Growing populations and industrialization have increased water demand, leaving 36% of the global population with inadequate water supplies. Contaminated water is a major problem, especially in low–and middle–income countries. Advanced Oxidation Processes (AOPs), particularly photocatalysis using TiO2, offer a solution by oxidizing organic pollutants. While TiO2's photocatalytic activity was discovered in 1972, its widespread use is hindered by limitations such as a large band gap energy and aggregation. However, modifications like doping and surface modification improve TiO2's light absorption, charge separation, and pollutant adsorption. TiO2–based AOPs are applicable to various industrial wastewaters, including textile, municipal, pharmaceutical, and petroleum waste. Future research should focus on developing cost–effective and reusable TiO2 photocatalysts to enhance sustainability.