This Week's Citation Classic®

CC/NUMBER 8
FEBRUARY 23, 1987

Painter H A. A review of literature on inorganic nitrogen metabolism in microorganisms. *Water Res.* 4:393-450, 1970.
[Water Pollution Research Laboratory, Stevenage, England]

The importance to the water cycle of inorganic nitrogen reactions, especially the oxidation of ammonia, is discussed. [The *SCI*® indicates that this paper has been cited in over 160 publications.]

H.A. Painter
Water Research Center
Henley Road, Medmenham
Buckinghamshire SL7 2HD
England

October 29, 1986

The oxidation of ammonium salts to nitrite and thence to nitrate (nitrification) became of interest in the UK in the 1960s because of greater loadings of both biochemical oxygen demand (BOD) and ammonium being received at sewage works, coupled with the greater use of xenobiotic organic chemicals.

Ammonium salts were already well known to be much more directly toxic than nitrate to fish and, in any case, ammonium discharged to rivers would be oxidised (nitrified), causing depletion of dissolved oxygen. In extreme cases the depletion alone would be sufficient to cause the death of fish. Yet nitrification in sewage treatment could also be desirable: the autotrophic bacteria that convert ammonium to nitrite (largely *Nitrosomonas* spp.) and thence to nitrate (largely *Nitrobacter* spp.) grow comparatively slowly. Thus, a treatment system allowing nitrification (high sludge retention times) would also allow the retention of heterotrophs capable of degrading xenobiotic organic chemicals at rates comparable with the rate of oxidation of ammonium. At lower retention times the normal organic matter (BOD) is fairly efficiently removed, but ammonium and most xenobiotics are not.

As UK rivers were becoming more polluted and as sewage treatment works were increasingly reporting lack of nitrification, it became necessary to study the nutrition, inhibition, kinetics, and other aspects of the nitrifiers.[1]

It was customary at the Water Pollution Research Laboratory to have frequent meetings of people interested in sewage treatment to discuss results and to plan ahead. At one such meeting in 1965, the then director (the late B.A. Southgate) demanded that someone should review nitrification, and, since I had already started on this, I volunteered. I was later dismayed to find that the task had increased to the whole field of inorganic nitrogen metabolism-deamination, nitrification, denitrification, and fixation.

I took on the task largely as a spare-time occupation on weekends and during evenings. When complete, copies were sent to colleagues, but, in spite of my objections, the review was not presented for publication since the director thought that nobody else would be interested in it.

A few years later the late Sam Jenkins (editor of *Water Research*) invited literature reviews for the first time, and a colleague, Harry Montgomery, responded with one on measurement of oxygen uptake. This spurred me on to pester the director to allow me to publish mine; after first refusing, he later agreed. I quickly brought it up-to-date and prefaced it with a contents list. It was published in 1970 without the list, which my group leader thought unnecessary. I regret not fighting his decision.

There was little interest in the topic in North America at the time, but in the last decade much more interest has arisen for much the same reasons as in the UK earlier, and it has been gratifying to see the review quoted so frequently on both sides of the Atlantic.

I am often asked, by nonbiologists, whether there is an organism that converts ammonium directly to gaseous nitrogen, instead of having three sets of organisms to produce nitrite, nitrate, and then dinitrogen. My biochemical friends have ready arguments as to why this cannot be, but they sound somewhat specious to me.

Currently, I am trying to find the optimal concentration of nitrifying inhibitor to suppress nitrification completely for 28 days in tests for biodegradability, using oxygen uptake in BOD bottles and respirometers.[2]

I hope to attend the conference on nitrogen in Belgium in 1987 as my swan song on the subject that has interested me for over 25 years.

1. **Painter H A & Loveless J E.** Effect of temperature and pH value on the growth rate constants of nitrifying bacteria in the activated sludge process. *Water Res.* 17:237-48, 1983.
2. **Painter H A.** Nitrification in the treatment of sewage and waste waters. (Prosser J I, ed.) *Nitrification.* Oxford: IRL Press. 1987.

242