PHOSPHATE PROBLEMS IN WASTER WATER TREATMENT PLANTS AND THE BENEFITS OF ONLINE MONITORING OF PHOSPHATE CONCENTRATIONS

Sources of phosphate in wastewater

Sewage Treatment Plants (STPs)/Wastewater Treatment Plants (WWTPs) have a high phosphate content, usually due to human activity. The main causes are:

- Agriculture and animal husbandry: derived from fertilizers and animal excrements.
- Urban waste: mainly detergents, which are rich in phosphate.
- Industrial activity: phosphate products can be discharged, as well as many other toxic components.

The total phosphorus load consists of, mainly, orthophosphate, polyphosphate and organic phosphorus compounds, with orthophosphates being the most significantly abundant component.

Problem: eutrophication

Eutrophication is the excess supply of nutrients (mainly nitrogen and phosphorus) to an aquatic system, leading to uncontrolled algae proliferation. The excessive growth of algae in aquatic environments such as lakes, rivers, reservoirs, etc. causes a high consumption of oxygen in the water, contributing organic matter. The resulting adverse effects are:

- Low water quality, which can cause respiratory and health problems in humans.
- Affecting fish life in the area, as the low amount of oxygen can become incompatible with the life of the fish.
- Affecting watercourses, making it impossible to navigate them.
- Indirect consequences for birds and mammals, as there are ideal situations for the proliferation of bacteria that produce lethal toxins for them.

Current legislation in Spain

Out of European Union, each country uses its own regulation to control phosphorus. In Spain, according to EU Directive 91/271/EEC, the requirements for discharges from urban wastewater treatment plants depend on the capacities of the plant, using the unit of measurement population equivalent (PE), which is the biodegradable organic load with a five-day biochemical oxygen demand (BOD 5) of 50 grams of oxygen per day. Thus:

- 2 mg/L P for plants from 10,000 to 100,000 PE.
- 1 mg/L P for plants > 100,000 PE

In addition, in both cases a minimum reduction percentage of 80% is required, which is related to the inlet flow load.

However, due to the growing problem and concern that eutrophication causes, more exhaustive control measures are foreseen for wastewater treatment plants, especially in large urban

centers and with more economic resources, as currently more than 70% of Spanish wastewater treatment plants do not eliminate excessive phosphate concentration.

Phosphorus removal systems

Nowadays, the average concentration of total phosphorus at the inlet of municipal wastewater treatment plants is 9 mg/L, i.e., more than 4 times the permitted value in plants with less than 100,000 PE and 9 times the limit in plants with more than 100,000 PE, and elimination treatments are necessary.

There are two processes of total phosphorus reduction.

- Biological phosphorus removal. This involves storage of more phosphate than normally required in activated sludge and depends on the presence of sufficient readily biodegradable organic matter (BOD_5).
- Chemical phosphate precipitation. Chemicals (iron salts, aluminum salts or calcium compounds) are used which cause orthophosphate compounds to precipitate as metal phosphates.

Generally, a combination of both processes is the most economical and feasible option often used by WWTPs.

Advantages of online analysis and monitoring of phosphate concentration.

As mentioned above, the total phosphorus in STPs is mainly composed of phosphates. This is why daily monitoring of the phosphate concentration brings great benefits for the plant, mainly economic ones. In view of the need to reduce the amount of phosphates, its control makes it possible to adequately regulate the discharge of chemical products in accordance with the amount required at any given time, without exceeding the amount at those times when the concentration is lower, which represents a great economic saving.

Example of economic savings

In order to be able to make calculations that represent the economic savings that continuous phosphate control entails, a plant of 500,000 PE and an approximate capacity of 100,000 m^3/day of cabal is taken as a reference. As indicated above, the treatment plants have an average of 9 mg/L of phosphorus at the inlet (at 27.60 mg/L as phosphate), which is equivalent to 2.76 tons of PO_4^{3-} daily. Taking into account that due to the conditions of the plant, 9 times its content must be reduced, 2,453 kg must be eliminated. Again, using previous references, WWTPs usually use a mixed disposal system (economic disposal + chemical disposal). If it is taken that 20% of the content is removed by chemical precipitation (491 kg PO_4^{3-}) and online control of the analyzer would allow a 2% improvement of the excess chemical addition (values chosen as a reference), **the daily saving is 9.81 kg PO_4^{3-} per day.**

Aluminum salt – Aluminum sulphate ($Al_2(SO_4)^3$)

According to the chemical reactions:

$Al_2(SO_4)^3 \leftrightarrow Al^{3+} + SO_4^{2-}$

$Al^{3+} + PO_4^{3-} \leftrightarrow AlPO_4$

And the following conversion factors,

$$9{,}81\ kg\ PO_4^{3-} \cdot \frac{1\ mol\ PO_4^{3-}}{94{,}973\ g\ PO_4^{3-}} \cdot \frac{1\ mol\ Al_2(SO_4)_3}{1\ mol\ PO_4^{3-}} \cdot \frac{342{,}15\ g\ Al_2(SO_4)_3}{1\ mol\ Al_2(SO_4)_3} = 35{,}35\ kg\ Al_2(SO_4)_3$$

This means that 35.35 kg of excess raw material is added daily, i.e., **annually savings are approximately 12,900kg**.

Instran Phosphate Analyzer®

The Instran online analyzer is an analyzer for monitoring phosphate concentration continuously, with a frequency of up to 1 analysis every 10 minutes. The Instran phosphate analyzer is characterized mainly by its accuracy (±2% over full scale) and repeatability of measurement. In addition, it has two different adaptable methods for phosphate measurement, depending on the measuring range. Thus, the high range method uses only one reagent, with a low consumption of only 0.9 mL of reagent per analysis, requiring only 0.5L of reagent per month at a frequency of 1 analysis per hour.

In addition, the specific cleaning systems of the equipment allow to deal with dirty water from sewage treatment plants, without affecting the measurements with cross interferences in subsequent analyses. Finally, its simple design makes it easy for plant operators to become familiar with the equipment and its maintenance is very low. All these features make the *Phosphate Instran®* analyzer unique in the market with exceptional performance for the control of phosphates in wastewater treatment plants and its consequent economic savings, as well as complying with current legislation.

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PHOSPHATE INSTRAN FOR WASTE WATER TREATMENT PLANTS

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