



*THE APPLICATION OF VIROFLOW™ TECHNOLOGY
USING VIROPHOS™ REAGENT
FOR THE REMOVAL OF PHOSPHORUS*

TECHNICAL PAPER



ViroFlow™ Technology plant holding reagents

INTRODUCTION

Phosphate is widely used in the agricultural industry, and sources of phosphorus are sewage plants, farms, fertilisers and detergent manufactures. Condensed phosphates are added to some water supplies during treatment to prevent corrosion, and large quantities are found in laundering and commercial cleaning fluids.

Phosphorus is an essential nutrient for both plants and animals, and a small amount in natural water is crucial for a healthy ecosystem, but high levels of phosphorus causes eutrophication.

Eutrophication generally promotes excessive plant growth and decay, favors certain weedy species over others, and is likely to cause severe reductions in water quality; it reduces dissolved oxygen in the water when dead plant material decomposes and can cause other organisms, such as fish, to die. In aquatic environments, eutrophication enhances growth of choking aquatic vegetation or algal blooms resulting from even relatively low levels of phosphorus (>2.0 mg/L), and disrupts normal functioning of the ecosystem, causing a variety of local and downstream problems.

ViroFlow™ Technology incorporates the use of ViroPhos™ reagent, a patented environmentally safe reagent. The properties of ViroPhos™ reagent include high acid neutralising capacity, excellent settling rate characteristics, and high phosphate and metal binding efficiency.

Virotec has developed its ViroPhos™ reagent, as an integral part of ViroFlow™ Technology, to remove phosphate and decrease sludge volumes from industrial wastewater and processes.

ViroFlow™ Technology ensures selection of the best application strategy. Management of the treatment process is based on Virotec's:

- > Extensive research database;
- > Practical experience with commercial scale applications; and,
- > Results of laboratory tests for each treatment application.

ViroFlow™ Technology can be easily added to existing treatment facilities and requires minimal capital works, depending on the application.

BACKGROUND

The widespread dispersal of phosphorus from sewage effluent, industrial wastewater, detergents, and run-off from urban and agricultural land has played a major part in the eutrophication of many freshwater and marine ecosystems throughout the world. The relationship between phosphorus and eutrophication has been known for many years, and the role of sewage effluent, above other point and diffuse sources of phosphorus in water pollution, has been well documented.

In order to help tackle eutrophication in inland and coastal waters, more stringent measures are being applied to, for example, agricultural pollution and detergents, and stricter discharge consents are being imposed by environmental regulators on phosphate (PO_4^{3-}) concentrations in effluent from wastewater treatment plants (WWTP). Phosphate consents (or licenses to discharge treated effluent into creeks or rivers) have dropped (or will drop) from typically

between 5.0mg/L and 10mg/L to <2.0mg/L in most developed countries. These limits may be further tightened to <1.0mg/L in more eco-sensitive areas.

The need for stricter consents is supported by studies in the United Kingdom on seven lowland river catchments, which have concluded that phosphate in effluent presents a greater eutrophication risk to the environment than agricultural run-off. This study found that at all 54 monitoring sites there was a strong correlation between soluble phosphate emissions and algal growth, with effluent being the main source. However, research has shown that municipal wastewater has a high eutrophication effect, even after biological treatment, and that a deterioration of a WWTP phosphate removal efficiency occurs after heavy rainfall. Similarly, inadequate control of aeration that might occur over weekends when operators are not present or during rain events, for example, also has an adverse effect on phosphate removal efficiencies. Hence the need for strict operational standards and ways to supplement biological treatment are imperative.



A classical example of Eutrophication

Research conducted by the Centre for Ecology and Hydrology in the UK has shown that the removal of phosphates from the effluent streams of smaller WWTP could be more important than from larger works, as smaller WWTP are typically closer to headwaters and therefore the discharge of phosphate has a more profound impact on downstream nutrient loadings in creeks and rivers and along sensitive tributaries. These and other findings have led to a significant increase in the number of water bodies designated as “sensitive” to algal growth and toxic blooms, with 297 sensitive areas having been declared in England alone since 1994.

Added to this challenge for smaller WWTP, whose effluent discharges apparently represent the largest environmental impact, is the fact that smaller sites are often unmanned but are the plants that increasingly attract the tightest consent levels due to their eco-sensitive location in farmlands and at inland headwaters. Moreover, these smaller WWTP also pay the highest price per kilogram to remove phosphate.

The move to more tightly control phosphate concentrations in discharge water and other sources of nutrient contamination have come from a host of government agencies, as well as from the water framework Directives of the European Union. For example, the UK government has found that currently 65% of England’s rivers fail current phosphate limits, with lakes being more sensitive to contamination; the government predicts that up to 70% of English lakes and up to 25% of Scottish lakes risk failure of phosphate limits. In Europe, governments have estimated that 50% of phosphate contamination originates with agriculture, 35% from sewage, and 7% from industry.

As a consequence of these developments and as a result of these widespread findings, companies throughout the world are faced with the prospect of having to implement additional treatment methods in order to supplement traditional biological, chemical and physical processes for reducing phosphate. However, finding the best application to reduce phosphate can be problematic, particularly when extremely low consents are required and when the WWTP is at a remote and unmanned location.

The challenge for industry is to identify treatment options for phosphate removal which can effectively achieve these lower treatment standards.

VIROFLOW™ TECHNOLOGY APPLICATION

ViroFlow™ Technology incorporates the use of ViroPhos™ reagent, a patented environmentally safe reagent that can be added directly to the contaminated water or used as the active ingredient in flow-through treatment systems.

ViroPhos™ reagents A and B are added in liquid form at pre-determined rates for optimum removal of phosphorous. ViroFlow™ Technology produces a dense, stable sediment that is easily recovered and dewatered, and can be integrated into facilities where wastewater is produced and requires minimal capital works and plant modifications. This makes ViroPhos™ reagent a cost effective solution for removing phosphorus from wastewater.

The major advantages of using ViroFlow™ Technology can be summarised as:

- > Substantial reduction in phosphorous concentrations in discharge water;
- > Reductions in COD and suspended solids loads in discharge water;
- > Reduction in sludge volumes generated;
- > High pH buffering capacity;
- > Compliance with trade waste discharge limits;
- > Increased settling rates resulting in improved water quality; and,
- > Elimination of the need for major capital upgrades by increasing effluent throughput.

The ViroPhos™ reagent that has been used to remove phosphate does not lose its inherent metal binding or acid neutralising capacity and thus, the sediment formed when ViroPhos™ reagent settles and dries could be re-used in other applications where the acid neutralising and metal binding capacity can be used.

Additionally, because a proportion of the bound phosphate is plant available, but not water leachable, the sediment is ideal for reuse as a fertiliser/soil ameliorant in agricultural soils. A trial carried out at a chicken processing facility showed that ViroPhos™ reagent reduced phosphate levels to be low 1.5mg/L, and was thus able to remove over 98% of the phosphate in digester effluent that had an initial phosphate concentration averaging 30 mg/L and >96% of PO_4^{3-} from solution with an initial phosphate concentration of 190 mg/L.

For sensitive locations, ViroPhos™ reagent can be further enhanced for greater phosphorus removal, reducing phosphate levels to below 0.5mg/L, and “spent” or fully-charged reagent can be reused in agriculture, as they are “phosphate-enriched”.

The chemical properties of ViroPhos™ reagent are unique, as the reagent can neutralise between 3.5-7.5 moles of acid/kg, has a very high metal binding capacity (up to 1,500 meq of metals/kg), contains a multi-charged surface for potential PO_4^{3-} reaction sites, is classified as a product and approved for use in the UK and Australia, and are registered under TOSCA in the United States.

CHEMISTRY OF VIROFLOW™ TECHNOLOGY

ViroPhos™ reagent works by forming strong chemical bonds with the phosphorus in the leachate pond or water body. ViroPhos™ reagent effectively immobilises the metal into an insoluble, nonreactive sediment, and has a high charge-to-mass ratio that increases its ability to strip metal ions from solution.

The heterogeneous mineral surfaces in ViroPhos™ reagent catalyse ion precipitation from solution at a pH lower than that achievable with conventional alkaline treatments such as lime, sodium hydroxide and magnesium oxide by providing nucleating surfaces and acting as substrates for precipitation.

For these reasons, ViroFlow™ Technology can be summarised by the following:

- > Uses environmentally sustainable range of patented products;
- > Is a viable solution for acidity, metal and phosphate problems
- > Neutralises acidity;
- > Removes phosphates (>85%) from wastewater and clean water;
- > Removes metals (>99%) from wastewater and drinking water;
- > Destroys objectionable odours;
- > Binds heavy metals in non-leachable and non-bioavailable form;
- > Binds phosphates in a slow release bioavailable form; and,
- > Direct addition to wastewater creates a dense, easily dewaterable sediment, reducing sludge volumes substantially.

ENVIRONMENT AND SAFETY

The use of ViroFlow™ Technology is both environmentally sustainable and economically viable. ViroPhos™ reagent consists of minerals that are not considered to pose any environmental risk.

ViroPhos™ reagent is environmentally safe and the exhausted material may be disposed of as a non-leachable solid residue. Used ViroPhos™ reagent is not hazardous or prescribed waste material. Even after use in many applications, it can be usefully reused in other applications.



Virotec's reagents are considered non-toxic to plants, animals or humans.

The leaching of used ViroPhos™ reagent cannot result in the release of any trace elements at potentially environmentally hazardous concentrations. ViroPhos™ reagent is classified as a nonhazardous, inert substance for transportation and is safe for unskilled workers to handle.

ViroPhos™ reagent consists of minerals that are not known to pose any environmental hazard. Virotec recommends checking with local environmental regulations before final disposal.

CONCLUSION

ViroFlow™ Technology has proven to be applicable for the treatment of phosphorous, trace metals and acidity problems encountered in a typical industrial setting. ViroPhos™ reagent is non-toxic, non-hazardous and environmentally safe. Used ViroPhos™ reagent is not a hazardous or prescribed waste material, and can be easily disposed of to local landfill.

CASE STUDY 1: LARGE CONSUMER GOODS MANUFACTURE

ViroFlow™ Technology is currently used to successfully treat over 480,000L of effluent per week at the plant of this large consumer goods manufacturer.

ViroFlow™ Technology was applied and the following outcomes were achieved:

- > Compliance with Local Water Authority trade waste standards. All parameters are now consistently below the required 10ppm prior to discharge into sewer;
- > Prevention of capital plant upgrades that would normally have been necessitated by growth in effluent plant volumetric throughput;
- > Reduction in sludge volumes. This resulted in a direct landfill cost saving, allowing for potential solids re-use or recycling;
- > Increased settling times resulting in improved water quality and plant throughput; and,
- > A fully automated treatment system that is easy to use and cuts down on the time needed to treat the effluent.



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TABLE 1: METAL CONCENTRATIONS BEFORE AND AFTER VIROPHOS™ REAGENT ADDITION

Parameter	Raw Effluent	Before ViroFlow™ Technology Treatment	After ViroFlow™ Technology Treatment	Council Discharge Limit
pH	6.8	7.1	6.9	6 - 10
Phosphorous (mg/L)	40	28	0.6	10
TSS (mg/L)	2,647	700	22	400
COD (mg/L)	1,360	1,200	76	1,000

The above table show that following the treatment with ViroPhos™ reagent, results for total phosphorous concentrations were below the Council discharge limit of 10mg/L when compared to the previous reagents (polymer) used.

The implementation of ViroFlow™ Technology at the manufacturer's treatment plant resulted in dramatically reduced phosphorous, TSS (Total Suspended Solids) and COD (Chemical Oxygen Demand) loads whilst maintaining accurate pH control, and meeting all Council trade waste limits.