Microbial Treatment Process for Removal of Nitrogen Compounds from Wastewater

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ABSTRACT

Removing nitrogen compounds (ammonia, nitrate, NOx) from wastewater has been a great concern in recent years because of the increasing N discharge to receiving streams. Biological removal processes are the most efficient way for the nitrogen removal. Recent research was mostly focused on the improvements of efficiencies and energy saving in traditional pathways and identification of new processes (sometimes new microorganisms) to convert ammonium to harmless forms. This paper reviews some new processes in nitrogen removal: Partial nitrification, SHARON, Anammox, Canon, NOx cycle. This paper addresses the mechanism and the application of them in nitrogen removal and mentions the future research and development in nitrogen removal.

KEYWORDS

nitrogen removal, nitrification, denitrification, partial nitrification, SHARON, Anammox, Canon, NOx cycle

INTRODUCTION

Nitrogen pollution has caused great concern in recent years because the following reasons: nitrogen can cause eutrophication because it can be a nutrient to aquatic organisms; ammonia is toxic to fish and many other aquatic organisms; ammonia will deplete the dissolved oxygen in receiving water because its oxygen-consuming properties; nitrate ion is a potential public health hazard, especially for infants; Contaminated groundwater, agricultural drainage, and municipal wastewater, once considered unusable, are now being seriously considered as sources of municipal wastewater. As a result, a great deal of investigations on the techniques for reducing the nitrogen content of both waste water and ground water efficiently has been done. The removal of nitrogen can be achieved by physical-chemical methods such as ion exchange (IE), air stripping, break-point chlorination, reverse osmosis (RO), membrane separation, electrodialysis(ED), ultrafiltration, precipitation etc. and biological treatment processes. Because costs for the physical-chemical methods are generally higher than that for the biological method, the biological treatment is the most common method reported for the nitrogen removal. The first experiments with biological nitrogen removal from wastewater were performed thirty years ago and the first full-scale plants were in operation soon afterwards. Nevertheless, nitrogen removal was not widespread until the 1980's. Typically the removal of nitrogen biologically is done in two steps. The first step is nitrification, in which ammonia is converted aerobically to nitrate (NO_3^-). The second step is denitrification, in which nitrates are converted to N_2O or nitrogen gas (N_2) under anoxic conditions. The operation unit for nitrogen removal includes attached-growth (biofilm) system which includes the most widely used technique such as Trickling towers, Rotating Biological Contactors (RBC), Upflow Fixed Bed Reactors (UFBR) and the suspended growth (activated sludge) system. Recent researches focus on increasing the conversion capacity, decreasing the area/volume ratio and reducing the excess sludge production by optimilizing reactor performance, combining nitrification and denitrification in a single reactor or linking the conventional processes in a more efficient way.

NITRIFICATION

The following are the major reactions involved in the nitrification:

$$NH_4^+ + 1.5O_2 \Rightarrow 2H^+ + H_2O + NO_2^- (\Delta G^{0'} = -275kJ/mol) \quad (1)$$

$$NO_2^- + 0.5O_2 \Rightarrow NO_3^- (\Delta G^{0'} = -74J/mol) \quad (2)$$

Although there are many organisms, including bacteria, algae, fungi and protozoa, which are