products, which is a major contribution to the total volume and loading of the wastewater from the larger bottling plants. There may also be product losses from the syrup production and bottling lines which include washing, rinsing and, for some producing juice drinks, pasteurisation.

The main pollutant from bottling or beverages plant is BOD and COD, which is mostly all due to dissolved organics. Typically, the mixed wastewater will have a BOD of 2,000-3,000 mg/L and COD of 3,000-5,000 mg/L with a relatively low TSS of 100-400 mg/L and TDS values mostly <3,000 mg/L. However, there are MBR applications with effluents of high syrup or juice content where the influent wastewater BOD may be as high as 20,000 mg/L. One such effluent, at a bottling plant in North America, is treated by a pumped sMBR which achieves an effluent BOD of <500 mg/L (>97% BOD removal) and operates well despite the feed containing 125-150 mg/L FOG at times. For such high loads anaerobic pre-treatment is often viable.

An example of the use of anaerobic pre-treatment is at a juice and sport drinks processor in Florida US, which had its existing anaerobic treatment (based on the ADI-BVF® reactor, a proprietary low-rate anaerobic system) upgraded in 2007 to include an aerobic iFS MBR (Kubota) with downstream RO polishing to meet more stringent discharge standards on final BOD and TDS. In this case the feedwater contains 3,000 mg/L COD, 1,700 mg/L BOD and 2,200 mg/L TSS, the COD being reduced to 450 mg/L by the ADI-BVF® reactor and then to 35 mg/L by the MBR. In this case the MBR is required to treat only half of the effluent to attain the stipulated discharge water quality standard.

### 3.2.4 Cereals and snack foods

Companies in this sector produce ready-to-serve cereal, breakfast snack bars and cereals such as oatmeal that must be cooked prior to eating. The most popular cereals are made with corn, wheat, oats, mixed grains, or rice mostly as flaked, puffed, shredded or shaped products. Many cereals are sweetened by adding malt, white sugar, brown sugar, corn syrup or concentrated fruit juice. They may also include flavours such as chocolate and cinnamon.

Cereal facilities can produce significant amounts of wastewater mostly from the cleaning of equipment (i.e. cookers, conveyors, rollers, extruders, flavour tanks, pipework, etc.), normally sterilised with pressurised steam, plus water discharged from scrubbers and site utilities. The influent wastewater quality is typically 300-500 mg/L TSS and 2,000-3,000 mg/L COD, but it may be much higher (possibly 2-3 times more) from some facilities if there are more product losses, use of sweetener coatings and frequent product changes entailing more cleaning operations. As such, there may be a requirement for primary treatment, normally using DAF-based clarification, to reduce the higher influent TSS of 1,000-2,000 mg/L and associated COD of 5,000-10,000 mg/L.

Early MBR plants installed for treating cereals manufacturing wastewaters include the sMBR at the Kellogg plant in Manchester, UK, in 2004. The original installation was designed for 1,500 $m^3$/d (at 4,000 mg/L COD) but was later upgraded to a 2,100 $m^3$/d plant treating 7,100 mg/L of COD. The upgrade included the addition of a fifth bank of membranes and the conversion of the balance tank into a bioreactor using pure oxygen for enhanced aeration to address the additional load. The upgraded MBR provides 99% removal of the influent COD, with permeate COD and BOD values of 10-100 and <10 mg/L respectively with downstream RO for effluent reuse. A similar pumped sMBR technology has been installed at the General Mills facility at Covington, GA, which achieves a comparable effluent quality from a similar feedwater. In this case, 50% of the effluent is recycled for use in non-potable factory applications (such as the dust scrubbers) and as demineralised feedwater for the boilers, significantly reducing the total site operating costs associated with chemicals use and blow-down wastage.