Table 1
Total nitrogen removal efficiency, chemical input, economic evaluation, main technical parameters of different nitrogen removal process compared to conventional process.

Operation technique	Total nitrogen removal efficiency	Chemical input	Economic evaluation	Main technical parameters	References
Partial nitrification via nitrite	1.5–2 fold increase of nitrite reduction rates in the subsequent denitrification stage	40% reduction of COD	25% reduced oxygen demand, 300% biomass reduction, 20% CO_2 emission during denitrification	pH, temperature, DO, real-time aeration control, sludge retention time, substrate concentration, alternating anoxic and aerobic operation, inhibitor, ultrasonic treatment	Ge et al. (2015)
Partial nitritation /anammox	≥85% of nitrogen removal	No need of external carbon source	60% reduced oxygen demand, 80% reduced sludge production, 24 Wh/p/day, compared to a 44 Wh/p/day consumption in conventional treatment	Carbon concentrating pretreatment, suppression of NOB especially under low temperatures (15–10 °C), intensification of anammox biofilm activity, reactor design, final polishing	Cao et al. (2017)
Simultaneous nitrification and denitrification (SND)	82% nitrogen removal	Requirement of external carbon source	Saving cost for anoxic tank, applicable only for low C/N ratio ($<$ 5) wastewaters	Reactor design, oxygen availability for nitrification, effective carbon source utilization for denitrification	Guo et al. (2005)
Shortcut nitrification and denitrification	Nitrite denitrification rate is 1.5 to 2 times higher than nitrate denitrification rate	40% lower demand of electron donors in anoxic phase	25% reduced oxygen demand in aerobic phase with 60% saving energy, applicable for high ammonium concentrations or low C/N ratios wastewaters	DO, SRT, pH, temperature, substrate concentration and load, operational and aeration pattern, inhibitor	Peng and Zhu (2006)
Nitritation/anammox	81% nitrogen removal	No need of external carbon source	60% reduced oxygen demand, energy recovery by methane production, minimal surplus sludge production, consumption of inorganic carbon CO_2, no nitrous oxide emission, decrease in energy consumption from 2.66 to 1.50 kWh per kg N removed for reject water treatment	Poor effluent water quality, need of post-denitrification process	Du et al. (2015); Ma et al. (2016); Li et al. (2016a)
Simultaneous partial nitrification, anammox, and denitrification (SNAD)	99% nitrogen removal	Low concentrations of organic matter	Simultaneous removal of inorganic nitrogen and organic carbon, applicable for wastewater with complex composition and high ammonia concentration and low C/N ratio	Intermittent aeration, pH, DO	Zhang et al. (2017)
Denitrifying ammonium oxidation (DEAMOX)	94% nitrogen removal, simultaneous nitrate and ammonium removal	80% reduced demand of organic carbon	100% reduced aeration demand, 64.8% reduced sludge production, low nitrogen contained wastewater, low/high-strength nitrate and ammonium containing wastewater, reduced greenhouse gas (CO_2 and N_2O) emission	Co-existence of partial-denitrification and anammox bacteria	Du et al. (2017)
Partial-denitrification/anammox	More than 90% nitrogen removal	79% reduced demand of organic carbon	45% reduced oxygen demand, reduced biomass production, applicable for high-strength wastewater	Avoiding high organic matter in the effluent of partial denitrification reactor	Ma et al. (2016), Cao et al. (2016)
Denitrification by bioelectrochemical systems	100% nitrate removal	Required carbon source and buffering agent	100% reduced oxygen demand, producing power and current densities of 2.1 W/m3 and 26.6 A/m3	Generation of high concentrations of ammonium in anode and cathode	Naga Samrat et al. (2018)

COD- chemical oxygen demand; DO- dissolved oxygen concentration; SRT- sludge retention time; Wh/p/day- watt hours per person per day.