $\ell^{-1}$ PHOSPHATE STANDARD: WHY IT DOESN'T WORK – A CRITIQUE

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Eutrophication – or the enrichment of rivers, lakes and dams with nitrogen and phosphorus, constitutes the single greatest threat to surface waters worldwide. This process fuels a suite of progressive water quality problems that encompass human and animal health, ecosystem degradation and increased water treatment costs. South Africa is no exception and serious problems with burgeoning eutrophication were clearly apparent as early as the 1960s. Recognition thereof in a country where effluent return flows and urban runoff often form a considerable part of the annual runoff to impoundments, led to major research programmes for eutrophication being initiated.

Effective control of nutrient enrichment is best achieved via the attenuation of phosphorus (P) – as the multiple elemental forms and availability of nitrogen (N) render the latter considerably less easy to manage. Thirty-five years ago (August 1985) the so-called 1 mg  $\ell^{-1}$  ortho-phosphate standard was promulgated in an effort to begin to thwart the progress of eutrophication in South African dams. Since that time, there has been a notable lack of practical and pragmatic measures to thwart eutrophication in this country – this caused in considerable measure by a notion promoted by the Department of Water Affairs (DWA) that eutrophication was not an issue of concern – this mind-boggling conclusion coming at a time when groundbreaking work undertaken in South Africa had significantly raised the global awareness of the problem!

All aquatic ecosystems have a natural assimilable capacity to cope with nutrients added to them. If this capacity is exceeded – and depending on a combination of other hydrologic and biophysical factors, the affected waterbody will begin to develop various symptomologies of eutrophication. Not all dams are equal in respect of their ability to cope with eutrophication – some are considerably more sensitive than others. If allowed to proceed uncontrolled, the process of eutrophication will progressively alter the chemical and ecological nature of the waterbody. At the same time resilience to remediation increases dramatically.

Prior to and at the time of the promulgation of the aforementioned standard, there was a clear understanding that eutrophication of standing waters (dams) was load-dependent – i.e. changes to the trophic condition of the receiving water would be incurred should the loading of phosphorus exceed the assimilable threshold within an annual hydrological cycle. Equally-available were the means to determine, within reasonable limits of confidence, what the threshold was for individual dams. Based on this knowledge, the Best Management Practice for off-setting or attenuation eutrophication would, therefore, be to ensure that the aggregate catchment loading to an impoundment does not exceed the annual loading limit. In 1975, research revealed that 11% of South Africa's dams were eutrophic – with 40% incipient

eutrophic! As early as 1979, a Department of Water Affairs report acknowledged that “*increased volumes of nutrient-rich effluents have been discharged to rivers for the past two decades and South Africa is already experiencing the classical eutrophication problems*”. At the same time, the DWA also reported that “*in Southern Africa, the technology exists whereby wastewater can be completely reclaimed as potable water*” !

Currently, the acceptable phosphorus loading thresholds of many South African dams are massively exceeded – to the extent that a regional water crisis exists in Gauteng Province, with incipient problems emerging elsewhere.

Despite expert criticism at the time – and indeed since, promulgation of the  $1 \text{ mg } \ell^{-1}$  ortho-phosphate standard went ahead regardless. Evidence for dams such as Roodeplaats, available ten years previously, illustrated the shortcomings of the adopted standard. The inadequacy of the approach was acknowledged by senior departmental (DWA) scientists at the time “*the introduction of a uniform standard is clearly not the best strategy for controlling eutrophication....*”. The approach is significantly, indeed fatally, flawed in that a concentration-based standard cannot provide protection in a variable-flow environment – i.e. it made no allowance for population development and increased wastewater and runoff discharges. Equally, the  $1 \text{ mg } \ell^{-1}$  P level was arbitrarily selected and as the Best Available Technology at the time for wastewater treatment works outflows – which are simply point-source discharges within a catchment of multiple and varied sources. Crucially, the approach takes no heed of the load-based assimilable capacity of the receiving water. So, while the implementation of the standard could potentially reduce the overall loading and hence improve water quality, it would not necessarily bring about the reduction required for in-lake nutrient levels that is necessary to offset the problems of eutrophication.

Implementation of load-based nutrient management approaches have reached various levels of sophistication elsewhere in the world. In the USA, refinement to a Daily Loading Level, per the TMDL (Total Mean Daily Loads) strives to apportion the total assimilable loading to individual catchment sources. This approach is not without problems as it is administratively onerous – yet significant reductions have been achieved. For South Africa a TMAPL (Total Mean-Annual Phosphorus Loads) approach has been recommended.

The South African concentration-based standard also took no recognition of the negative impacts that would accrue to river ecosystems being used to act as conduits to transport effluent at this phosphate-concentration to dams. Damage to riverine systems has been shown to occur at a phosphorus concentration threshold of  $20 \mu\text{g } \ell^{-1}$  (as P) – orders of magnitude less than  $1 \text{ mg } \ell^{-1}$ . South African reservoirs show a tipping point threshold – above which the frequency of eutrophication problems increases, at  $35 \mu\text{g } \ell^{-1}$  (as P). Furthermore, the standard was based on ortho-phosphate, whereas the accepted scientific approach – at the time and since - was to use Total Phosphorus (TP) as the determinant for load modeling. Measurement of TP was only included in South African national monitoring protocols years later.

Implementation of the standard was met with considerable resistance from local authorities who maintained that they could not afford the costs of meeting the standard (works upgrades). This was pandered to by only implementing the standard in priority catchments – and even then with no subsequent enforcement. This relaxation was further deprecated by the notion that eutrophication could be allowed to proceed to a point and then be managed. This extremely short-sighted viewpoint made no effort to consider not only the loss in ecosystem capital (degraded dams) but also the future cost of having to treat water that was more polluted. A viewpoint that the need to simply get water – irrespective of quality - into the dams was the overriding need – and that how to treat it would be considered later – prevailed. As noted in published work, the litany was “*eutrophication is bad, the cure lies within an engineering solution*”. The finite limits of engineering solutions have been long exceeded.

It might be argued that the implementation of the 1 mg  $\ell^{-1}$  ortho-phosphate standard was intended as the first-step in a wider-reaching process of eutrophication management and that it would be built-on using a catchment by catchment approach to bring catchment-derived loads into line with assimilable capacities. It is, however, now thirty-five years later and no such initiative has been launched. The subject of reservoir-limnology continues to receive scant attention and the DWA has no professional reservoir-management limnologists in service – nor any reservoir management directives in place. Despite the existence of a eutrophication-linked monitoring programme, there is no linked programme of action or intervention related to the findings – which suggests that while some administrative attention is occurring, the underlying problem, regrettably for South Africans, remains willfully ignored.

## References

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