Forward osmosis (FO) is a low energy-intensive process since the driving force for water transport is the osmotic pressure difference, $\Delta \pi$, between the feed and draw solutions, separated by the FO membrane, where $\pi_{\text{draw}} > \pi_{\text{feed}}$. The potential of FO in wastewater treatment and desalination have been extensively studied; however, regeneration of the draw solution (thereby generating clean water) requires application of an energy-intensive process step like reverse osmosis (RO). In this study, the potential of applying FO for direct water recirculation from diluted fermentation effluent to concentrated feedstock, without the need for an energy-intensive regeneration step (e.g. RO), has been investigated. Butanol production during crude glycerol fermentation by Clostridium pasteurianum, has been selected as a model process and the effect of cross-flow velocity and the dilution of draw solution on the water flux during short-term experiments (200 min), were investigated. Statistical analysis revealed that the dilution of the draw solution is the most influential factor for the water flux. Subsequent modelling of an integrated FO-fermentation process, showed that water recoveries could lead to substantial financial benefits, although the integrated FO-fermentation process demonstrated lower water flux than expected. FTIR analyses of the membrane surface implied that the decrease in water flux was due to the presence of proteins, polysaccharides and other extracellular polymeric substances on the membrane active layer, indicating the presence of a fouling layer. Based on these findings, possible fouling alleviation strategies and future research directions are discussed and proposed.