MILLIPORE

Towards Sustainable Production - Closing Water and Solvent Cycles at Millipore

AT A GLANCE

Millipore discharges aqueous wastes contaminated with solvent from membrane manufacturing to its onsite biological wastewater treatment plant. This approach results in the loss of valuable raw materials (ultra pure water and organic solvents). Furthermore, the wastewater treatment process is resource intensive (operating costs typically are €0.5m/annum).

The original objective of this project was to implement membrane technology to recover solvents as well as ultra pure water, from specific process streams, for reuse in production. The projected environmental benefits were an approximate 80% reduction in COD & hydraulic load to effluent treatment plant, and consequent savings in energy and natural resources used in the treatment process. Other trials were carried out using reverse osmosis, pervaporation and vacuum distillation.

These technologies were not found to be economically feasible. Therefore, the approach of the project was changed to focus on elimination of the solvent from the wastewater through process improvement. Prevention at source was implemented through the use of wiper blades to prevent solvent carry-over to the next step in the process. There was insufficient time to carry out the requisite number of trials to prove this alternative technology conclusively.

Millipore Ireland BV

Millipore Ireland B.V, is located approx 1 Km south-west of the village of Carrigtwohill east of Cork City. Millipore manufactures filtration devices and diagnostic membranes for analytical laboratories as well as the biopharmaceutical and microelectronics industries. The facility was constructed in 1987 on a green field site, which was previously used for agriculture, and manufacturing operations have increased significantly in the intervening years. The plant currently employs approximately 500 people and operates 24hr/7 days. Manufacturing at the site can be broadly categorised into membrane manufacturing and device assembly.

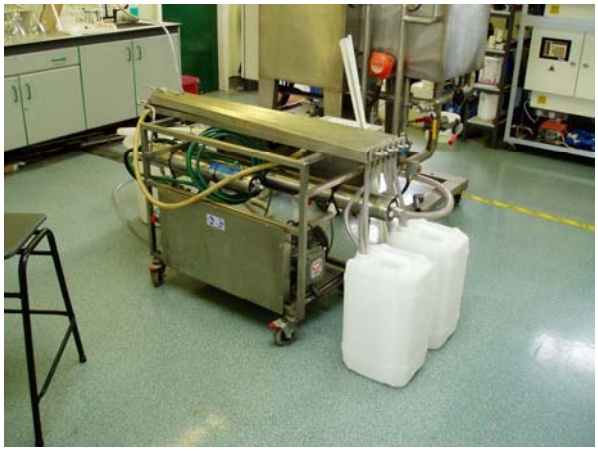

Photo 1: Reverse Osmosis pilot plant

AIM OF THIS PROJECT

Millipore Ireland discharges aqueous wastes contaminated with low levels of solvents, principally acetone and methanol, from its membrane manufacturing operations to its onsite biological wastewater treatment plant. This results in the loss of valuable raw materials (ultra pure water and organic solvents). Furthermore, treatment of this wastewater is a significant cost to the company.

The aim of this project initially was to implement a suitable technology to recover solvents as well as ultrapure water for reuse in production. The environmental benefits would include a significant reduction in COD loading to the wastewater treatment plant.

This project aimed at recovering low concentrations of solvent typically 3-4% methanol from an aqueous waste stream using techniques such as reverse osmosis, advanced

filtration or pervaporation, which have not traditionally been associated with treatment of wastewater. These techniques would be used to concentrate the solvent to a level where it could be recovered for re-use in the on-site Solvent Recovery Unit. Through extensive trial work as well as research, the above techniques were found to be either technically or economically unfeasible. Therefore, the approach of the project was changed to focus on elimination of the solvent from the wastewater through process improvement.

PROJECT DESCRIPTION

The wastewater streams generated throughout the manufacturing process and which are sent to the wastewater treatment plant were identified and analysed in terms of solvent concentration, by Gas Chromatography and loading to the Wastewater Treatment plant in terms of Biological Oxygen Demand (BOD) / Chemical Oxygen Demand (COD). This study was carried out to help prioritize the streams in terms of the potential for recovery of solvent and the loading that each stream exerts on the wastewater treatment plant. From this work, the wastewater stream to be targeted was determined.

The VMF4 membrane manufacturing process was identified as the largest single waste stream that contributes to COD/BOD whilst at the same time it had the highest and most consistent solvent concentration. Several technologies were investigated to establish their suitability to concentrate the solvent up to 50% so it could be recovered in the solvent recovery unit.

The results of the initial assessment of the waste streams increased understanding of the origins of wastes sent to the wastewater treatment plant. The VMF4 membrane manufacturing process waste stream was determined to exert the highest BOD/COD loading to the wastewater plant while at the same time it had the highest consistent solvent concentration (3-5%). It also showed, upon further investigation of the VMF4 membrane manufacturing process, that there was a potential to make large savings in terms of reduced consumption of solvents and reduced running costs for the wastewater treatment plant if the BOD/COD and solvent concentration of the VMF4 waste stream could be reduced. It highlighted the inefficiencies in the VMF4 process as well as the potential to reduce the consumption of solvent, principally methanol. Furthermore, the potential to re-use water from the extraction tanks was identified and explored further. A literature search was carried out in the Clean Technology Centre to determine suitable available technologies and the Questor centre, at Queens University, Belfast were commissioned to investigate and trial various technologies.

On of the main problems encountered in the course of this trial work is that methanol and water are chemically similar making them difficult to separate. The solvent content in the wastewater streams are also very dilute, ~2-4% methanol which made sourcing a cost effective commercial way of extracting the solvent from the wastewater a significant challenge. Millipore in conjunction with the Questor Centre at Queen's University have carried out extensive trials and research on different membrane technologies in order to obtain methanol free water.

ACHIEVEMENTS

A Reverse Osmosis trial was run in Belfast under the supervision of Aqua Separation Technology using a 200L sample from the wetting tank in VMF4. The trial was not successful in concentrating the methanol from 4% up to the required concentration of 50% which is required for entry to the onsite solvent recovery unit. The achieved permeate concentration was only 8%.

Pervaporation research and trials have been investigated in detail through a US based company and a European university. The former source suggested that their hydrophilic ZeoSep a membrane which has very high selectivity's for the separation in question could achieve the desired final concentration. To reduce the energy requirement he had suggested constructing a hybrid system using simple distillation to concentrate the methanol from 4 to 10% and then using the pervaporation unit to extend this figure to 50%. However the entire flow to the unit would need to be vaporized to reduce the area needed which would incur high energy costs.

This membrane is still in the R&D stage and therefore is not commercially available.
The European University suggested that we operate a pervaporation system using 2 units of suitable membrane with the required high selectivity. The permeate from one unit would feed to another unit but selectivity changes depending on the feed composition which may be problematic. In addition, the permeate from unit 1 would need to be liquefied to feed the second unit requiring significant energy input thus encountering greater costs.
A Vacuum Distillation trial was carried out in the UK successfully but the separation is found to be financially unfeasible.
Research into advanced filter media such as activated carbon, ion exchange resins and impregnated zeolites have been carried out but they are found to be very expensive to regenerate or dispose of once spent. There would be a small uptake in solvent from the wastewater by the carbon as it is hydrophobic. This is as a result of the carbon and water having similar polarities and chemistries.

The results of this investigative and trial work meant that the focus of the project had to be revised if the aims were to be achieved. Thus the focus of the project changed from recovery of solvent lost in the waste stream to examination of ways to avoid the waste at source. It had already been established that 50% of the loading to the wastewater treatment plant comes from the methanol exchange tank in VMF4 and so this was targeted. Subsequent trials were carried out which aimed at reducing the solvent carryover into this tank and thereby eliminate the problem at source.

OBSERVATIONS

The initial focus of the project was finding ways of treating the VMF4 waste stream to concentrate the solvent content for on site recovery.
Many technologies were examined and trials carried out at the Pilot Facilities at the QUESTOR Centre. From this extensive literature research and trial work no technology was identified as fitting the requirements. They were either not financially viable or commercially available. Therefore the focus of the project was changed to prevention of wastewater generation at source.
A number of opportunities for reduction were identified and trials carried out.

LESSONS

The initial research work showed that treatment options were not a viable work option and work began on investigating ways of reducing the BOD/COD and reducing the solvent concentration in the waste stream at source. Opportunities to reduce the use of excess methanol in the VMF4 methanol-wetting tank and to reuse some of the water in the VMF4 methanol exchange tank were identified and work began on ways of achieving that aim. A wiper system was designed an trials were carried out which proved positive and therefore the focus of the project changed from recovery to prevention of wastewater emission through reduction of methanol entry into the process waste stream.

Although this trial work was successful there is more work to be carried out with regard to impact of the wiper on membrane quality as well as whether consistent running can be achieved using this system.

MORE INFORMATION

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CLEANER GREENER PRODUCTION IS…

the application of integrated preventive environmental strategies to processes, products, and services to increase overall efficiency and reduce risks to humans and the environment.

- Production processes: conserving raw materials and energy, eliminating toxic raw materials, and reducing the quantity and toxicity of all emissions and wastes
- Products: reducing negative impacts along the life cycle of a product, from raw materials extraction to its ultimate disposal.
- Services: incorporating environmental concerns into designing and delivering services.

CLEANER GREENER PRODUCTION REQUIRES…

new attitudes, better environmental management, and evaluating available technology options. We need to take good environmental practice to the stage where it is an inherent part of any business operation.

HOW IS CLEANER GREENER PRODUCTION DIFFERENT?

Much of the current thinking on environmental protection focuses on what to do with wastes and emissions after they have been created. The goal of cleaner, greener production is to avoid generating pollution in the first place. This means:

- Better efficiency
- Better business
- Better environmental protection
- Lower costs
- Less waste
- Less emissions
- Less resource consumption

WHY IS THE CLEANER GREENER PRODUCTION PROGRAMME BEING RUN?

The Irish Government, through the National Development Plan 2000 - 2006, has allocated funds to a programme for Environmental Research, Technological Development and Innovation (ERTDI).

The long-term goal is to ensure that cleaner, greener production becomes the established norm in Ireland. The programme seeks to promote environmentally friendly business through increased resource productivity, waste reduction, recovery of materials, improved efficiency in a product value chain, energy management, and a change of culture within organisations.

The programme aims are focussed on avoiding and preventing adverse environmental impact rather than treating or cleaning up afterwards. This approach brings better economic and environmental efficiency.

WHERE CAN I GET FURTHER INFORMATION?

This case study report is one of the reports available from the companies that participated in the second phase of the Cleaner Greener Production Programme. A summary of all the projects and CD containing all the reports are also available.

More information on the Programme is available from the Environmental Protection Agency

Dr Brian Donlon,

Environmental Protection Agency,

Richview,

Clonskeagh,

Dublin 14,

Ireland

Or their website www.epa.ie, by selecting the link to cleaner production.

PROGRAMME MANAGERS:

The Clean Technology Centre (CTC) at Cork Institute of Technology has been appointed to manage the technical aspects of the programme.

The CTC was established in 1991 and is now nationally and internationally regarded as a centre of excellence in cleaner production, environmental management and eco-innovation across a range of industrial sectors.