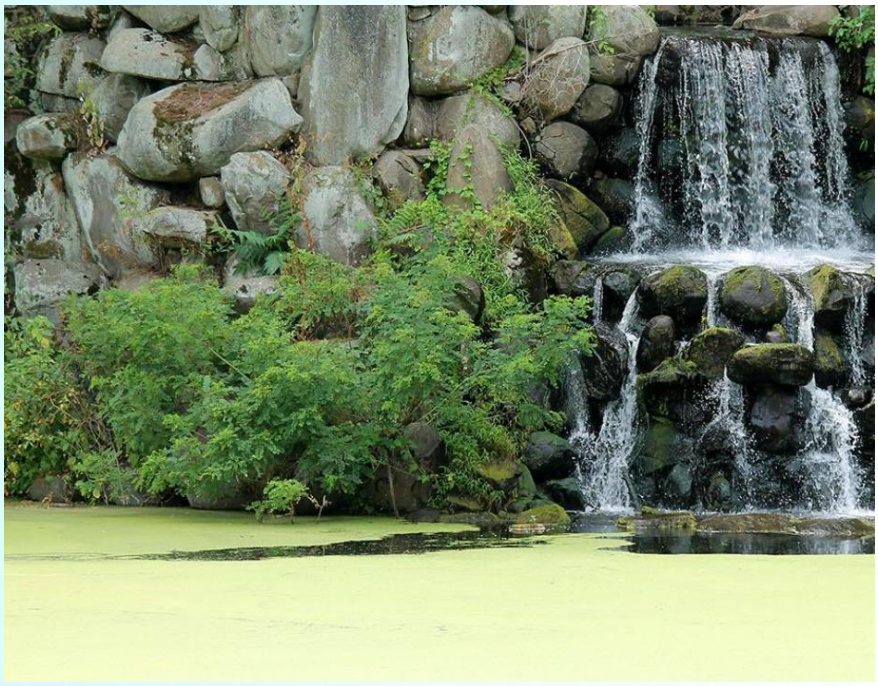

How to remove phosphorus more cost-effectively

www.wes.ltd.uk
01256 819777

Phosphorus, in the form of various mineral phosphates, is a key cause of eutrophication in lakes, rivers and other surface waters. This white paper will summarise eutrophication's effects and the challenges it creates for water companies – both practical and financial. Chemical treatment, which is an essential element in phosphorus removal strategies, is discussed along with other methods including an easier and more economical approach.

Problems for nature

Eutrophication is the over-enrichment of water by mineral and organic nutrients which stimulate excessive growth, referred to as 'blooms' in algae. Freshwater algae are a group of simple plants divided into microscopic species, suspended in the plankton, and colonies of larger filamentous species. Planktonic algae (phytoplankton) can turn the water into a green 'pea soup', while filamentous algae may form thick floating mats.

Algal blooms deprive submerged plants and creatures of sunlight and ultimately suffocate them. Although they generate large amounts of oxygen through photosynthesis during daylight, they consume it with their respiration at night and may reduce it to levels at which some animals cannot survive. Eventually the algae die and are decomposed by bacteria which strip the water even further of its oxygen, leading to mass killing of fish, invertebrates and planktonic animal life (zooplankton).

Problems for the community

Some algal blooms also produce toxins which may be lethal to livestock, dogs or other animals drinking the water. Humans can be affected by skin irritations and other symptoms resulting from contact with affected water. Their health may also be damaged by toxins passed through food chains.

Communities are naturally concerned by these dangers, by the impacts on wildlife and by the loss of recreational and amenity value in affected habitats. At present, many waterways and lakes are failing to meet strict standards set for nutrient levels under the UK's Water Framework Directive. To customers, it may seem inevitable that water bills will increase as extra purification efforts are made to deal with this issue.

Problems for water companies

Water companies are under pressure from environmentalists, from the public and from legislators to tackle eutrophication. At the same time, they are being pressed to achieve improvements without spending too much.

In AMP7, the water industry's Asset Management Period covering the years 2020 to 2025, more stringent phosphorus removal levels are expected. As well as increasing the demands on larger sites, it will require treatment on small sites which previously had no requirement for chemical dosing. In many cases the smaller sites will have little or no historical data on which to base dosing specifications, so testing will be needed. Installation of dosing systems within the confined space of small sites will be another challenge.

Meanwhile, industry regulator Ofwat's latest price review, PR19, has challenged companies to deliver more cost-effective and efficient solutions than their current framework designs allow. It wants customers to receive better value for money, with improved services but no increase in bills.

Increasing eutrophication

The main sources of phosphorus reaching our waters include:

- Run-off of agricultural fertilisers (artificial and organic) and animal waste from fields
- Human waste from sewage systems
- Detergents from household drains
- Waste discharged into waterways from various industries

If these are not properly addressed, the potential for eutrophication will grow.

Eutrophication problems are also likely to be increased by climate change. While heavy rainfall and flooding events are becoming more frequent in the wetter months, summers are becoming hotter and drier. Higher phosphorus concentrations in water during drought periods, together with higher temperatures, will certainly boost algal growth.

Phosphorus treatment options

Traditionally, chemical treatment to remove phosphorus usually involves dosing the water with metallic salts which react with dissolved phosphate to produce solid precipitates. These materials can then be removed using a solids separation process such as clarification or filtration. Salts commonly used for phosphorus removal include ferric chloride, ferrous chloride, ferric sulphate, ferrous sulphate, aluminium sulphate (alum), sodium aluminate and calcium carbonate.

The chemical method can be applied in conjunction with biological treatment using anaerobic and aerobic digestion. These processes provide conditions favourable to the growth of anaerobic and aerobic bacteria, respectively, which feed on soluble phosphates and thereby remove them from the water itself. The bacteria, along with the phosphorus they have consumed, are then separated into the resulting sludge. When used in combination, digestion tends to come first. Chemical treatment then reduces phosphorus to a lower level (below 1.0 mg/L).

Before chemical treatment and digestion, the larger particles of material containing phosphate can be removed by simple processes like sand filtration and solid settlement. After the main treatments, some companies may wish to reduce phosphorus levels even further by passing the water through a membrane filtration system.

Sanitising treatments

The 2000 Water Framework Directive, led to 0.5-1.0 mg/l limits being typically imposed by the Environment Agency in AMP6. However, it is thought that limits as low as 0.1 mg/l will be necessary going forward. These targets create some limitations for current stand-alone chemical dosing treatment including problems with elevated Iron levels and the fact that ferric sulphate may become more expensive as UK steelmaking reduces. (ferric sulphate is a by-product of steelmaking).

As a result of these challenges, phosphorous removal has been a focus for innovation during AMP6 and a series of trials of alternative technologies has been supervised by the EA and with support from UK Water Industry Research (UKWIR). These trials have introduced some interesting new technologies most of which however still require chemical dosing, albeit at reduced levels.

Establishing dosing levels

When planning chemical treatment for a site whose dosing needs are unknown, like the many smaller sites now being targeted, testing is required. Jar tests are of limited value, as they give only a snapshot of the conditions. The operator needs, instead, to gain a full picture of the upper and lower dosing limits. This can be achieved economically by hiring a dosing rig from WES on a short-term basis.

The smallest and simplest WES packaged systems for this purpose consist of a WES DosingCube™ and an IBC (intermediate bulk container) of chemical, sitting on a double IBC bund. Larger options include a self-contained system within a waterproof enclosure with a 1,000-litre storage tank and a DosingCube™. For further size and functionality, there is the option of a containerised systems with 10,000-litre storage tank, duty and standby pumps and local control panels.

With such equipment, tests can be run in real time over a typical hire period of between four and 12 weeks. The levels established by tests in these situations will tend to require very low dosing flows, often down to 0.1 L/hr. This has important implications and potential pitfalls for system design, but WES has extensive experience in this field and an engineer any problems out of its temporary and permanent packages.

Long-term or permanent solutions

Once dosing needs are known, WES can supply a long-term solution appropriate to the site. All packages have a compact footprint and are designed for easy transport and installation.

Typical specifications start with 1,500 litres of storage, giving enough capacity to refill from an IBC without having to interrupt the dosing. To this is normally added a fill point panel, pipework, a set of duty and standby pumps, and a WES proprietary or client-compliant control system.

These components are set within a suitable enclosure, chosen from a range of options. They vary from a rotationally moulded model to a fabricated bund with a GRP (glass-reinforced plastic) weatherproof kiosk and a walk-in enclosure. The larger packages are designed to fit the footprint of a 20-foot shipping container. On-site civil engineering requirements are minimal.

Depending on the individual requirements at the site, storage tanks of many sizes can be provided. There are also 10,000 litre fully containerised options.

Space for an extra set of pumps can be added to any of the packages if needed. Prices naturally rise with increasing sizes and specifications, but even the high-end versions are more compact and cost-effective than typical framework

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Case study

WES recently added two new packages to its range in response to a framework tender call from one water company. This specifically related to increased or upgraded dosing with ferric chloride for removal of phosphorus at multiple locations. The two resulting size variants, at 7,500 and 10,000 litres, offer versatility for a variety of different circumstances but with a standardised approach that saves on costs.

Even the largest version is compact and lightweight enough to be delivered easily on a single, non-articulated, flatbed truck. WES saves further time and expense by fully constructing and testing each package in the factory, rather than assembling it on site. With quicker installation, involving fewer personnel, on-site health and safety risks are also reduced.

Buy or hire

Complete chemical dosing set-ups can be bought or hired from WES, complete with all necessary storage tanks, bunds, filling and safety systems, pipework, connectors and control features. All components are pre-assembled and pre-tested to save on installation time.

WES operates the UK's largest chemical dosing hire fleet. In addition to their cost-saving application in testing of treatment strategies, as discussed earlier, hired systems are ideal for dealing with urgent needs, short-term increases in demand and scheduled shutdowns.

In addition, they help conserve capital expenditure. For further information, visit www.wes.ltd.uk.