

Application Note AN-PAN-1009

Online analysis of ammonia, nitrate, and nitrite in wastewater

Water is the source and basis of all life. As a solvent and transporting agent, it carries not only vital minerals and nutrients, but also, increasingly, harmful pollutants which accumulate in aquatic or terrestrial organisms.

Because of the associated health risks, the World Health Organization (WHO) has issued guideline values for about 200 substances found in water, including nitrogen compounds such as ammonia (NH_3), nitrate (NO_3^-), and nitrite (NO_2^-). Therefore, the treatment of wastewater is a critical topic and compliance with the legal limits is very important to help safeguard the environment from these mobile pollutants.

This Process Application Note deals with online measurements of ammonia, nitrite, and nitrate in wastewater treatment plants. These nitrogen compounds are analyzed simultaneously using a drift-free colorimetric measurement in a multi-parameter process analyzer from Metrohm Process Analytics.

INTRODUCTION

The importance of nutrient removal in the form of nitrogen and phosphorus in industrial and municipal wastewater has increased significantly over the past decade to minimize water pollution and avoid eutrophication of water bodies. Nitrogen is present in wastewater as mostly organic nitrogen, ammonium/ammonia, and nitrate. This wastewater must be properly treated to meet stringent effluent requirements imposed by legislation.

Biological nutrient removal (BNR) processes are put in place at modern wastewater treatment plants (WWTP) to treat and remove the nitrogen compounds, and these involve both nitrification and denitrification process steps. Nitrification (Reaction 1A) takes place in the aeration basin (Figure 1) where ammonium is oxidized to nitrate via nitrite using oxygen and different species of nitrifiers (bacteria). During subsequent denitrification (Reaction 1B), the nitrate is further converted to nitrogen gas (N_2) using specialized heterotrophic bacteria in the absence of oxygen (i.e., anoxic zone). The N_2 formed is harmlessly released into the atmosphere. It is therefore very important to measure the ammonia, nitrate, and nitrite concentrations continuously throughout both process steps to ensure complete nitrogen oxidation and subsequent nitrogen gas conversion.

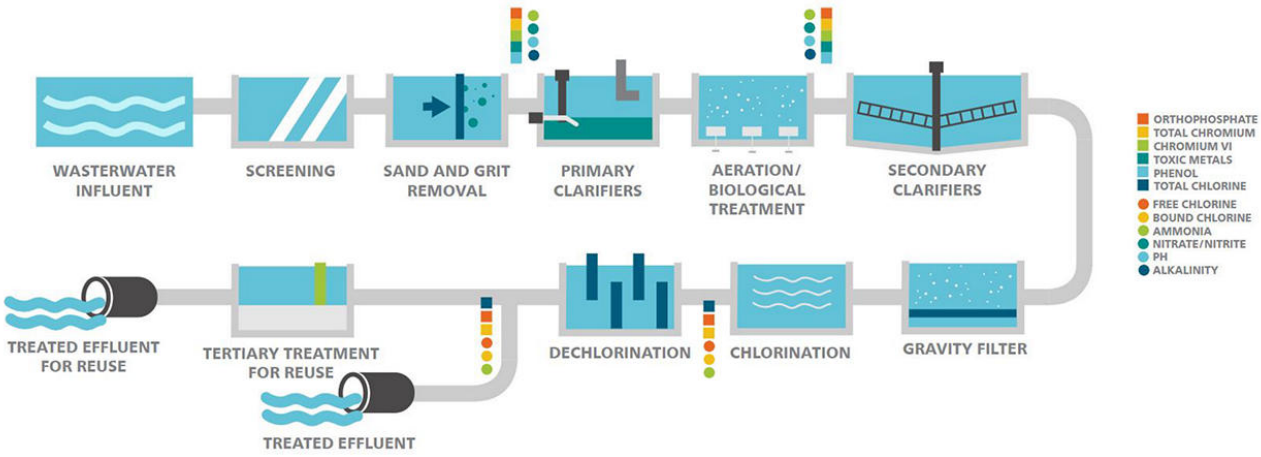


Figure 1. Illustrated diagram of process analyzer locations and measurement parameters in the wastewater treatment process.

$$\text{A)}\quad NH_4^+ \rightarrow NO_2^- \rightarrow NO_3^-$$

$$\text{B)}\quad NO_3^- \rightarrow NO_2^- \rightarrow NH_4^+ \rightarrow N_2$$

Reaction 1. Overall reaction of biological nitrogen conversion in wastewater treatment plants. (A) Nitrification and (B) denitrification.

An increase in ammonia and nitrite levels in the effluent indicate that either an insufficient aeration step or a change in toxicity or pH is disturbing the nitrification process. On the other hand, an increase of nitrate in the effluent can indicate that the anoxic zone is not developing correctly or the Biochemical (or Biological) Oxygen Demand (BOD) food source in the effluent is lower than usual.

The ammonia and nitrate/nitrite content must be constantly monitored in wastewater effluent to ensure environmental compliance. Traditionally, these parameters can be measured by laboratory analysis. However, this methodology does not provide «real-time» results and requires constant maintenance and human intervention to adapt to current operation conditions. Robust self-cleaning online process analyzers are the only reliable measurement solution for industrial, sewage, and municipal wastewater applications with high concentrations of solids and bacteria.

Metrohm Process Analytics offers a multi-parameter process analyzer solution for the simultaneous analysis of ammonia, nitrate, and nitrite over a wide concentration range covering all influent and effluent requirements—the 2060 TI Process Analyzer (Figure 2). This process analyzer can also monitor nitrogen compounds online, guaranteeing high nutrient treatment efficiency and low operating and energy costs.



Figure 2. 2060 TI Process Analyzer for wastewater treatment plants.

APPLICATION

NH_3, NO_3^-, and NO_2^- can be analyzed simultaneously using a drift-free photometric measurement. The 2060 TI Process Analyzer is able to measure a wide range of NO_2^-, NO_3^-, and NH_3/NH_4^+ concentrations, from µg/L to mg/L (Table 1).

Table 1. WWTP measurement parameters and concentration ranges before and after treatment processes.

Parameters	Influent [mg/L]	Effluent [mg/L]
NH_3	0–6000	0–60
NO_3^-	140–1400	0–88
NO_2^-	160–320	0–16

REMARKS

Other parameters like Chemical Oxygen Demand (COD), free and total phosphate, total nitrogen, pH, heavy metals, chlorine, and more can be measured online in wastewater streams using Metrohm process analyzers.

CONCLUSION

Ammonia, nitrite, and nitrate are important parameters to measure in wastewater treatment plants. For increased analysis frequency, the 2060 TI Process Analyzer from Metrohm Process Analytics can prevent out-of-specification data of wastewater streams and help to guarantee compliance with governmental regulations.

RELATED APPLICATION NOTES

AN-PAN-1039 Ortho- and total phosphate phosphorus analysis online according to EN ISO 6878

AN-PAN-1030 Monitoring of chromate in wastewater streams

AN-PAN-1002 Free, total & WAD cyanide in gold leach slurry & wastewater

OTHER RELATED DOCUMENTS

8.000.5358 Environmental Testing Industry I - Online Analyzers for Municipal Wastewater Analysis

8.000.5359 Envionmental Testing Industry II - Online Analyzers for Potable Water Processing

BENEFITS FOR ONLINE PROCESS ANALYSIS

- **Fully automated diagnostics** – automatic alarms for when samples are out of specification parameters.
- **Guarantee compliance** with governmental regulations.
- **Avoid unnecessary costs** by measuring multiple parameters simultaneously in a process stream.



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CONFIGURATION



2060 Process Analyzer

The 2060 Process Analyzer is an online wet chemistry analyzer that is suitable for countless applications. This process analyzer offers a new modularity concept consisting of a central platform, which is called a «basic cabinet».

The basic cabinet consists of two parts. The upper part contains a touch screen and an industrial PC. The lower part contains the flexible wet part where the hardware for the actual analysis is housed. If the basic wet part capacity is not sufficient enough to solve an analytical challenge, then the basic cabinet can be expanded to up to four additional wet part cabinets to ensure enough space to solve even the most challenging applications. The additional cabinets can be configured in such a way that each wet part cabinet can be combined with a reagent cabinet with integrated (non-contact) level detection to increase analyzer uptime.

The 2060 process analyzer offers different wet chem techniques: titration, Karl Fischer titration, photometry, direct measurement and standard additions methods.

To meet all project requirements (or to meet all your needs) sample preconditioning systems can be provided to guarantee a robust analytical solution. We can provide any sample preconditioning system, such as cooling or heating, pressure reduction and degassing, filtration, and many more.