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学 位 論 文 内 容 の 要 旨

博士の専攻分野の名称 博士（工学） 氏名 Muhammad Ali

学 位 論 文 題 名

Rapid start-up of anaerobic ammonium oxidation (anammox) process for nitrogen removal from
wastewater

(排水から窒素を除去するための嫌気性アンモニア酸化 (アナモックス) プロセスの迅速な立ち上げ)

The dissertation is associated with the field of biological wastewater treatment and more precisely focus on nitrogen removal from wastewater. The nutrients removal (mainly N and P) from wastewater is necessary in order to avoid the eutrophication of the surface waters. Nitrogen compounds (NH_4^+ , NO_2^- and NO_3^-) removal is commonly performed by means of biological processes due to the lower cost as compared to chemical treatment. The conventional nitrogen removal process consists of two steps, nitrification and denitrification (N&DN). During nitrification, ammonium is oxidized to nitrite by ammonia oxidizing bacteria (AOB), then nitrite is oxidized to nitrate by nitrite oxidizing bacteria (NOB). In denitrification process, heterotrophic denitrifying bacteria reduce nitrate to nitrogen gas by utilizing organic carbon as an electron donor under anoxic condition. However, this process is not the most appropriate to treat NH_4^+ -rich wastewater streams. While treating NH_4^+ -rich wastewaters by N&DN process, more oxygen is required and an external carbon source has to be added that result in high operational cost.

Autotrophic nitrogen removal by anaerobic ammonium oxidizing (anammox) bacteria is an alternative to conventional nitrogen removal process for treatment of NH_4^+ -rich wastewater streams. This biological process was first discovered in nitrifying reactor about two decade ago in the Netherlands. Anammox process oxidize ammonium, with nitrite as an electron acceptor, to dinitrogen gas under anoxic condition. Currently, this process is being used for the treatment of reject water from anaerobic digesters and industrial wastewaters with high NH_4^+ concentrations and low organic matter content. Anammox process has several advantages over conventional N&DN process e.g. high nitrogen removal rates, less oxygen demand, no external carbon source required, less sludge production rate, and less/no greenhouse gas (N_2O) production etc.

However, growth rate of anammox bacteria is extremely slow and takes about one to two weeks to get double. Slower growth rate of anammox bacteria results in longer start-up period of anammox treatment plant. This doctoral endeavour was to lessen start-up period of anammox process. In order to achieve the rapid and stable start-up of anammox process sufficient amount of active anammox biomass is required. In order to secure enough seeding biomass, inoculation with highly active preserved anammox biomass could be one of possible solutions. Chapter three of the dissertation focuses on simple, rapid and effective preservation and reactivation of anammox bacterium "*Candi-*

datum "Brocadia sinica". Subsequently, chapter four presents innovative immobilization technique for anammox bacteria to achieve rapid and successful start-up of anammox process. In order to shorten start-up period of anammox process it was essential to understand ecophysiology of anammox bacteria. Chapter five highlights the physiological characteristics of anammox bacterium related to genus "Ca. Jettenia" one of the six proposed genera in the taxonomic group of anammox. Further, this chapter describes proteomics and cellular metal analysis of the same genus. Finally, chapter six details conclusions and recommendations drawn during doctoral endeavour.