Industrial Water Reuse Case Studies

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1. INTRODUCTION

In view of the limited availability of fresh water resources and the need for their conservation, the implementation of water recycling concepts within the framework of sustainable water management strategies is of crucial importance. Industry is increasingly implementing such concepts due to growing economic pressure, regulatory developments and supportive funding at governmental level. The benefits of wastewater reuse derive mainly from savings in the freshwater supply and a reduction in wastewater generation, including related treatment costs and sewerage charges. In addition, the security of the water supply is improved. In recent years, VA TECH WABAG has realized several water reclamation plants for industrial reuse. These plants have been built mainly for the pulp & paper, chemicals, foods, textiles and petroleum refining branches.

2. INDUSTRIAL WATER REUSE CASE STUDIES

2.1 Petrochemical Industry

At Jamnagar in India, the Reliance Petroleum Limited operates the world's largest grassroots refinery. The approximate capacity of the naphtha-based, cracker refinery is 18 million t/a. The wastewater reclamation plant has a capacity of 48,000 m³/d, which makes it the biggest effluent treatment plant in India (Fig. 1).

Fig. 1: Jamnagar Wastewater Reclamation Plant

The reclamation plant is designed for the maximum reuse of the wastewater coming from the operational units of the refinery. To achieve this goal, as shown in Table 1, the wastewater is treated in three separate, identical trains, two for wastewater containing low total dissolved solids (LTDS I and II) and one for wastewater with high total dissolved solids (HTDS).

The LTDS stream is a mixture of oily condensates and contaminated storm waters. The TDS is lower than 500 mg/l and the chloride content below 300 mg/l. The treated water is reused as make up in the fresh water cooling tower, as fire water make up and for local green belt development and irrigation.

The HTDS stream is a mixture of oily wastewater from the crude unit desalters and contains dissolved salts such as sodium chloride, neutralized spent caustic and contaminated cooling water blow-down. The TDS of this stream is 1,000 – 2,000 mg/l. The treated water is reused as partial make up in the seawater cooling tower.

Basically, the process consists of oil removal (API-separator and dissolved air flotation), biological treatment (biotowers with plastic packings and activated sludge process), tertiary filtration (dual media filters) and polishing with granular activated carbon. Plant operation has shown that the treated water standards can be met without any problems.

The investment costs for the reclamation plant were approx. € 12.5 million with electrical & mechanical equipment totaling € 8.3 million and civil works, € 4.2 million. Operating costs amount to € 0.32/m³ (capital costs € 0.11/m³, operating costs € 0.21/m³), which is more economic than seawater desalination.

Parameter	Refinery Wastewater				Treated Water Standard
	LTDS		HTDS		
	Normal	Maximum	Normal	Maximum	
pH	6 – 9	12	6 – 9	12	6 – 8
TDS (mg/l)	200 – 500	2,000	1,000 – 2,000	10,000	-
TSS (mg/l)	50 – 100	500	50 – 100	500	< 5
COD (mg/l)	330 – 750	750	550 – 750	1,100	< 50
BOD_5 (mg/l)	140 – 300	300	200 – 300	440	< 15
NH_3-N (mg/l)	5 – 20	50	5 – 30	50	< 5
PO_4 (mg/l)	-	-	-	-	< 5
Oil and grease (mg/l)	300 – 10,000	10,000	300 – 2,000	10,000	< 5
Sulphide (mg/l)	5 – 10	30	5 – 30	30	< 0.5
Phenols (mg/l)	10 – 40	60	10 – 40	60	< 1
Cyanides as CN (mg/l)	2 – 4	6	2 – 4	6	< 0.2
Bio-assay (%)	-	-	-	-	90[a)]

[a)] Survival of fish after 96 hrs in 100% effluent

Table 1: Raw water characteristics and effluent quality standards

The reclamation plant at the Panipat refinery in India provides another example in this area. In this plant (Q = 17,000 m³/d) secondary refinery effluent is largely converted into boiler feed water. Basically the process steps consist of solid contact clarification, pressure sand filtration, ultrafiltration (NORIT), reverse osmosis and ion exchange in mixed bed filters. Plant start-up is scheduled for 2006.

2.2 Chemical Industry

At the Du Pont production centre in Hamm-Uentrop, Germany, biologically pretreated chemical wastewater (including nitrogen and phosphorous removal) is reclaimed and then mainly reused as process water for fiber production and as boiler feed water. In general terms, the reclamation plant comprises tertiary filtration with ultrafiltration (NORIT), activated carbon adsorption, UV disinfection, reverse osmosis and ion exchange in mixed bed filters.

The economic feasibility of this reuse project derives primarily from a cut in wastewater discharge from 600,000 m³/a before recycling, to 60,000 m³/a after the implementation of the reuse scheme. This represents an annual reduction of 540,000 m³ and provides corresponding savings in water from the municipal network (drinking water). Positive environmental effects stem from reductions in chemical oxygen demand (15%), nitrogen (60%) and phosphorus (67%).

2.3 Paper Industry

The Palm-Eltmann paper mill in Germany produces newsprint on the basis of 100% recycled paper.

As part of an increase in production to 420,000 t of newsprint per year, the biological treatment plant also had to be enlarged. The aim was to meet the need for both direct discharge into the River Main and the reuse of the effluent as process water. To this end, the effluent from the biological treatment plant required further purification. Dual media filtration and nanofiltration were chosen as additional treatment steps, in order to remove residual suspended solids, COD, dissolved dyes, AOX and bivalent ions.

In the nanofiltration unit, spiral wound membranes from Koch were initially employed, but now have been replaced by Microdyn-Nadir membranes. The permeate flux is approx. 190 m³/h. This corresponds with a recovery rate of approx. 90%. The concentrate is treated with lime precipitation and then evaporated. COD, color and AOX removal exceeds 90% and the nanofiltration permeate is reused at sensitive points of the paper machine.

2.4 Reuse of Municipal Wastewater for a Paper Factory

In the city of Taian in northern China, municipal wastewater has been partially reused since the mid-1990s, going largely to the paper industry.

Municipal wastewater with a relatively high industrial portion is reclaimed in a two-stage activated sludge plant (AB-process) with tertiary sand filtration and chlorination. The capacity of the plant is 50,000 m³/d and until 2003 approx. 20,000 m³/d (40%) thereof were reused as cooling water in a paper factory. According to current information, the reclaimed water is now discharged into a river in the City of Taian, which regularly runs dry, while a smaller amount is reused for urban irrigation. The paper factory is again employing groundwater, which is reportedly cheaper than the reclaimed water.

2.5 Textile Industry

At the Drews Meerane textile company in Germany, two differing wastewater streams are treated separately. The first consists of wastewater from textile finishing, which cannot be reused due to non-recyclable constituents. The process involves anaerobic digestion for biological decolorization and highly loaded activated sludge treatment. This stream represents approx. 40% of the total wastewater volume.

The second stream is made up of wastewater from textile pretreatment (dye house, printing, stretching and laundry) and is treated by anaerobic digestion for biological decolorization, highly loaded activated sludge treatment, MBR with ZENON membrane modules (Fig. 2) and oxidation with ozone. The reclaimed water (60% of total process water) is recycled to the aforementioned textile pretreatment steps. This reuse scheme is highly economic, primarily as a result of a substantial reduction in sewerage charges.

Fig. 2: Membrane Bioreactor

2.6 Brewery/Malt Industry

At a German malting plant, wastewater is reclaimed for reuse in barley steeping. The reclamation system consists basically of a fine screen (0.5 mm) and membrane bioreactor treatment (KUBOTA). The fine screen had to be installed, in order to remove barley glumes, which would otherwise clog the subsequent MBR modules. The capacity of the plant is approx. 100 m^3/d and the reused MBR permeate amounts to approx. 6 m^3/h. The raw water and reclaimed water qualities are listed in Table 2. Up to now, the plant has been in successful operation for 5 years without membrane replacement.

Parameter	Raw Wastewater	Treated Water
BOD_5	1,000 mg/l	< 5 mg/l
COD	1,800 mg/l	< 150 mg/l
SS	230 mg/l	n.d.
TKN	12 mg/l	< 1 mg/l
Germs		n.d.

Table 2: Raw wastewater and treated water qualities

3. CONCLUSIONS

Wastewater reclamation and reuse are technically feasible. There is a wide range of proven technologies (conventional and advanced) available and water recycling systems can be tailored to meet specific demands. The reclamation and reuse of municipal and industrial wastewater provides a sustainable option within industrial development. As a consequence, in many cases, water recycling constitutes an economically attractive and environment-friendly solution.