Aluminum monitoring lowers risk and demonstrates compliance

Problem

Algae in the surface water supply of a water provider in Italy necessitates the employment of Aluminum salts as coagulants in the treatment process. However, Aluminum residuals represent a potential risk to health and the aesthetic value of water. Regulatory compliance is also necessary.

Solution

The Hach® EZ1000 online Aluminum analyser has been installed, providing the range and sensitivity required to ensure that Aluminum levels in drinking water quality are minimised, and to demonstrate regulatory compliance with the 200 µg/L limit.

Benefits

Continuous monitoring helps to identify trends or potential problems so that mitigation can be implemented without affecting clean water production. The health of consumers is therefore protected and potential risk to aesthetic water quality is avoided. Coagulant usage is optimised and costs are minimised.

The following text explains the reasons for monitoring Aluminum in water; how the latest technology is able to do so reliably and continuously; and we highlight the benefits of continuous Aluminum monitoring with a case study on a water supplier in southern Italy, serving 500,000 people.

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Background

Aluminum is the most abundant metallic element on earth, occurring naturally in the environment as silicates, oxides and hydroxides, combined with other elements, such as sodium and fluoride, and as complexes with organic matter. In addition to its many uses in industries such as construction, automotive and aircraft, Aluminum is also widely employed in water and wastewater treatment. Salts of Aluminum are employed as coagulants, aiding in the removal of organic matter, pathogens and a variety of inorganic species. The effectiveness of aluminum coagulants arises from their ability to form multi-charged polynuclear complexes with enhanced adsorption characteristics. Aluminum salts therefore flocculate suspended particles in water causing them to settle, and thereby aiding in sedimentation.

The concentration of Aluminum in water can vary considerably – concentrations in waters with near-neutral pH values usually range from 0.001 to 0.05 mg/L but rise to 0.5–1 mg/L in more acidic waters or water rich in organic matter. Nevertheless, it is possible for raised levels of residual Aluminum to occur where salts of Aluminum have been used in the treatment process.

Raised levels of Aluminum are undesirable in drinking water because of the effect on colour, and also because of health concerns. Similarly, raised levels can cause problems in industrial processes, where water and steam can create deposits and scaling.

5 Reasons for monitoring Aluminum

Health

Research to-date has been inconclusive with regard to the health effects of Aluminum. However, some observations indicate a possible role in dementia. The World Health Organisation (WHO) says: "Some of the epidemiology studies suggest the possibility of an association of Alzheimer disease with Aluminum in water, but other studies do not confirm this association. There is a need for more research to determine whether Aluminum from various sources has a significant causal association with Alzheimer disease and other neurodegenerative diseases."

In 1988, around 20,000 people in Camelford, UK, were exposed to unknown but increased levels of Aluminum in drinking water for at least 5 days. The water was poisoned when a relief delivery driver mistakenly tipped 20 tonnes of Aluminum sulphate into the wrong tank at the Cornish water treatment works. The incident resulted in almost 1,000 complaints to the water authority, and reported symptoms included nausea, vomiting, diarrhoea, mouth ulcers, skin ulcers, skin rashes and arthritic pain. It was concluded that the symptoms were mostly mild and short-lived, and no lasting effects on health could be attributed to the known exposures from Aluminum in the water. Nevertheless, a post-mortem examination found abnormally high levels of Aluminum in the brain of a local resident who died aged 59 in 2004.

Regulatory

For many, there is a regulatory requirement to ensure that Aluminum does not exceed a specified maximum concentration. According to the WHO practicable levels based on optimisation of the coagulation process in drinking water plants using Aluminum based coagulants are 0.1 mg/L or less in large water treatment facilities, and 0.2 mg/L or less in small facilities. In view of the importance of optimising coagulation to prevent microbial contamination and the need to minimise deposition of Aluminum floc in distribution systems, it is important to ensure that average residuals do not exceed these values.

The EU Drinking Water Directive 98/83/EC of November 1998 on the quality of water intended for human consumption says: For the purposes of the minimum requirements of this Directive, water intended for human consumption shall be wholesome and clean if it: (a) is free from any microorganisms and parasites and from any substances which, in numbers or concentrations, constitute a potential danger to human health, and (b) meets the minimum requirements set out in Annex I, Parts A and B. However, the Directive includes a standard for Aluminum in Annex 1, Part C 'Indicator Parameters' of 200 µg/L, and remains at this level in the 2018 revision to the Directive. In the UK for example, the 200 µg/L limit has been adopted as a mandatory standard in order to help ensure that tap water quality is not allowed to deteriorate.

In the United States, the US EPA has established Secondary Maximum Contaminant Levels (SMCLs) for contaminants that affect the aesthetics of drinking water but do not pose a risk to human health. SMCLs are not federally enforceable, so public water treatment facilities are not necessarily required to monitor them unless required to do so at a State level. The federal SMCL for Aluminum is 0.05 to 0.2 mg/L or ppm. The US EPA believes that if these contaminants are present in water at levels above the standards, the contaminants may cause the water to appear cloudy or colored, or to affect the taste or odour. This may cause people to stop using water from the public water supply system even though the water is actually safe to drink. Secondary standards are therefore set to give public water systems some guidance on removing these chemicals to levels that are below what most people will find to be noticeable.

Complaints

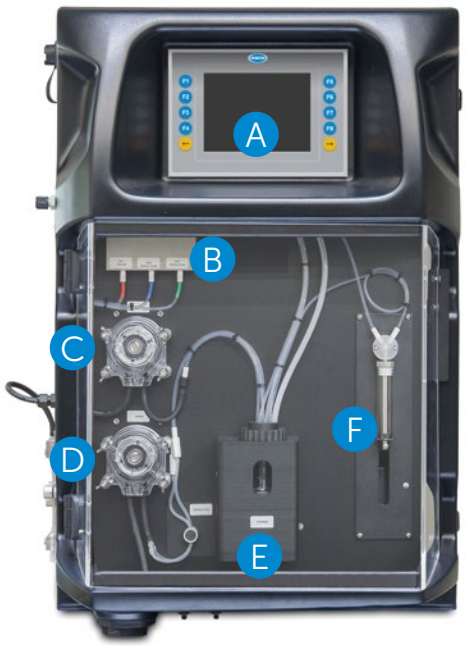
Color or cloudiness in tap water is one of the most common causes of drinking water complaints from members of the public. The handling of these complaints, and the implementation of investigation and remediation measures, can be very expensive. Turbidity monitors can help to raise alarms so that action can be taken to divert cloudy water from the distribution network, but turbidity can be caused by a wide range of issues, whereas raised Aluminum levels are most likely to have been caused by a problem with water treatment chemicals.

Scaling

Aluminum can be present as Aluminum hydroxide, a residual from the use of alum (Aluminum sulphate) or as sodium aluminate from clarification or precipitation operations. The presence of these chemicals has been known to cause deposits in cooling systems and to contribute to boiler scale. Aluminum may also precipitate at normal drinking water pH levels and accumulate as a white gelatinous deposit.

Coagulant cost reduction

By monitoring residual levels of Aluminum in treated water, it is possible to ensure that over-treatment does not take place. The dosing of coagulants should meet the need of the water because excessive dosing would result in high residual Aiuminum levels and wasted cost.



Colorimetric EZ1000 Online Analyser
*Components: **A** industrial panel PC, **B** high precision micropumps, **C** sample pump, **D** drain pump, **E** photometer, **F** dispenser for internal dilution (optional)*

Continuous monitoring of Aluminum – how it works

The EZ Series of analysers employ online colorimetric technologies to measure key water quality parameters accurately and reliably. The EZ1000 Aluminum Analyser is generally located at the outflow of the clarifier following flocculation and sedimentation. The instrument employs colorimetric measurement using the pyrocatechol violet method at 578 nm. Reagent consumption is low due to the instrument's precision micropumps, but high sensitivity (detection limit ≤10 µg/L) is achieved with a long optical path length. Smart, automated features contribute to enhanced analytical performance, minimised downtime and negligible operator intervention. Cleaning is automatic and both calibration and validation frequency can be set by the user.

Importantly, the measuring range of the EZ1000 is 0-150 µg/L Aluminum, with a detection limit ≤10 µg/L, so it is ideal for global regulatory requirements. Nevertheless, internal sample dilution is available to accommodate higher ranges if necessary.

The EZ1000 series has the ability to measure multiple streams simultaneously, up to a maximum of 8. This reduces the cost per sampling point, but must be specified at the time of ordering.

In applications with high levels of suspended solids, a different version of the analyser, the EZ2000, is available with a built-in digester to enable the measurement of both dissolved Aluminum and total Aluminum.

The advantages of continuous monitoring

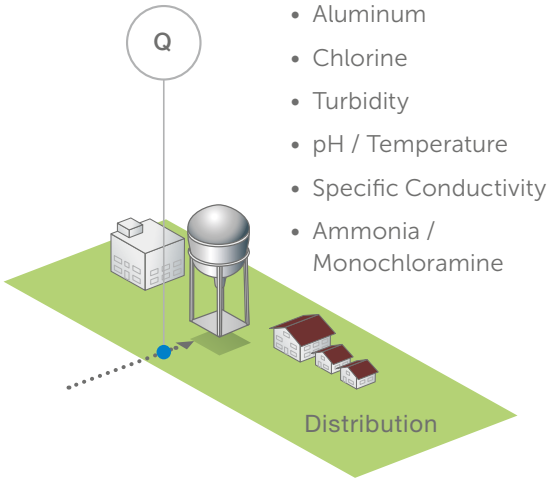
In general, laboratory analysis of Aluminum increases risk; not just because of the time delay between sampling and the delivery of a result, but also because occasional sampling risks missing a spike in the concentration. Continuous monitoring therefore helps to identify the causes of raised concentrations.

With a cycle time of just 10 minutes, the EZ1000 can provide a standard 4-20 mA signal output with alarm processing, so that any increase in Aluminum concentration is detected almost immediately. This means that alarms can be raised and appropriate and timely action can be implemented.

Case Study: Molise Acque

The Molise Acque water authority provides water and wastewater services to 170 municipalities in Molise, Puglia and Campania in southern Italy. One of the key water sources is the Liscione Dam, which intercepts the River Biferno and provides a usable capacity of 137 million m^3.

Water from the Liscione Dam is treated to the levels required by the EU Drinking Water Directive before entering the distribution network. However, one of the key challenges of this water source is the level of algae in the water, and Aluminum salts are employed as coagulants as part of the treatment process. In common with other parts of Italy where surface water is used as a water resource, Molise Acque has a regulatory requirement to ensure that the level of Aluminum in the finished water is below 200 µg/L and a new Hach EZ1000 has been supplied to replace an old Hach Aluminum monitor.



Typical monitoring parameters at the end of the treatment process

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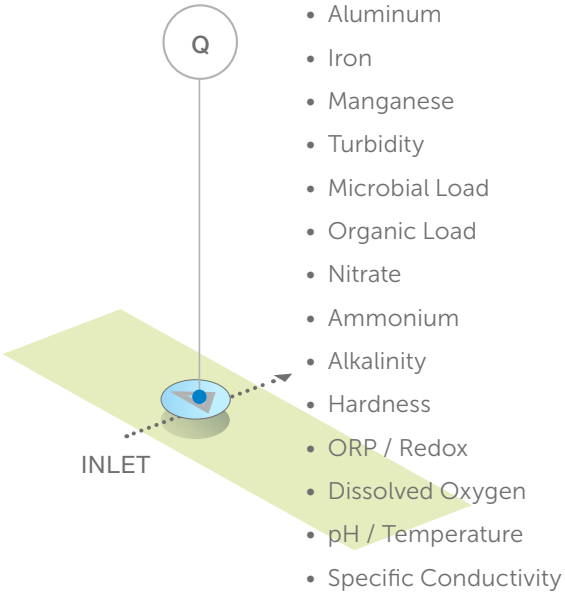

Monitoring parameters at the raw water intake

The new monitor was installed in November 2018 and checked in-situ against a Hach DR3900 spectrophotometer. The instrument performed very well with just a few µg/L deviation for typical readings of 60-70 µg/L. Going forward, the instrument will take a reading every 6 hours and will issue alarms if Aluminum levels are elevated; providing the authority with an opportunity to further treat the water if necessary.

Algae removal is an essential part of the treatment process, because algae produce toxins and also affect the appearance and smell of the water. By installing the monitor, Molise Acque will eliminate the risk of non-compliance with the 200 µg/L limit and ensure the protection of drinking water quality from any possible effects derived from the coagulation process.

The installed instrument has the capability to measure two sample streams and, as well as the outflow from the treatment plant, the surface water intake will also be monitored in the near future.

Dr. Maurizio Storani from Molise Acque said: "The EZ1000 instrument meets our requirements in terms of measuring range, accuracy and precision, and we are familiar with the quality of service from Hach, so it was an easy decision to purchase the Hach analyser for this important application."

Summary

The health impacts of Aluminum in water remain inconclusive; however, regulatory authorities around the world have adopted a position which protects the public and industry from possible adverse effects, whilst also protecting aesthetic value. The Hach EZ1000 was developed to meet this need, providing users with a simple, accurate and effective instrument for demonstrating compliance and removing potential risks through continuous monitoring.

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