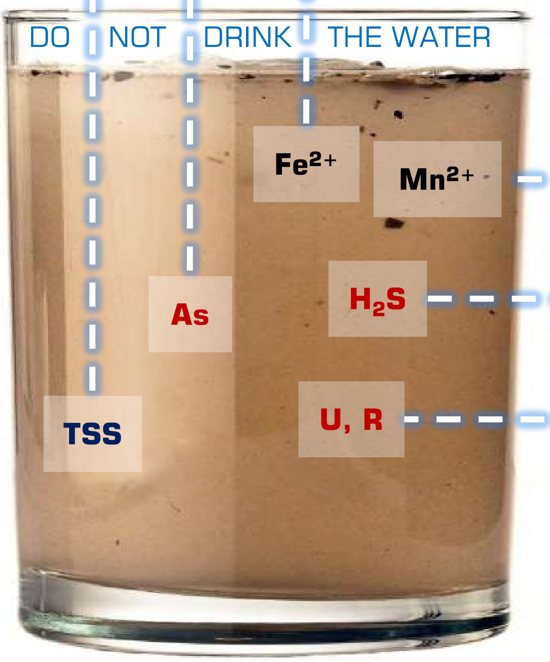
# WATCH

# What's in the Water?

1 **Total Suspended Solids** (TSS) are solids in water that can be trapped by Katalyst Light filter. High concentrations of suspended solids can cause many problems for health.

2 **Arsenic:** Yes, you should install filter certified NSF/WQA to remove Arsenic. It is always better to install certified medias than no certification at all!

3 **Iron:**



4 **Manganese:**

5 **Hydrogen Sulfide:**

6 **Uranium & Radium:**

And that's just the beginning…

## WITHOUT KATALYST-LIGHT

## $H_2$Oh NO!

## YOUR WATER IS IN TROUBLE !

www.watchwater.de

# INDEX

## Chapter Page

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# Definitions in freshwater Pollutions

## Change in pH:

Unpolluted deposition (Rain) in balance with atmospheric Carbon dioxide, has a pH of 5.5 almost everywhere in the world. Power-stations and industrial plants like the mining and smelting of high-sulfur ores and the combustion of fossil fuels emit the largest quantities of sulfur and nitrogen oxides and other acidic compounds. These compounds mix with water vapor at unusual proportions to cause acid deposition with pH of 4.2 to 4.7. That is 10 or more times the acidity of natural deposition.

## What happens when pH decreases:

When the pH in water falls, metal solubility increases and the metal particles become more mobile. The is why metals are more toxic in SOFT WATER.

The Most common Heavy Metal pollutants are

- Arsenic
- Cadmium
- Chromium
- Copper
- Nickel
- Lead
- Mercury

The Acidification of freshwater in an area is dependent on the quantity of Calcium ($Ca^{2+}$) and Magnesium ($Mg^{2+}$) or Calcium carbonate ($CaCO_3$) in the Surface Water or Ground Water. Only Calcium carbonate can (buffer, see below) neutralize the acidification of fresh water. The effects of Acid deposition are much greater on Groundwater with lifted buffering capacity

## Buffer

A Solutions that minimizes changes in hydrogen ion's concentration that would otherwise occur as a result of a chemical reaction. Case studies have proven water with less Buffering Capacity is a result of "ACID SHOCK". This is caused by sudden run-off of large amounts of highly acidic water and dissolving all kinds of heavy metals into lakes, streams, surface water which ultimately lands in ground water.

# Introduction

*Definition & frequently used terms in our literature*

## Acid Solution:

- Any water solution that has more Hydrogen ions ($H^+$) than hydroxide ions ($OH^-$)
- Any water or solution with pH less than 7.0

## Buffering Agent:

- Drives an acidic solution to the neutral pH (7.0)

## Heavy Metals:

A general term is given to ions of metallic elements. They are removed from any kind of water or wastewater by forming an insoluble precipitation and that's what

***Change them into METTALIC HYDROXIDE***

## METAL:

Metals are elements which has a characteristic lustrous appearance, is a good conductor of electricity and generally enters chemical reactions as a positive ion or cations. These are Nickel, Copper, Cobalt, Zinc, Cadmium, Lead and Mercury.

## Water Pollution:

Any physical or chemical change in surface or ground water that can harm living organisms or make water unfit for any applications. Pollutions, the introduction by man in to the environment of substances or energy liable to cause hazards to human health Examples (phosphates) harm to living resources and ecological systems, damage to structure or amenity or interference with legitimate use of environment.

## ONE

## Suspended Solids

Total Dissolved Solids refer to any minerals such as sand, Heavy metals, cations and anions dissolved in water. This includes anything present in water other than the pure water molecules and suspended solids. Suspended Solids are any particles that are neither dissolved nor settled in the water such as waste pulp. Some dissolved solids come from organic sources such as silt, plankton and industrial waste and sewage. They can also come from inorganic materials such as Arsenic, Iron, Manganese, Hydrogen Sulfide including Uranium and Radium. Municipal water always pick up metals such as Lead or Copper as they travel through pipes which is used to distribute water to consumers.

These metals (ions) are associated with staining, taste, precipitation. With respect to trace metals, they mostly contribute to health risk.

And Important

To keep in mind that water from desalination or Reverse Osmosis with a very low TDS concentration is corrosive and corrosive water always leak toxic metals such as Iron, Manganese, Copper and Lead from household plumbing. This also means not only well water and surface water but also city water bring trace metals which could pose a health risk.

$H_2$Oh Yes!

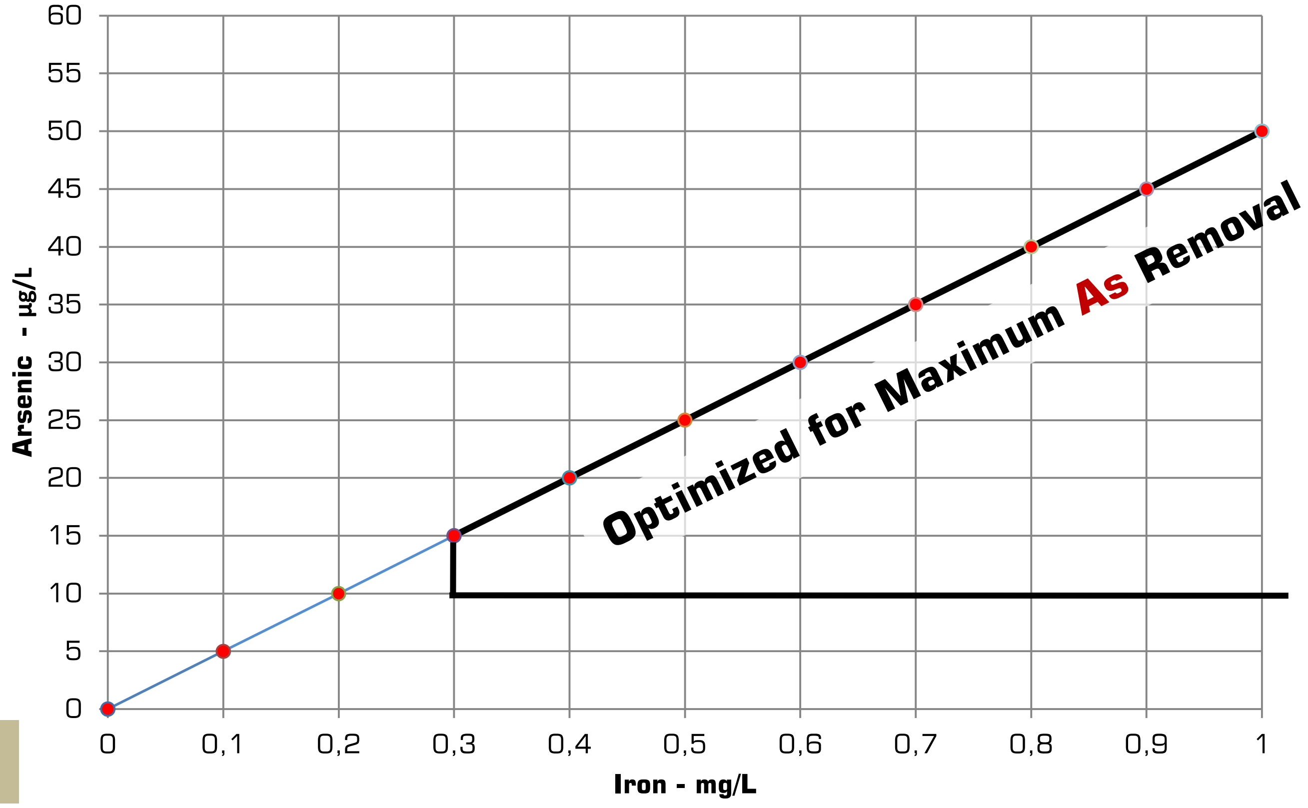
WITH **Katalyst**-LIGHT®

YOUR WATER

IS NOW **WITHOUT** TROUBLE !

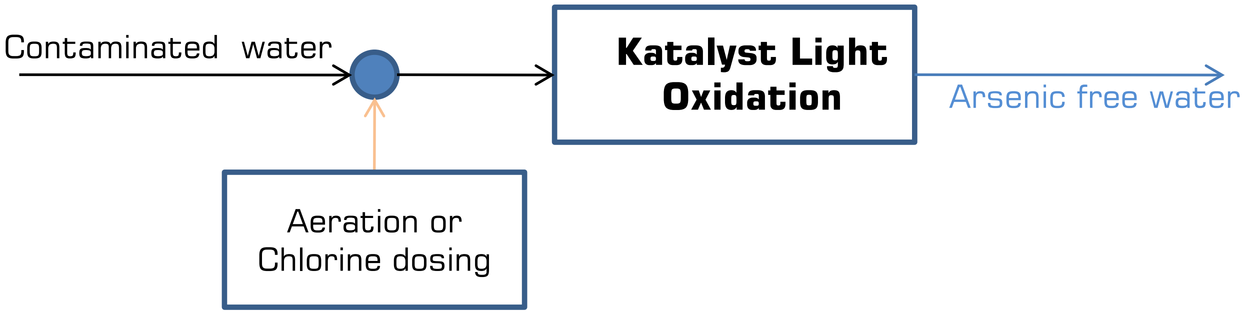
# Arsenic Removal

Katalyst Light® Arsenic treatment



Removal of **1 mg/L** of iron achieves

removal of **50 µg/L** arsenic *As[V]*



Contaminated water

**Katalyst Light Oxidation**

Arsenic free water

Aeration or Chlorine dosing

## Iron and Arsenic (and Mn) Removal

- Iron removal is equal to Arsenic removal
- Chlorine is important as an oxidant
- Point of oxidant application is important

THREE

# IRON Removal

Iron is a common water contaminant. It can be difficult to remove because it may change its valence state that is change from the water soluble ferrous state ($Fe^{2+}$) to the insoluble Ferric state ($Fe^{3+}$). When Oxygen or an oxidizing agent is introduced, ferrous states changes to ferric which is insoluble and it precipitates, leading to a rusty (red-brown) appearance in water. This change can occur when deep well water is pumped into a distribution system where it adsorbs oxygen. Ferric iron has to be removed before it destroys valves, piping all other water treatment equipments and water-using devices. Katalyst Light® provides a large filtration area and high catalyst to speed up the process.

## KATALYST-LIGHT® OXIDIZING FILTERS

Use a ZEOSORB media treated with oxides of manganese as a source of oxygen to oxidize a number of contaminants including Iron, Manganese, Arsenic, Hydrogen sulfide, Uranium and Radium from contaminated waters.

## Clear Water through Oxygen

Katalyst Light® is a solid Heterogeneous Catalyst and is in a different physical state from liquid $H_2O_2$.

**Experiment:**

If a pure manganese dioxide (Catalox, Filox, MangOx, Pyrolox etc.) is added to hydrogen peroxide – very little oxygen is given off. However when Katalyst Light® is used a large amount of oxygen is produced and the reaction is much faster.

This experiment shows:

a) Only a light Catalyst is needed

b) Katalyst Light® is more effective because if provides a much larger surface area on which the oxidation reaction accelerates.

*In "Genie in a Bottle"*
*the catalyst is Katalox Light®*

# IRON Removal (continued...)

## Water pH and Carbon dioxide ($CO_2$)

### Principle:

Carbon dioxide dissolves in water to form carbonic acid ($H_2O$ + $CO_2$) which has a pH less than 7.0, so pH will tend to fall when carbon dioxide is high. Carbonic acid dissolves Iron, Manganese, Arsenic, Calcium and Magnesium and making the water hard.

There is some quite complex chemistry involved here which we will ignore and save to point out that when water pH levels fall below 6.5 then the potential for carbon dioxide problems increases. Drinking water, Boiler water, Cooling water, Heat exchangers' feed water pH should be ideally around 8.0 to 8.5 but don't panic if it is 9.5. what we are looking for is a very stable pH with very little oxygen from 6.5 to 8.5.

Carbon dioxide problems in the water can be controlled by oxidation that make water go blue with Oxygen.

Oxygen and Carbon dioxide also work in concert with each other. In simple terms as Carbon dioxide levels increase in water then oxygen levels tend to decrease.

## Aeration of Water

One of the best and most economical ways to aerate is the use of venturis. You can never have too much additional aeration.

WOW :

1) Oxygen levels increase
2) Carbon dioxide is "blown" out of the water and this tends to push up and stabilize pH levels without chemicals.
3) ORP and water quality increases

If you can not see your water living you are not adding enough oxygen.

# IRON Removal (continued...)

## High efficiency at very low operation costs

In comparison to air, pure oxygen has a 5 times higher theoretical oxygen saturation concentration in water. Thus the increase of the Oxygen content is easily possible without any byproducts by air. Compared to air, the oxygen volume that has to be fed into raw water is dramatically decreased, reducing the amount of carbon dioxide that is lost through stripping to atmosphere.

Since there is no disruption of the Katalyst-Light® operation through Nitrogen emission, the Katalyst-filter life is extended and there are less operating costs for backwashing.

## Chemistry of Iron Removal

Iron oxidation and its removal is based on the transformation of the soluble form of iron ($Fe^{2+}$) to an insoluble form of Iron ($Fe^{3+}$).

In simplified notation:

- $4Fe^{2+} + O_2 + 2H_2O \rightarrow 4Fe^{3+} + 4OH^-$ .......(1)
- $4Fe^{3+} + 4OH^- + 8H_2O \rightarrow 4Fe(OH)_3 + 4H^+$ .......(2)

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- $4Fe^{2+} + O_2 + 10H_2O \rightarrow 4Fe(OH)_3 + 8H^+$ .......(3)

**Equation (1):**

shows that about 0.14 mg of Oxygen ($O_2$) is required for the oxidation of 1 mg of Iron (II). Therefore, the Oxygen concentration is aerated water is theoretically sufficient for the complete oxidation of iron (II) which is normally present in the natural ground water.

# IRON Removal (continued...)

## Chemical Oxidation

The atmospheric oxygen which is introduced into water during aeration is usually effective in the oxidation of Iron (II). However, when the iron is *organically complexed*, aeration alone is not sufficient. Secondly, IRON OXIDATION is very slow at pH <7.0. Alternative Oxidants like OXYDES, Chlorine or Hydrogen Peroxide could be employed for Iron Oxidation when aeration is not satisfactory. Chemical oxidation is frequently applied when Iron and Manganese are to be removed simultaneously in a single filtration step and Manganese Oxygenation is very slow at pH <9.5.

The Oxidation of IRON (II) by different oxidants can be described by the following chemical reactions:

1. OXYDES (solid state $H_2O_2$):

   $2Fe^{2+} + H_2O_2 + 4H_2O \rightarrow 2Fe(OH)_3 + 4H^+$

1. Chlorine:

   $2Fe^{2+} + Cl_2 + H_2O \rightarrow 2Fe(OH)_3 + 2Cl^- + 6H^+$

2. Hydrogen peroxide:

   $2Fe^{2+} + H_2O_2 + 4H_2O \rightarrow 2Fe(OH)_3 + 4H^+$

**IMPORTANT**

In each of the above cases, hydrogen ions are produced. Thus based on the these reactions alone, pH will decrease significantly in the absence of sufficient buffer capacity. pH will increase with higher buffer capacity.

Huge problems are associated with oxidation of iron by strong oxidizing agents such as chlorine, chlorine dioxide, potassium permanganate and ozone. These chemicals contributes to unwanted byproducts.

# Manganese Removal

If Manganese is not removed it can lead to health problems, staining or discolored water in the distribution systems. The removal of dissolved manganese from water requires a strong catalyst such as Katalyst Light® to handle pH and an oxidant such as OXYDES, Chlorine or Hydrogen peroxide.

Manganese precipitates out faster with higher pH-values and greater concentration of oxidant.

The reaction with Katalyst Light
$2CO_2 + Ca(OH)_2 = Ca(HCO_3)_2$
$Mn(HCO_3)_2 + O + Ca(OH)_2 = MnO_2 + Ca(HCO_3)_2 + H_2O$

Waters containing carbonate hardness and a little free Carbon dioxide ($CO_2$) have a pH of about 7.5 to 8.5 or over.

## Fast reaction with Katalyst-Light®

$Mn(II) + MnO_2$ (Katalyst Light) $Mn$ (II) $MnO_2$

Because of its adsorptive properties, Katalyst Light® ($MnO_2$) accelerates the removal of Mn(II) form solution and causes the mixed oxide to form. It is the presence of this manganese dioxide ratio on the ZEOSORB filter media that makes the removal of Mn(II) during oxide coated media filtration so effective. It makes it the most effective media available in the water treatment industry. Another benefit to us e Katalyst Light® media is that comparatively higher filtration rates are possible with the application to remove iron and manganese as it raises pH. The increased pH rate can increase higher filtration rate, reduced filter size and construction costs.

# RADIUM

Removal of natural radionuclides from DRINKING WATER have become increasingly important for WATCH WATER. This is mainly attributed to major health concerns from RADIUM and URANIUM.

RADIUM is one of the most hazardous elements with respect to internal radiation exposure. At high exposure level both RADIUM isotopes can cause Osteoporosis, Anemia, Kidney and Liver disease and also bone cancer in humans. It can cause stomach, Lung and other organ cancer as well.

Radionuclides removal with Katalyst Light® optimized with iron and manganese filtration is the most effective and economical way for RADIUM and also for URANIUM removal.

# URANIUM

URANIUM is a naturally occurring Radioactive contaminant which is found not only in ground water but also in surface waters. URANIUM can be very toxic to kidneys.

- The highest concentration of RADIUM & URANIUM have been determined in tap waters from Canada, Italy, Turkey, Greece, Serbia, India and Morocco.
- $^{226}$Ra and $^{228}$Ra concentrations in natural water are a serious problem in all over the world and are increasing rapidly.

# RADON

RADON is a noble, heavy gas which tends to accumulate in the basements or other low places in housing and building. It has no color, odor or Taste. $^{222}$Rn is produced by the decay of RADIUM, its half life is 3.8 days and it emits an alpha particle as it decays to $^{218}$Po and eventually to stable Lead (Pb). RADON can be easily CATCHED (absorbed) onto CATCH-R granulated special carbon.

The subject RADON REMOVAL is discussed on CATCH-R Brochure. The highest RADON removal degree (98 - 100%) can be achieved by using CATCH-R carbon technology.

## FIVE

# RADIUM and URANIUM Removal

Radionuclides Removal with optimized Iron and manganese filtration using Katalyst Light®. This is the most natural and probably also the most easiest way to remove $^{228}$Rn, $^{226}$Rn and $^{238}$U in all Drinking and waste water units during removal of ferrous iron.

$Fe^{2+}$ with Katalyst Light® is oxidized to ferric iron ($Fe^{3+}$) which readily forms the insoluble iron complex, insoluble iron hydroxide complex $Fe(OH)_3$

Ditto happens with Manganese ($Mn^{2+}$) with Katalyst Light® ($Mn^{2+}$) is oxidized to $Mn(OH)_4$ which further forms insoluble $MnO_2$:

$$4\ Fe(HCO_3)_2 + H_2O + O_2 = 4\ Fe(OH)_3 + 8\ CO_2$$

$$2\ Mn(HCO_3)_2 + H_2O + O_2 = 4\ Mn(OH)_4 + 4\ CO_2$$

Manganese dioxide works most efficient at a pH of 7.5 to 9.5.

The chemistry of Radium is controlled by buffering capacity of other elements. Hydrous oxides of Fe(III) and Mn(IV) have high sorption capacities for divalent metal ions. Hydrous manganese is a better adsorbent for divalent metal cations ($Ra^{2+}$, $Ba^{2+}$, $Mg^{2+}$, $Ca^{2+}$) due to the fact that differently from hydroxide iron oxide particles, which are positively charged, the hydrous manganese particles of sorption of metal ions on oxides and hydrous oxides particles are negatively charged.

## Mechanism of Sorption (MOS)

Mechanism of Sorption (MOS) of metal ions on oxides and hydrous oxides and the exchange of bound H+ ion on the oxide surface with cations is described by WATCH WATER

$$\mathbf{M}^{n+} + \mathbf{x}\ [=R\text{-}OH] = M\ [=R\text{-}O]^{(n-x)+}_{\mathbf{x}} + \mathbf{x}\ H^{+}$$

Where **M** is the metal ion to be sorbed, **x** is the number of moles in oxide or hydroxide and [R=OH] and [R=O] are the oxide surface sites. These apply also to RADIUM.

## SIX Mechanism of Sorption (MOS) (continued...)

Katalyst Light® Media and its catalyst $MnO_2$. In the oxidation-reduction reaction MnO2 is reduced to MnO and the ferrous iron is oxidized to ferric iron forming ferric hydroxide which is precipitated.

$$2Fe(HCO_3)_2 + MnO_2 + H_2O = Fe(OH)_3 + MnO + 4CO_2 + H_2O$$

The company Watch Water in Germany founder of combined treatment technology of Aeration, Oxidization and Katalytic Filtration (Katalyst Light® + OXYDES) for Radon, $^{226}Ra$ and $^{228}Ra$ removal. As a result of removal of RADIONUCLIDES together with Iron and Manganese. Using Katalyst Light® manganese coated media is the most effective and relatively inexpensive for RADIUM and URANIUM removal. The preliminary total cost of this process are about 0.02 Euro/$m^3$.

It is recommended that Iron & Manganese removal filter should be back washed only once a week to allow the backwash water to discharge into the sewer with very low content of radionuclides.

- Levels up to 10 µg/L is allowable worldwide to discharge of the backwash water directly to the sewage.

**Note**

# Nr. ONE: ION EXCHANGE

Radionuclides removal using ion exchange process is not simple and economical. Ion exchange softening has two significant disadvantages, it adds sodium to product water and it produces a regenerant waste water typically having about 100 times the radioactivity level of the raw water.

# Nr. TWO: Membrane Technology

Same disadvantage of the membrane technology is generation of 25% of highly concentrated radio-active wastewater flow, which as a high level radioactive waste which has to be disposed according to very strict regulations. Consider RO pre-treatment needs Katalyst Light® pre-treatment anyway to remove IRON and MANGANESE.

# Nr. THREE: Pure Manganese

CATALOX, FILOX, PYROLOX and many pure manganese dioxide (>75%) are used as a filter media in water treatment and mineral water (Bottled Water) systems to reduce Iron, Manganese, Hydrogen sulfide and the co-precipitation-filtration of Arsenic. Pyrolucite (CATALOX, FILOX, PYROLOX) are very heavy, weighing 1900 kg/m$^3$ (119 lb/ft$^3$) . Because FILOX, PYROLOX, MangOx is so heavy the backwash rate in the order of 61 m$^3$/h/m$^2$ to 73 m$^3$/h/m$^2$ (25 – 30 gpm/ft$^2$) are required to adequately expand the filter bed to allow for effective cleaning. The backwash flow rate required for FILOX, PYROLOX and MangOx is 4 times greater than the flow rate required for cleaning Katalyst Light® media. One of the reason the world demand on Katalyst Light® media has raised to 100 folds.

One of the reason FILOX, PYROLOX or MangOx having insufficient backwash flow rates, the media have become permanently fouled and ineffective.

**EIGHT**

## Sustainability & Ease of Operations

Very low wastewater volumes make Katalyst Light® Filtration an extremely efficient process which reduces pumping costs and places less loading on the sanitary systems. Increased production rates between backwashing also makes it an EXCELLENT process in countries and areas with limited water resources. Katalyst Light® filtration reduces the chemical demand to only low dosage of OXYDES or Chlorine and significantly reduce chlorine disinfection by products and disinfectant residuals, this makes Katalyst Light® very advantageous.

Katalyst Light® Filtration also reduces regulatory issues regarding the quality of process wastewater disposed as iron, manganese are consumed rather than concentrated.

Little to no chemicals significantly reduces operational and maintenance cost and creates a less hazardous environment for operators.

## KATALYST LIGHT® is THE FUTURE

Katalyst Light® followed by all membrane systems

**UF: Ultra Filtration**

**NF: Nano Filtration**

**RO: Reverse Osmosis**

-limits the formation of scale, fouling suspended solids. This makes membranes work much longer without chemicals cleanings. Only very low dosage of Membrane Anti-scalant is (I-SOFT ROB) is needed, which should significantly prolong the life of the membrane systems.