Project SWAN

Save Water & Attend Nature

RECYCLING OF MALTING PROCESS WATER

Executive Summary of EUREKA SWAN project AR0916

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Executive Summary of a UK and French Consortium project code-named 'SWAN' to determine how to recycle steep process water for re-use in subsequent malt manufacture.*

Water – A Key Resource

Water is one of the key resources on our planet and the expected dramatic increase in world population up to 2020 is considered to place many of the world's communities at or near their natural level of water availability. With water usage at this unprecedented capacity the generation of wastewater will likewise peak. Thus it is paramount that plans are developed now to conserve water use and to reclaim and recycle to effectively extend our available supplies. The EU Water Framework Directive is a direct response to this situation.

Manufacturing processes that use significant amounts of water must contribute to research and development of effective and food safe methods of recycling water. The easy option is to perform some rudimentary water treatment that renders the recycled water suitable for plant washing or other non-process operations. Often, however, in food manufacturing businesses the amount of water required for processing exceeds this by many times. The target for food processors then is to understand how to treat water such that it can be regenerated to a standard at least equivalent to that of fresh water be that from boreholes served by aquifers or from the local water supply company. As focus on water looks set to intensify over the next decade there could well be increased costs of abstraction or supply, reductions in permitted abstraction volumes and increased costs of effluent disposal and treatment. Although water quality is an essential aim, any treatment process must be cost effective.

A consortium of UK and French maltsters were successful in obtaining grant support from the UK and French governments for a 3 year project to investigate the possibility of recycling water from steeping and treating it sufficiently to allow it to be used again in subsequent batches. Overall the aim was to reuse up to 85% recycled water in each steep. This type of project had been attempted before but since the 1950's it had been known that an inhibitor of barley germination was present in the steep water. The result was that, although steep wastewater could be treated to potable drinking water standards, it was still inhibitory to barley germination and therefore markedly slowed down the malting process. This project identified the inhibitor and showed how it can effectively be removed.

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Aim: Reduce water usage in the steeping operation by up to 85%.

Although wastewater from steeping can be treated to bring it back to potable drinking water quality it has long been known that an inhibitor of barley germination remained. The germination of the next batch would consequently be slower than normal and adversely affect malt quality and throughput tonnage. The challenge was to identify this inhibitor and design a water treatment system that would remove the inhibitory compound and generate water suitable for use in the next steep.

The project identified for the first time the nature of the inhibition and provided a safe way to remove the inhibitor.

SWAN: Consortium Members and Financial Support

Maltsters Association of Great Britain (MAGB)

Malteurs de France

Institut Français de Boissons, de la Brasserie et de la Malterie (iFBM)

Laboratoire des Sciences du Génie Chimique of the Centre National de la Recherche Scientifique

EUREKA Funding of €500K matched an equivalent contribution from UK and French maltsters

Project total €1,000,000

* EUREKA SWAN - Reduction of water use in the EU Malting Industry (AR0916)

Water Use In Malting

The production of malting barley, maltsters' basic material, has strong links to the sustainability of agriculture. UK maltsters have been in the forefront of UK energy efficiency practices since the early 1970's, and are signatories to a sector Climate Change Levy Agreement. Now energy use in malting has been significantly reduced, the spotlight is turned on water consumption. Malting is now considered a food industry and as a consequence water use for cleaning production equipment has increased.

This project seeks to explore a way to solve the problems that have prevented the re-use of water in malting, in particular to find a method to treat the effluent from the steeping of grain, to enable its re-use in the steeping process. It is known that when grain is immersed in water to increase its moisture content from 14% to 45%, substances are leached or washed from the grain, and pass into the resultant effluent. One or more of those substances is known to inhibit grain germination if it is re-applied to steeped grain. The project identified and quantified the elements present in the steeping water that caused inhibition of germination resulting in the production of an inferior quality of malt. Trials were carried out on a pilot and laboratory scale at iFBM, France and at the 30 tonne batch size drum maltings at Muntons plc in England. This drum maltings is part of Muntons 78,000 tonne capacity site in Stowmarket, England. The goal was to produce a viable economic procedure for the re-use of treated water, after removing the inhibiting agent.

During steeping between 0.5% and 1.5% of the grain's dry weight dissolves in the steep water. Steeping a 100 tonne batch of dried barley can add around 1 tonne of solids into the total volume of effluent from the batch (over the 2 or 3 wets during steeping). Biological oxygen demand (BOD) increases with the length of contact time between grain and steep water. Larger volumes of water result in more dilute effluent. This project addresses the issue of production of potable water (with the germination inhibitor removed), to generate water suitable for subsequent steeping. It is important that the project addresses the different site needs in relation to existing water treatment plants. Consideration has to be given as to how the design for steep water re-use can be most efficiently and cost effectively incorporated into existing plants where there are different sources of water and methods of handling wastewater.

What is Malting?

Malting is the controlled germination of cereals, to turn barley that is hard, into a friable, easily milled malt.

Malting makes use of the natural processes that occur when grain germinates, but controls these so that the process is stopped just before the shoots grow and use the starch inside. This starch is what makes flour for milling or is mashed with hot water to make a sugar solution (wort) for processes like brewing.

As soon as possible after harvest barley is dried and held in safe storage at below 14% moisture content. The barley grain embryo will only grow when immersed in water, which is done through the ***steeping*** process. Usually taking 48 hours grain is sequentially immersed and drained of water to raise the grain water content to 45% , which is sufficient to allow it to ***germinate*** for the next 4 to 5 days.

The germination process removes those components that make the grain hard and is halted by drying the barley gently in a hot air kiln for 24 hours, which creates a malt rich in flavour, natural enzymes, starch, protein and minerals.

How Much Water Is Used In Malting?

On average for every tonne of malt produced 4.5–5.0 m^3 water is required for the steeping process and the wastewater generated is approximately two thirds of this.

Annual data for EU maltsters:

44 million m^3 water
30 million m^3 wastewater

Cost varies depending on how water is sourced and wastewater treated.

Using average costs water sourcing and treatment approach **€ 100 million per annum**

SWAN PROJECT: HEADLINE SUMMARY

A consortium of UK and French maltsters secured funding through the EUREKA scheme and launched EUREKA project E!3068 in November 2003. A successful outcome was achieved by the end of the project in 2007.

A variety of technologies currently available to purify steep wastewater were investigated individually and in combination: granular activated carbon (GAC), ultrafiltration, nanofiltration, reverse osmosis and membrane bioreactors. The most suitable was a combination of membrane bioreactor coupled to reverse osmosis (MBR+RO). There are two distinct examples of membrane treatment in the bioreactor: submerged banks of membranes operating at low pressure, or sealed membrane units outside the bioreactor operating at high pressure. Although both of these membrane systems performed well in removing inhibition, the team investigated the sealed membrane system in more detail because it is often assumed to be a potentially higher consumer of electrical energy. Commercial trials indicated, however, that the enclosed membranes did not appear to need excessively higher energy input - thus either system could be implemented.

The capital costs of installation and running costs of the MBR+RO technology is currently at a level that does not make it competitive for many malting companies to implement where they have their own wastewater treatment. Where the malting plant takes water direct from the local authority and sends wastewater direct to the local sewer the charge is much higher and the MBR+RO system may well show a favourable medium term payback. For most malting sites using borehole water and a dedicated wastewater treatment plant it is most likely that the introduction of MBR+RO treatment will only become viable if there is a very significant increase in water abstraction or disposal costs through pressure on our water resources.

One of the key outputs of the SWAN project was the manufacture of malts using recycled water that had the same malt quality as malts made with fresh water. These malts were also brewed in a commercial brewery and made perfectly acceptable normal lager beers.

There is still uncertainty amongst the malting companies who participated in this work as to how their customers will view malts made using recycled water. From a technical and analytical perspective there is absolutely no reason to doubt the robust standards of food safety that have been achieved. In many cases manufacturers have programs and policies in place to improve the recycling of other raw materials used in packaging and use green energy to the greatest degree possible. It is a logical step then to allow suppliers of raw materials such as malt to use recycled resources where they have no negative impact on product quality. For those maltsters who currently find their costs would significantly increase by introducing this technology it is doubtful that these costs could be passed on through the supply chain unless there was legislative environmental pressure requiring greater use of recycled water.

SWAN PROJECT SCOPE

The project was carried out in three stages:

Stage 1 surveyed steep wastewater from UK and French commercial malting plants and their treated effluent where those companies had wastewater treatment plants. The result was a comprehensive analysis of steep water effluent and an initial insight into the nature of the inhibitor.

An initial design for laboratory scale recycling of steep wastewater.

Stage 2 focussed on determining the most appropriate treatment technology both technically and economically that could be tested at pilot scale. It was linked to the 1 tonne pilot malting plant at iFBM, Nancy.

Stage 3 was designed to test and prove the concept on a commercial scale. A larger treatment plant was designed and installed at a UK sales maltster's site and trialled over a period of six months. The aim was to evaluate the economic viability and water treatment performance of an industrial scale pilot plant.

SUCCESS!

The SWAN project demonstrated the following:

- **Steep wastewater waters do contain germination inhibitors**
- **Inhibition can be effectively removed by non-chemical treatment systems.** It remains to be seen if maltsters' customers will permit the use of recycled waters and accept the increased costs of water treatment.

KEY OUTPUTS FROM THE PROJECT

STAGE 1

- **Identification of the main compounds present in steep wastewater**

Preliminary experiments showed that the ***reuse of steep wastewater in the malting process resulted in malt of very poor quality***, particularly poor friability. The effects were greater with longer steep times due to greater release or generation of inhibitors, but greatest in wastewater from the first steep. This confirmed the necessity to treat the steep wastewater before reuse.

A total of 37 steep wastewater samples (accompanied by detailed plant and sample descriptions) provided by French and British maltings and the iFBM pilot plant were analysed for a wide range of constituents: organic acid content, pesticides, mycotoxins, sugars and phosphorus contents, grain microflora, total and soluble COD, BOD, conductivity and total phenolics.

- **Quantification of Germination Inhibition**

A reliable test for germination inhibition was developed. **All steep wastewater and conventionally-treated effluent samples inhibited germination in the range 4% to 38%.** Inhibition here meant that grains were slow to germinate over 24 and 48 hours. Although the inhibition eventually diminished, this early lack of germination dramatically affected modification during malting resulting in malt of poor quality.

The inhibitory effect of steep wastewater increased with steeping time and varied with steep phase. ***A good correlation was found between steep water colour and inhibition rate***.

A literature survey for potential germination inhibitors generated a list of candidates that could be screened in these trials.

- **Fractionation of Steep Waters, Identification and Quantification of Inhibitors**

Fractionation tests revealed that substances with molecular weights <500 Da were not involved in the inhibition mechanism. Interestingly, phenolic compounds in the outer layers of the grain were not found to be inhibitory. This was not what was initially expected because it was known the barley and the husk extracts from Caminant, a low proanthocyanogen barley, showed very low levels of inhibition (1%) compared with those from Scarlett (26%), which suggested a direct role for phenolic compounds in inhibition. This was confirmed by adding various phenolic compounds and their final oxidation products to laboratory steep waters and also finding no inhibition. More detailed studies with cysteine, however, showed that blocking quinones - a dynamic group of oxidised phenolic intermediates - eliminated the inhibitory effect. Similarly, the addition of polyvinylpyrolidone (which absorbs certain condensed polyphenol classes) to steep waters only caused a minor drop in inhibition. ***The conclusion was that inhibition was due to quinones, oxidation intermediates of phenolic compounds.***

KEY RESULTS – STAGE 1

- **Steep waste water inhibits germination**
- **Inhibition of germination as high as 36%**
- **Effect of inhibitor evident for the first 2 days of germination**
- **Inhibition is correlated with steep waste water colour**
- **Inhibitor is an oxidation product of a polyphenol – a QUINONE**

IFBM Pilot Plant, France

- **Laboratory Investigations into Recycling Plant Options**

Coagulation-flocculation tests showed that high amounts of coagulant have to be used to treat steep wastewater. Biological treatments (batch and continuous reactors) decreased the inhibitory effect and inhibition diminished even further when a membrane bioreactor was used (from 38% to 9%). It should be remembered that this inhibition is seen only in the early stages of germination, but still results in poor malt modification during germination.

It was recognised from earlier investigations that malting plants with greater oxygenation in the steeping vessel showed the least inhibitory effect when steep wastewater was used for the next steep cycle. Using the small scale maltings at IFBM this factor was confirmed by the lack of steep inhibition when using overflowing steeps whereas without overflow steep wastewaters were as inhibitory as industrial waters.

- **Choosing an appropriate treatment system**

The treatment options chosen were: membrane bioreactor, reverse osmosis and activated carbon. Trials aimed to find one or more combinations of these systems that would remove not only inhibitory substances but also other heavy metals, mycotoxins and pesticides to ensure the water was safe according to EU drinking water standards and also suitable for re-use in malting.

STAGE 2

Stage 2 focused on MBR and RO treatment and pilot malting and brewing trials were conducted. Pilot malting trials (600 kg) generated steep wastewaters for pilot treatment experiments (5 m^3 reactors), and then recycled into the malting process. Malts made using recycled waters compared favourably to those made with tap water (control) and were used for brewing beer on a pilot scale.

Water analyses

To determine the effect of barley variety on the inhibition rate of the resulting steep wastewater, 7 spring barley varieties were steeped, and the inhibition rates varied from 25% to 45% for untreated steep wastewaters, and from 6% to 13% for membrane-filtered steep wastewaters.

When steep wastewater was treated with MBR the inhibitory effect reduced to just 2%. There was an accompanying reduction in heavy metals and COD, but levels remained higher than legal limits. Three additional treatments were: reverse osmosis, nanofiltration or adsorption on activated carbon. Reverse osmosis and nanofiltration produced considerably better water quality than activated carbon treatment. In terms of safe water production, only reverse osmosis was suitable because nanofiltered waters still had high phosphorus concentrations.

Malt analyses

Micromalting tests and subsequent analysis showed that steep wastewater treated by MBR + nanofiltration gave a malt of equivalent quality to reference malt (made with tap water), whereas steep wastewater treated by MBR + reverse osmosis gave a slightly better malt than with tap water.

MORE KEY RESULTS FROM STAGE 1

- **Membrane bioreactors reduce inhibition to <10%**
- **Greater steep aeration reduces the inhibitory effect**

STAGE 2 Pilot trials

- **Reverse osmosis and nanofiltration are considerably better treatments than granular activated carbon (GAC)**
- **Membrane Bioreactor followed by Reverse Osmosis (MBR+RO) is the best water treatment option**
- **MBR-RO treatment removes pesticides, mycotoxins and heavy metals**
- **MBR-RO treatment using either submerged or cartridge systems is equally effective in removing inhibition**
- **Malt produced using recycled water produces beer that is no different to normal**

Pilot Scale Treatment: Plant Options

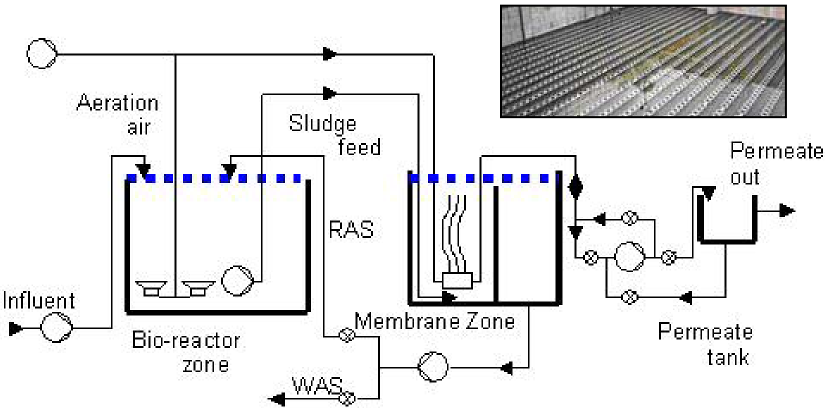
When considering the most suitable pilot plant a wide range of water treatment companies were approached. Very few expressed an interest in collaboration on this work, but finally two were selected to present a case for consideration by the SWAN project committee. There were two options. Both used an aerated bioreactor tank but differed in the membrane design, The first , proposed by ITT-Aquious, consisted of membranes immersed in the biomass. The reinforced chlorine-resistant hollow fibre membrane was designed for central coarse-bubble scouring and the base secured in a resin element. The second system, proposed by Norit / Aquabio, used membranes sealed in cartridge units located after the bioreactor tank. Initial separation was through ultrafiltration in sealed membranes operating under pressure.

Both companies presented detailed capital expenditure and running costs for their systems, but it was surprising to find that running costs were quoted as almost the same for both systems. It had been assumed that because the sealed cartridge membranes worked at higher pressure energy costs would be much higher.

Aquious Advanced Liquid Separation

ITT Industries Engineered for life

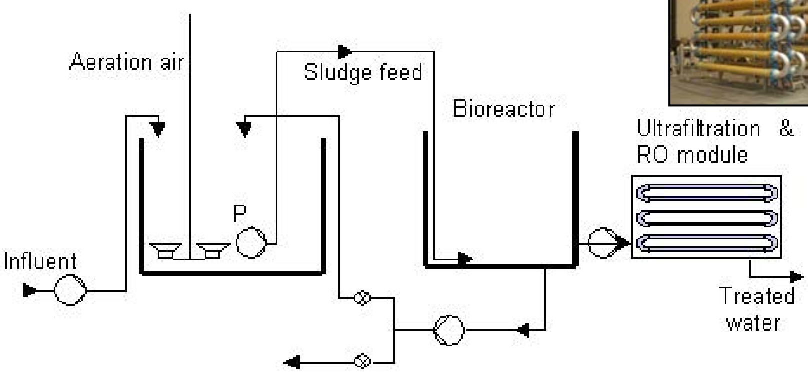
Fine bubble mat



NORIT MEMBRANE TECHNOLOGY

Aquabio

Cartridge membranes



STAGE 2 Treatment Alternatives

- **Aquious-ITT**
  An aerated receiving tank passes effluent to a second MBR tank in which the membranes are submerged. Fine bubble aeration scours the bundles of membrane fibres and treated effluent is taken off from the inside of the fibres for further RO treatment
- **Norit-Aquabio**
  An aerated receiving tank feeds an aerated MBR tank. Treated effluent is then passed through pressurised ultrafiltration membranes that are in enclosed cassettes before a final RO stage

Water quality

MBR treatments eliminated inhibition to a degree, but to obtain potable water it was necessary to include reverse osmosis. Minor differences in the levels of conductivity, total polyphenols and phosphorus were observed. The difference in conductivity and polyphenols was due to the cut-off of the filtration membranes selected, and the difference in the phosphorus was due to the high initial concentration of phosphorus in the sludge used.
To be absolutely certain that MBR+RO was effective at eliminating any mycotoxins and pesticides present, a specific trial was conducted using barley deliberately contaminated with HT2 toxin. The steep wastewater was in addition dosed with pesticides. All these contaminants were successfully removed by the combined MBR + RO system.

Malt quality

There was essentially no difference in malt quality between MBR+RO treatments whether membranes were submerged or cartridge. Activated carbon was not effective in generating potable water.

Beer quality
Analysis of the sensory and chemical composition of the beers produced with the pilot malts showed that there was no negative impact on beer quality. The beers were produced to the same standards as when using malts made with fresh water.

STAGE 3

The objective of Stage 3 was to confirm at a reasonable commercial scale that the combined MBR+RO treatment was effective using successive recycling treatments and to determine if the costs were broadly in line with those suggested by the manufacturer.

The plant also allowed an option to generate MBR + ultrafiltered water to test if this also could produce water of acceptable quality.

Trial plant location
A 30-tonne batch size drum malting which produces malt for the brewing and food industries was selected. Two $50m^3$ tanks were constructed, one to receive steep wastewater and the second to act as a bioreactor. A skid-mounted unit was located next to these tanks and housed the RO membrane system. A separate tank held treated water for the next steep. All installations were operated to food quality standards and a separate metered electricity supply used. Process control systems were industry standard. Throughout the trial the plant was monitored by fully trained wastewater treatment technicians. Food hygiene standards were excellent since this plant was sited at a maltings which had the British Retail Consortium – Global Standard Food, grade A – the highest standard of hygiene possible for a malting plant.

Water quality
MBR+RO treatment was used to recycle water over 20 consecutive batches of malt in all steeps. Up to 80% recycled water was used in steeps but for this smaller scale commercial plant it was more convenient to run the plant at around 65-70% recycled water. Indeed it may not be advisable to exceed 80% recycling because the treated water is devoid of minerals

Energy consumption
The enclosed membrane filtration modules were reported to have more favourable energy consumption figures than expected from anecdotal evidence of other RO systems. Although it was acknowledged that it would be difficult to establish true electrical consumption on such a small commercial plant the electrical meter would give an indication of how close to the manufacturer's figures a commercial plant would operate.

The measured energy consumption of the MBR+RO option was $7kWh/m^3$ – very close when compared with $9kWh/m^3$ predicted by the manufacturer for a 100,000 tonnes maltings.

Although the UF trials did not produce potable water in these trials the energy consumption was confirmed to be much less than RO at $3.0kWh/m^3$. This option remains of interest if water is to be reused in areas other than food processing.

STAGE 3
Commercial Trials

- **MBR+RO confirmed as the best treatment to remove inhibition**
- **Recycled water made good quality malt even after 20 recycling treatments**
- **Energy consumption for MBR+RO confirmed as approximately $7kWh/m^3$**
- **No build up of microbiological load during recycling**
- **Up to 70% recycled water was used for re-steeping**
- **Sludge generation was minimal**
- **Cleaning (caustic) required on this plant every week for 9 hours each time**

Malt quality
The malt produced using the MBR+RO treated and recycled water was of the same analytical quality as malt made by conventional fresh water steeping. There was no obvious relationship between the microbiological analysis and the number of recycle steps the water had passed through. All malts were free of pathogens.

Sludge Generation
During the trials almost no sludge was produced. It is not possible therefore from this scale to predict the sludge production on a larger scale.

Plant Operation – A User's Perspective

The plant generated recycled steep water for subsequent use in a series of 20 consecutive batches. Stabilisation of the bioreactor module took just 2 weeks. Although the target recycling was 85%, this was not possible to achieve throughout the entire trial due to restrictions of treatment plant processing time. The processing capacity of the various components was an issue that may be resolved on a full scale operation.

There was considerably more intervention required from the wastewater technician than had been anticipated. Frequent cleaning was needed to overcome fouling of the RO system. Pre-filters were found to be too fine resulting in a bio-slime.
The cleaning regime was:
RO alkaline rinse weekly: 9 hours
RO alkaline/acid rinse every 2 weeks (13 hours)

It had been expected that solid debris from the steeping process would block the aeration in the receiving and bioreactor tanks so a run-down screen (4mm) was fitted which was very efficient and required just a simple rinse on a routine basis. In the receiving tank for steep wastewater, the aeration rate was too high and generated too much foam and had to be down-rated to a simple stirring action.

Unusually for the UK, the ambient summer temperature rose to 38°C during the trials and this caused unexpected problems for the bioreactor. The heat caused a dry crust to form on the surface of the bioreactor that had to be manually broken up using a high pressure water hose. Crust formation was thought to be due to aeration design. In this plant there was coarse bubble aeration whereas fine aeration often results in more even surface movement and perhaps less likelihood to form a crust on the surface.

Although ultrafiltered water (UF) when used for steeping produced a malt within specification, the trials proved difficult to conduct and there was an indication that microbiological analysis of the water could be difficult to control. Much of this was likely due to the very high ambient temperatures that adversely affected microbiological growth resulting in quite high ammonia levels. A more extensive trial may have been able to eliminate the issues that arose during the UF trials and the possibility of using UF water should not be dismissed entirely. From a food safety perspective however, the increased risk to water quality may be unacceptable to companies wishing to minimise potential taints and contamination in the water supply. Using the RO treatment there is no possibility of microbial contamination hence no issue with taint.

SWAN Commercial Pilot plant at Muntons plc, England. The two green tanks are 50m^3 each and the blue box housed the UF and RO membranes

Analysis of water before and after treatment on the pilot plant

Analyte	Un-treated	MBR + RO	MBR + UF
COD (g/l)	4.5	0.05	2.3
Conductivity (mS/cm)	2.2	0.1	2.0
Polyphenols (mg/l)	210	0	45
Optical density (500nm)	0.5	0	0.1
Total organic acids (g/l)	2.8	0	0.4
Phosphorus (ppm)	71	0	35
Total Nitrogen (mg/l)	151	0	75
Inhibition (%)	25	0	10
Mycotoxins (ppb)			
Ochratoxin A	ND	ND	ND
DON	15	ND	9
T2	0.1	ND	ND
HT2	4.8	ND	1.6
Nivalenol	7	ND	3

Mineral composition
Water was also analysed for a range of metals: Manganese, Copper, Zinc, Lead, Cadmium, Mercury and Iron. All these were within potable water limits with the exception of Iron and Manganese. However, the level of these elements is naturally high in water from East Anglia where the maltings is situated, but still safe for food production – a derogation is allowed by the local authority

Pesticides
All the following pesticides were removed both by MBR+ultrafiltration and MBR+RO: pirimifos methyl, piperonyl butoxide, deltamethrin and malathion

Clearly MBR+RO is the best method to remove all potential hazards for production of potable and non-inhibitory water

Financial Appraisal

The costs determined during the 30 tonne batch size commercial trial should be a reasonable indication of those achievable for a full scale malting operation. Comparison of the manufacturer's energy consumption data at 9kWh/m^3 and the trial plant at 7kWh/ m^3 gives confidence in the data collected.

The major variables in this installation are the costs of water abstraction and wastewater treatment. Using UK costs as an example water cost can easily vary from €0.075/m^3 for abstraction from a borehole to €0.75/m^3 if water is taken direct from a local authority. Wastewater treatment using an on site treatment plant can be as low as €1.20/m^3 or up to €3.50/m^3 and more if disposal is via the water company sewer. Therefore three illustrations are given to indicate the range of payback situations that may be achieved.

Illustration for a 75,000 tonne maltings on an annual basis

Capital cost of plant	**€ 1,100,000**
Operational cost *	**€ 165,000**
Annual cost assuming 15 yr plant life	**€ 346,333**

*(*Operational costs are from manufacturer's data indicating €0.5/m^3)*

The manufacturer determines costs as follows:

Power (electricity)	**35%**
Membranes & Chemicals	**25%**
Sludge disposal	**20%**
Maintenance and Labour	**20%**

Power consumption figures claimed by the manufacturers of either treatment system are quite close:

Aquious-ITT submerged membranes 7.9kWh/m^3

Norit – Aquabio cartridge membranes 9.0kWh/m^3

Assumptions made to calculate the financial payback are:

Water used in malting: 4.5m^3/tonne malt produced

Waste water generated: 4.0m^3/tonne malt produced

Waste water recycled: 70%

Type of water use and treatment	Current total water & effluent costs/tonne	Annual savings possible	PAYBACK PERIOD
Own borehole and own on site wastewater treatment	€ 5	€57k	**19 years**
Local authority water source with own wastewater treatment	€ 12	€435k	**3 years**
Local authority water sourced and wastewater going to local sewer	€15	€820k	**1.3 years**

Payback here assumes a plant life of 15 years to determine an annualised payback but does not include finance costs nor depreciation. It is thus a simple payback calculation.

Clearly for some malting operations that rely entirely on local authority utilities this technology may already be an attractive proposition whereas for others it would not merit consideration. These figures are simply an illustration and each company will have to carefully consider true costs for each site.

The Commercial Scale Trial Was Successful !

MBR+RO is a technology with a future application. It is an acceptable method of producing water suitable for recycling in the malting process. Inhibitors of germination are removed together with pesticides, mycotoxins and heavy metals. Malts made with recycled water produce beer of the highest quality.

Financially, installation and running costs do not currently make it a viable option for malting companies with their own boreholes and wastewater treatment. Alternatively for companies facing rising costs of external water supply and disposal to sewers it may be possible to demonstrate an acceptable payback.

CONCLUSIONS

The project has successfully met its objectives in the following areas:

- Identified the inhibitory compound in steep waste water
- Developed a method to remove the inhibitory compound
- Determined that treatment in a Membrane Bioreactor followed by Reverse Osmosis generates a water suitable for human consumption and for subsequent re-use in the malting process
- The water recycled is free of pesticides, mycotoxins and heavy metals
- Shown that at least 70% of treated water can be recycled in the malting process
- That in some situations it may be financially viable to install a similar system in a commercial maltings

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Muntons plc for providing the commercial trial site

Aquious-ITT for participating in pilot trials and helping prove the concept of water treatment

Norit-Aquabio for participating in pilot and commercial trials, helping prove the concept of water treatment and building the commercial scale test unit

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