Process improvements for better wastewater treatment performance are necessary with stringent discharge requirements. The main objective of this research is to develop new wastewater treatment technologies for improved nutrient removal and the degradation of recalcitrant organic nitrogen compounds. In this research, a reverse A2/O system demonstrated better phosphorus removal efficiency than the regular A2/O system by inverting the sequence of anaerobic and anoxic zones. Placing an anoxic stage before the anaerobic stage in the reverse A2/O process resulted in a lower oxidation-reduction potential in the anaerobic zone, which contributed to higher P uptake by bacteria under subsequent aerobic respiration. With the development of emerging environmental nanotechnology, the effectiveness of nano zero-valent iron (NZVI) in nutrient removal was also determined under anaerobic, anoxic and aerobic conditions. The highest P removal efficiency (95% at the initial P concentration of 10 mg/L) by NZVI was observed under anoxic abiotic conditions. Furthermore, new applications of NZVI as an antiseptic/antimicrobial material were extended to sludge bulking control. In two Modified Ludzack-Ettinger (MLE) activated sludge treatment systems, a single dose of NZVI at the final concentration of 100 mg Fe/L in the mixed liquor reduced the number of filamentous bacteria Type 021N by 2-3 log units (a reduction of 99.9 and 96.7% in MLE tank #1 and #2, respectively). Additional benefits of the use of NZVI such as improved P removal was also determined. The side effect of the use of NZVI depended on sludge bulking conditions and biomass concentration. In the last part of this dissertation, process improvements to remove recalcitrant organic N compounds such as melamine were evaluated. Melamine is a nitrogen-rich (67% nitrogen by mass) heterocyclic aromatic compound that could significantly increase effluent total nitrogen concentrations. The degradation of melamine and its impact on activated sludge operation in conventional activated sludge (CAS) systems and MBRs with high biomass concentrations were compared. Melamine was dosed continuously in CAS and MBR systems at an influent concentration of 3 mg/L for about 100 days. Even after such a long period of sludge adaptation, melamine appeared not to be easily biodegradable in any of the CAS and MBR systems indicating that selective enrichment of special microbes (melamine degradation specialists) and the special enzymes responsible for melamine degradation cannot be induced through acclimation. However, a significant reduction in toxicity of melamine to the activated sludge was observed in MBR systems, demonstrating the significance of MBR operation at high sludge concentrations.