Responsible Water Treatment Pays

John Kleyn explains how new developments in microfilter cross flow membrane technology make recovery of 80-95% of rinse water feasible.

Zero Liquid Discharge (ZLD) plant is a term that has been around for many decades and in the past this was a pipe dream or miles too expensive and troublesome to run. Microfilter cross flow membrane technology is now available which makes ZLD financially viable and relatively simple to install and maintain. Microfiltration is the first step toward ZLD recovering from 80 – 95% of your water. The benefit of cross flow micro-membrane environmental friendly technology is that it saves you money whilst reducing your chemical usage and sludge. Justifying capital expenditure on equipment that shows no return, does not add to productivity, costs labour and chemicals whilst being billed for the product is a tough ask. The truth is we need this equipment to comply with Waste Water Regulations but our obligation is much bigger than compliance. **The next crisis is upon us and rumour has it that coping with ESKOM'S power failures was a walk in the park compared to living with water scarcity. Protecting our resources has become a national priority.**

At a recent water seminar it was estimated that the cost of water is expected to double in the next two years. This may sound out of line but in reality our water is currently inexpensive compared to the rest of the world. Some disturbing facts are that up to 60% of our municipal water supply is lost through failing infrastructure and water leaks. Cape Town has the best figures in the country, losing only 20% of its treated water. This infrastructure needs to be upgraded and somebody has to pay for it.

Benefits of cross flow membrane technology for sludge removal and water discharge.

The cross flow micro filter system replaces the clarifier in new or existing metal removal effluent plant and has the following benefits:

- ☑ The membrane filters solid particles out of the effluent up to 0.1 micron and other contaminants to ensure a much cleaner outflow.
- ☑ Sludge cannot escape from the membrane to overflow into the effluent discharge stream.
- ☑ There is no sludge build up in the filter as the sludge is directly decanted into the sludge catchment tank.
- ☑ Up to 80% of this water can be reused in non critical rinses without further treatment.
- ☑ The membrane outflow can be fed directly into the RO plant to give water of 5 microsiemens without risk to the RO membranes. This water is recycled back to the rinse water system.
- ☑ The system is self cleaning and is chemical resistant ensuring low cost of ownership with easy maintenance.

☑ The metal hydrates (or other metal precipitates) don't need to be treated with a flocculant as the particles are filtered by the membrane.

You can now recycle your effluent water, improve your rinse water quality to better than municipal water standards, reduce your volume of sludge, use fewer chemicals and reduce your utility charges. The major saving is your water consumption which will be reduced by between 80 and 100%. Municipalities currently charge between R8 and R10 per kilolitre of water. A discharge rate is levied proportionate to your water usage. This charge is usually calculated at 80 to 100% of your water usage and the charge varies between R6.00 and R8.00 per kilolitre. These are the standard rates providing your effluent meets the municipal specifications. The municipal charge is R16 per kilolitre or R0.016 cents per litre of water costing R17 000 per month for a medium sized plant running a single shift of 22 days a month. The estimated saving with an entry level plant will be 80% of your water account which should be around R13 000 per month. (This is typical but will vary from different councils)

Micro Filter System.

The influent wastewater to the plant is processed through a two-stage reaction system for pre-treatment prior to the micro filter. The pre-treatment chemistry used in the two-stage reaction system can be adjusted to fit the application for precipitation of heavy metals, hardness, silica, fluoride, etc. from the wastewater. Following the two stage reaction system, the wastewater gravity overflows into the concentration tank of the microfiltration system for solids separation. The membrane microfiltration system uses cross-flow filtration for the removal of suspended solids. The micro filter's polymeric membrane separates the precipitated particles generated in the two-stage reaction system from the wastewater. The process pump of the microfiltration system circulates water through the micro filter membranes. The water, virtually free of suspended solids, passes through the membrane, while the suspended solids remain and accumulate in the recirculation concentrate. The water containing the suspended solids flows inside the membrane tubes at a high velocity. Particles present in the water help to clean the membrane surface due to the high velocity of the flow (~4.25 m/sec), thus maintaining a stable filtration flow. Permeate from the microfiltration system is then directed to the reverse osmosis pre-treatment system. In this stage of the process, the wastewater is preconditioned to optimise the performance of the reverse osmosis system. This preconditioning can consist of pH adjustment, the addition of reducing agents, as well as the addition of an antiscalant.

Following the preconditioning step, the wastewater stream is processed through the reverse osmosis system. The reverse osmosis system is a water purification process using a semi

permeable membrane to purify the wastewater. The preconditioned wastewater is pressurized in the reverse osmosis system and processed through the reverse osmosis membranes.

Risk Management of Effluent Plant.

The risk with conventional effluent treatment is high as it's an open ended system due to the design using gravity as the settling process. The process is economical and very simple to operate but the drawback is that the system fails when your flow rate exceeds your clarifier capacity or when a pH error occurs. The flow rate typically exceeds capacity when maintenance is done or a contaminated rinse needs to be drained. This risk is increased exponentially with the discharge of low pH dragouts or concentrated effluent. The inherent risk in clarifiers is that they act as heavy metal time bombs due to the high concentration of sludge that remains between the baffle plates or in the conical catchment areas. When an operational error occurs this sludge either re-dissolves or spills over into the sewer and in many cases both.

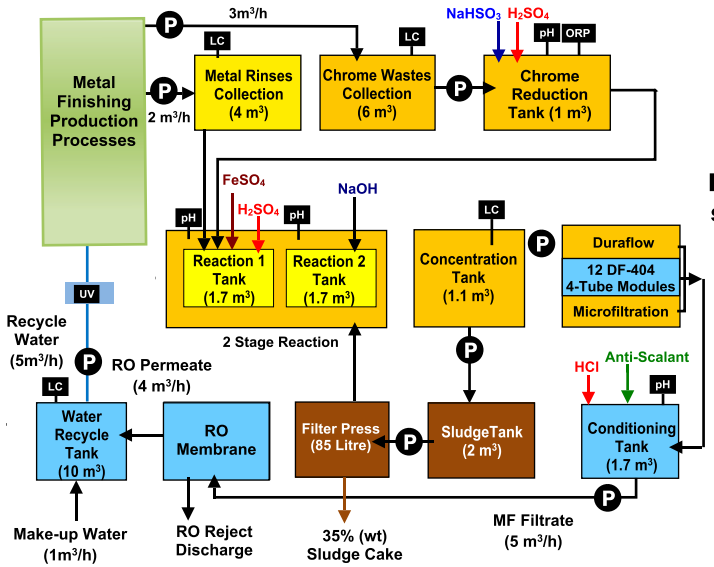
Typical causes of these errors are failure of the sludge drain valve with a replacement unavailable for a week or many rinse tanks that need to be drained or any of the operational gremlins that make their appearance; for example, pH probes broken, dosing pump faulty, chemical supplier on strike etc. Your sludge build up in your settling tanks rises resulting in settlement spill over or the pH drops below the required specification and that's when council samples your outflow. Your R 8.00 per kilolitre discharge fee escalates to between R80 and R480 per kL. In other words your R10 000 water purchase will cost between R80 000 and R480 000 to discharge. The examples of these types of penalties are more frequent and many water users are paying the price. These penalties are set to become even more frequent as the water discharge specification is to be amended this year with even more severe penalties. Councils throughout South Africa have been warning that the day of reckoning for the irresponsible water user will come. I am afraid that day is here. Best case scenario with clarifiers is that you just bought the water and now you are pouring it down the drain whilst paying for this luxury as you are left with no other option.

The risks with precipitation filters are high as the flow rate and flocculation chemical determines the quality of your outflow. The design of a clarifier plant is based on steady flow of treated effluent. These precipitation filters or clarifiers always have a high concentration of sludge which acts as a time bomb ready to dissolve or overflow at the first sign of an error. The precipitation method water quality is not sufficient for reuse in rinses or as inflow into RO plants resulting in the only option being discharge to sewer.

How does the Micro Filter System work and where does it fit in?

A typical effluent flow diagram [for CN free effluent] of a system using micro filter technology shows that the effluent handling prior to sludge removal remains the same and can typically be enhanced with additional dosing of treatment chemicals in small quantities. The clarifier is replaced with a microfilter and this filtrate can be used in non critical rinses or plumbed straight into the RO plant for high specification rinses.

What makes this possible is the high quality of filtrate received from the microfilter that is capable of filtering out both metal ions and aqueous salts as well as larger particles.



A typical effluent flow diagram without CN.

Effluent prior to sludge removal remains the same.

In microfiltration plants the pre treatment of the waste water remains the same as in the past where the metal containing effluent is treated with caustic or lime to precipitate the metals as metal hydroxides. The cross flow membrane then filters the precipitate without the use of flocculants. The membrane filters the solids from the effluent water to a particle size of 0.1 micron. The membrane works on high flow with low pressure which even filters bacteria. This membrane is totally chemical resistant and very robust. Reverse pulses flush the system regularly and periodically the membranes are washed with acid and caustic solution. The biggest risk to RO plants is the scaling and fouling of the membranes which is accelerated by larger particle sizes. The micro filter outflow is perfect for most rinses or it may be led straight into the RO plant to produce water with conductivity of up 5 microsiemens before polishing. The RO membranes last up to four times longer due to the high quality inflow. The resultant outflow from the micro filter is as below:

CONTAINMENT WASTEWATER CONC.	(mg/l)	MICROFILTER EFFLUENT (mg/l)	CONTAINMENT WASTEWATER CONC.	(mg/l)	MICROFILTER EFFLUENT (mg/l)
Aluminium	10-1000	0.5	Lead	2-100	0.05
Arsenic	1-50	0.005	Manganese	10	0.02
Cadmium	25-115	0.05	Mercury	3-30	0.005
Chromium	3-275	0.1	Nickel	4-300	0.1
Copper	1-1500	0.1	Rhodium	20-500	0.1
Cyanide	5-300	0.1	Silver	10-200	0.1
Gallium	4-20	0.5	Tin	20-75	0.1
Germanium	20-110	0.5	Uranium	1-15	0.01
Gold	1-12	0.15	Zinc	2-400	0.1
Iron	2-1500	0.02			

*Typical values achieved in practice may vary depending on equipment configuration and pre-treatment chemistry.

MARKET APPLICATION

- ☑ Metal Finishing - Removal of heavy metals to less than 0.1ppm
- ☑ Printed Circuit Board - Removal of heavy metals to less than 0.1ppm
- ☑ Semiconductor - Arsenic removal to less than 0.1 ppm
- ☑ Fluoride removal to below 5 ppm
- ☑ Cutting fluid recycle from silica grinding and slicing operations
- ☑ Deionised water recycle from wet blast and back grinding processes
- ☑ Heavy metals removal from tin/lead plating onto lead frames
- ☑ Groundwater Remediation - Removal of heavy metals to less than 0.1 ppm
- ☑ Battery Manufacturing - Removal of lead and cadmium from wastewater
- ☑ Automotive Removal of zinc and phosphate from phosphatising operations
- ☑ General Industry Removal of heavy metals from incinerator scrubber water
- ☑ Pre-treatment for reverse osmosis water recycling
- ☑ Lime softening of cooling tower blow down for water recycling
- ☑ General heavy metals removal to less than 0.1 ppm
- ☑ Replacement of clarifier or a clarifier followed by a sand filter

Through the use of new treatment technologies, and by using old technologies in novel ways, a significant impact can be made via Zero Liquid Discharge options on the amount and quality of water that a facility uses and discharges.

Many effluent plants around the country are struggling to achieve the required regulated requirements yet have the correct equipment. These plants can be audited and through minor chemical conversions or small additions can become compliant to below municipal regulations and in this process save water, chemical and sludge discharge fees. The added benefit is this water process can now be more stable ensuring the discharge is at all times within specification.

This editorial was submitted by John Kleyn of Accurate Automation & Consulting cc, a Siemens Technology Partner. The company designs and builds effluent plants to specification and has a cooperation agreement with the Siemens Membrane suppliers who manufacture under license to Siemens, retaining maximum local content whilst underwriting the process to international standards.