GG187
GUIDE

ENVIRONMENTAL
TECHNOLOGY
BEST PRACTICE
PROGRAMME

REDUCING WATER AND EFFLUENT COSTS IN FISH PROCESSING

GOOD PRACTICE: Proven technology and techniques for profitable environmental improvement

REDUCING WATER AND EFFLUENT COSTS IN FISH PROCESSING

This Good Practice Guide was produced by the Environmental Technology Best Practice Programme

Prepared with assistance from:

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and

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SUMMARY

The UK fish processing industry faces dramatic increases in trade effluent charges due to stricter legislative controls on discharges from sewage treatment plants, particularly those in coastal areas. As water companies upgrade their sewage treatment works, many fish processing companies are expected to experience increases in trade effluent bills of over 500%. In addition, water supply costs continue to rise. In the past, the fish processing industry has perceived water and effluent charges as low-cost and given them low priority. The challenges facing the industry mean that companies need to take action now to reduce these costs and thus remain competitive.

This Good Practice Guide identifies typical sources of waste in fish processing and describes a range of simple no-cost and low-cost measures to reduce water and effluent costs. For sites that treat their own effluent, this Guide will help them to reduce costs by minimising the load on the effluent treatment plant. Industry Examples are used to illustrate the cost savings that can be achieved by taking action to reduce waste.

The main reasons for water and effluent problems in the fish processing industry are:

- use of excessive amounts of water (and the consequent generation of large volumes of effluent);
- fish waste in contact with water leading to high strength effluents that incur high treatment charges.

The Guide, which is applicable to all sectors of the fish processing industry, takes you through the key stages involved in achieving cost savings, ie:

- establishing management commitment and involving staff;
- identifying where water is used and effluent is produced;
- identifying the processes that make the greatest contribution to the site’s water and effluent costs;
- targeting opportunities to reduce costs;
- implementing no-cost and low-cost measures;
- monitoring progress;
- maintaining continuous improvement.

The Guide contains blank worksheets, accompanied by worked examples, to help you identify priority areas for action to reduce water and effluent costs.

Whilst care has been taken to ensure that the guidance does not conflict with hygiene requirements, companies adopting the recommendations must be mindful of the need to comply with food safety and health and safety legislation, particularly the Food Safety (Fishery Products and Live Shellfish) (Hygiene) Regulations 1998 (SI 1998 No 994) which complements Council Directive 91/493/EEC.

CONTENTS

1 WHY REDUCE WATER AND EFFLUENT?

1.1 RISING COSTS

The UK fish processing industry uses large quantities of water and generates substantial amounts of effluent (see Section 2). Historically, water supply and trade effluent disposal have not been considered significant cost issues by the industry. However, fish processing companies now face dramatic increases in water supply costs and, in particular, trade effluent charges.

Effluent disposal for fish processing plants has traditionally been inexpensive. This is particularly true for fish processors in coastal areas where only limited treatment was carried out at the local sewage treatment works before final discharge to the sea. As a result, fish processing plants have tended to regard effluent drainage systems as cheap and convenient disposal routes for their high strength effluents containing considerable amounts of solid and organic waste materials.

Actual increases for individual companies will depend on several factors (see Section 2). However, a survey carried out by the Sea Fish Industry Authority (SFIA) in 1997/8 estimated that, for most white fish processors on Humberside, trade effluent charges would increase by 400 - 500%. This represents a typical increase of £1/m^3.

Dramatic increase in trade effluent charges

Trade effluent charges at a pelagic fish processor recently leapt from 38 pence/m^3 to nearly £3/m^3, an increase of over 600%.

1.1.1 Why are costs increasing?

The main reason for increased trade effluent charges is the implementation in the UK of the Urban Waste Water Treatment Directive (UWWTD) 91/271/EEC. This Directive demands tight control on the quality of effluent discharged to controlled waters, eg rivers, estuaries and coastal waters. It applies throughout the European Union to discharges from sewage treatment facilities and industry. This legislation will bring fish processing, which traditionally has not been subject to high effluent treatment standards, into line with other industries.

Implementation of the UWWTD in the UK means that:

- Most sewage treatment works - particularly those in coastal regions - are being upgraded to include secondary treatment.[1] Sewage treatment operators are passing on their increased costs to their customers as increased trade effluent charges.
- The Environment Agency and the Scottish Environment Protection Agency (SEPA) are setting more stringent consent conditions for discharges to controlled waters.

1.2 NEW LEGISLATION

The Integrated Pollution Prevention and Control (IPPC) Directive applies to fish processors with a finished production capacity greater than 75 tonnes/day. To obtain an IPPC authorisation, companies must use Best Available Techniques (BAT) to minimise and render harmless releases to the environment from their process. Besides the issues covered by Integrated Pollution Control (IPC), IPPC covers raw materials and energy efficiency.

[1] Use of biological and chemical processes to remove most of the organic matter present in the effluent.

Tip

For advice and information about current legislation governing the fish processing industry, contact the Environment and Energy Helpline on freephone 0800 585794.

1.3 ACTION YOU CAN TAKE

There is a great deal you can do to reduce the impact of these rising costs on your business without compromising hygiene standards.

Reducing the amount of waste produced in the first place is generally more cost-effective than treating the waste prior to discharge, ie waste minimisation at source is better than end-of-pipe treatment. Many opportunities to reduce waste involve simple changes to operating practices or minor modifications to equipment. Simple measures to reduce the amount of water used will also reduce the volume of effluent produced.

Even for companies that treat their effluent on-site, reducing the volume and strength of the effluent at source will help to minimise the capital and operating costs of the effluent treatment plant.

Non-process uses also merit attention. Dripping taps, leaking pipes, etc all cost money. Good Practice Guide (GG67) *Cost-effective Water Saving Devices and Practices* describes a range of measures to help industrial and commercial sites reduce their water use. GG67 is available free of charge through the Environment and Energy Helpline on freephone 0800 585794.

1.4 THE PURPOSE OF THIS GUIDE

This Good Practice Guide is intended to help you plan and implement measures to reduce water use and effluent generation. Many of the measures described in this Guide apply to all sectors of the fish processing industry.

The Guide, which is applicable to both existing processes and new sites, describes:

- how to calculate the impact of rising water and effluent costs on your business;
- how to identify what water is used for and where effluent is produced at your site;
- setting targets for improvement and monitoring progress;
- the main sources of waste in the fish processing industry;
- simple measures to reduce waste, applicable to all sectors of the fish processing industry;
- the cost savings achievable from no-cost and low-cost process changes;
- technology changes requiring capital investment and end-of-pipe treatment methods.

Blank worksheets, together with worked examples, are provided in Appendix 1 to help you identify which of your processes have the highest water and effluent costs. These processes are your priorities for action.

Industry Examples throughout the Guide highlight the cost savings already achieved by companies that have adopted good practice.

Care has been taken to ensure that the guidance does not conflict with hygiene requirements. However, companies adopting the recommendations are responsible for maintaining compliance with food safety and health and safety legislation, particularly the Food Safety (Fishery Products and Live Shellfish) (Hygiene) Regulations 1998 (SI 1998 No 994) which complements Council Directive 91/493/EEC.

2 WATER USE AND EFFLUENT PRODUCTION IN FISH PROCESSING

2.1 WATER USE

To maintain the high standards of quality and hygiene required, large amounts of water are used for processes such as cleaning, washing, cooling and during transportation.

The amount of water used varies according to the process and the type of fish being processed. As shown in Table 1, even companies carrying out the same process use different quantities.

Main process	Water used to produce 1 tonne of white fish fillets (m^3/tonne)		
	Minimum	Average	Maximum
Filleting	5.0	6.3	7.4
Defrosting and filleting	9.5	15.7	24.0
Defrosting, filleting and enrobing*	22.0	22.0	22.0

* Data from one company

Table 1 Water use for white fish processing

2.2 EFFLUENT PRODUCTION

Most of the water from processing and cleaning activities is discharged to drain as trade effluent. The charges imposed by the local sewage works are based on the Mogden Formula (see Appendix 2). Traditionally, charges have been based solely on the volume of effluent discharged using a figure obtained from flow measurements or derived from the volume of water supplied. However, more and more sewage treatment operators now base their charges on effluent composition (strength) as well as volume. In the Mogden Formula, strength is characterised in terms of total suspended solids and chemical oxygen demand (COD).[2] These values are determined from spot samples of the trade effluent taken by the water company.

High suspended solids and COD contents, together with large effluent volumes, lead to high trade effluent charges. The values of the various parameters in the Mogden Formula (see Appendix 2) are set by the particular water company and vary between geographical regions.

2.2.1 Effluent composition

- **Suspended solids** in the effluent from fish processing sites are typically due to pieces of fish, shell and sand.
- **COD** in fish processing effluents results from organic substances such as fish oils, proteins and blood. Effluents containing fish guts, batter and oil are exceptionally strong. The length of time the organic matter is in contact with water has a significant impact on the COD - the longer the time, the higher the COD. This is a particular problem for processors of pelagic fish as these species have a high oil content. They are often processed mechanically, involving long periods when waste materials are in contact with water.

[2] COD provides a measure of the organic matter present in the effluent.

2.3 TYPICAL INCREASES IN EFFLUENT CHARGES

Table 2 shows typical values for water use and effluent strength for a white fish and a herring processor.

Type of processor	Water use (m^3/tonne product)	COD (mg/litre)	Suspended solids (mg/litre)
Large white fish company	8 - 10	2 000	300
Herring processor	6	14 120	5 240

Table 2 Typical water use and effluent strength for two fish processors

section 2

Appendix 2 contains an example calculation of sewage treatment charges using the Mogden Formula for the white fish processor shown in Table 2. For sewage treatment that just involves reception and conveyance, the charge is only 11.7 pence/m^3. When primary treatment[3] is applied, the total charge increases to 21 pence/m^3. Upgrading the sewage treatment facility to incorporate biological treatment and applying a charge for removing suspended solids and COD produces a significant increase to **83.6 pence/m^3**. This represents an increase of 615% compared to simple reception and conveyance. A major part of this increase is due to the 52.3 pence/m^3 charged for removing COD.

A similar calculation for the herring processor shown in Table 2 results in an enormous charge of **£5.49/m^3** for primary and secondary treatment. Removing COD from this high strength effluent accounts for £3.70/m^3 and removing suspended solids for £1.57/m^3.

As shown in the Industry Examples in this Guide, simple measures to reduce the volume and strength of effluents from fish processing plants can reduce these charges significantly. Taking action to reduce water use, eg avoiding dripping taps and hoses left on, will also help to reduce your operating costs.

3 Primary treatment involves using physical processes, eg screening and sedimentation, to remove floating and settleable solids.

3 GETTING STARTED

Much can be done to reduce water and effluent charges through simple, no-cost and low-cost measures (see Section 6). However, before implementing these measures you need to plan your course of action.

Here are the key steps to achieving success and cost savings:

- establish management commitment;
- involve staff;
- identify and quantify waste;
- target opportunities to reduce waste;
- implement a training and awareness programme;
- implement measures to reduce water use and effluent;
- maintain continuous improvement through monitoring and evaluation of progress.

Adapt the methods described in this Guide to suit your business and the resources available, and with regard to the hygiene and safety legislation to ensure compliance.

3.1 OBTAINING MANAGEMENT COMMITMENT

To be successful, a waste minimisation programme needs the support, interest and involvement of senior management. Senior management can demonstrate its commitment by:

- being involved in setting objectives and targets;
- asking for regular updates on progress and successes;
- allowing staff the time to carry out the necessary work.

3.1.1 The role of the waste Champion

Crucially, the senior management should choose a waste minimisation Champion for the site. The Champion's role is to facilitate and co-ordinate the waste minimisation programme - not to do it all! A team or teams of other people will actually achieve the results.

The job of the Champion includes raising staff awareness, setting targets, getting the right people involved at the right time, evaluating progress and providing feedback. The level or area of the company from which the Champion is selected is not critical.

The key characteristics of a Champion are:

- enthusiasm and willingness to learn;
- credibility with colleagues at all levels;
- good communication, motivational, organisational and facilitation skills;
- the ability to collect, analyse and report data;
- the tenacity to make progress despite obstacles and other priorities.

Waste Champion takes the lead

The Chairman of F Smales & Son (Fish Merchants) Ltd, a fish processor based in Hull, is dedicated to minimising water use and effluent production. He has appointed a Champion to take responsibility for the waste minimisation project. This has proved an excellent foundation for the improvements Smales has already achieved and continues to implement. During the first three months, Smales reduced water use by approximately 35%.

3.2 INVOLVE STAFF

Another critical factor in the success of any programme to reduce waste is the involvement of the entire workforce. To integrate waste minimisation into your company's culture, you need to involve staff from all areas. Remember, involvement creates ownership. Publicising achievements and providing feedback are also vital.

Tip

'People' issues and the Champion's role are discussed in more detail in Good Practice Guide (GG27) *Saving Money Through Waste Minimisation: Teams and Champions*. GG27 is available free of charge through the Environment and Energy Helpline on freephone 0800 585794.

3.3 TRAINING AND AWARENESS

You will achieve cost savings more easily and for less capital cost by:

- explaining to staff why water and effluent costs need to be reduced and the benefits to them as individuals, eg greater job security due to the business's improved performance;
- providing training for staff in new working practices and the use of new equipment.

Good practice measures save on end-of-day cleaning up

One small white fish company actively encourages all filleters to turn off water when they are not at their benches and to minimise the amount of scrap on benches and the floor. Not only does this help to save water and reduce effluent, it also reduces the time and effort needed for cleaning at the end of the day.

The waste Champion should take on the role of training staff at all levels. All staff should be made aware of:

- which processes have high water and effluent costs;
- the implications to the business of their actions and how these could be changed, eg turning off water during breaks could save 5 m^3/day - at, say, 70 pence/m^3, that represents a saving of £3.50/day.

Training can be carried out in a number of ways. The following methods have proved effective:

- Short, simple presentations made to all staff - particularly operators - in small groups to minimise disruption to production.
- Brainstorming sessions with groups of operators to get ideas about how to achieve cost savings.

- Posters in appropriate locations to emphasise points made in presentations, eg a poster asking the question ‘Have you switched off the water and cleaned your area before you go for a break?’ Make sure that posters placed in food processing areas comply with hygiene regulations.
- Include issues relevant to reducing water and effluent costs in the training of new staff.
- Provide forms for staff to suggest ways of reducing water use and effluent production. It may be possible to integrate such a scheme, which could include rewards, with an existing one for maintenance or quality.

Tip

Explain to staff the benefits to themselves and the company of taking action to reduce waste.

Keep staff informed of improvements, eg in briefing sessions or by publishing the effects of their actions in the work area.

Use visual aids, eg pie charts, as much as possible in presentations and feedback.

4 IDENTIFYING AND QUANTIFYING WASTE

Having obtained management commitment to a waste minimisation programme, the next step is to:

- identify the processes that incur the highest water and effluent charges;
- find ways to reduce these costs.

4.1 PREPARING A WATER AND EFFLUENT BALANCE

A water balance is a valuable tool in defining your water and effluent streams. It will help you to establish the strength of your final effluent and prioritise your efforts in areas with the greatest potential for cost savings. A water balance is also useful in identifying leaks.

A water balance is a numerical account of where water enters and leaves your process (ie as effluent) and where it is used within the process. In the balance, the volume of water entering the process should equal the volume of effluent plus other volumes that can be accounted for (see Fig 1).

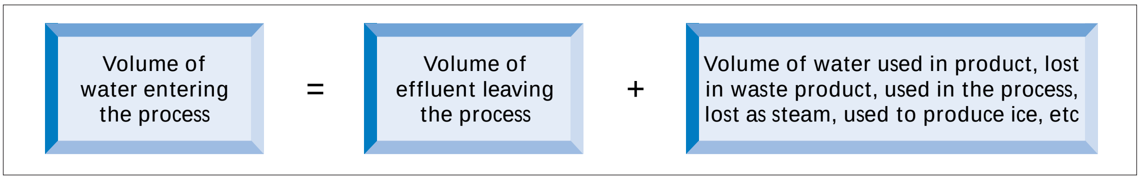


Fig 1 Schematic representation of a water balance

The procedure described below involves quantifying flows into and out of the process and those of the individual streams. If the process has been well characterised, the total of the individual flows should be in reasonable agreement with the overall value.

Appendix 1 contains a worked example balance and cost estimates. Appendix 1 also contains three blank worksheets to help you collect information and perform the necessary calculations.

More detailed advice on how to prepare a water balance and then to use this information to reduce water use is given in Good Practice Guide (GG152) *Tracking Water Use to Cut Costs,* available free of charge through the Environment and Energy Helpline on freephone 0800 585794.

4.1.1 Obtaining base-line information

Some of the basic information you need to prepare your water and effluent balance will already be available on-site. Existing sources of information include:

- water and effluent bills;
- existing meters;
- drainage plans (these will show where the effluent comes from and goes to);
- information on where water comes into the site and where it goes.

Start by looking at this information and then, with the help of the tips given below and the worksheets in Appendix 1, decide what further work is needed to prepare your water and effluent balance.

4.1.2 Total site water and effluent

Use your site bills to determine the total quantity of water supplied and trade effluent discharged to sewer. If possible, try to find at least a year's worth of data.

Trade effluent volumes are generally calculated by subtracting from the volume of water supplied to the site, allowances for water leaving the site in or with the product, by evaporation and during domestic use. The allowance for domestic use is based on the number of employees and the extent of staff facilities.

Tip

Check how the water company calculates your trade effluent charges.

Are the correct allowances being used to obtain the trade effluent volume used for charging purposes?

Have you told the water company how much water leaves in the product or is a standard percentage used? Remember, ice arriving or leaving your site may need to be allowed for.

Remember to tell the water company about major changes in staff numbers or modifications to staff facilities that may affect water consumption.

4.1.3 Individual process water use and effluent volumes

To construct a water and effluent balance for your individual processes, start by listing all the water users and effluent producers at the site. Remember to take into account:

- processes where water goes into the product or is used within a process, eg ice production, glazing, brining and batter manufacture;
- water used to raise steam.

The next stage is to determine how much water is used or effluent produced. Remember, if you do not measure it, you will not be able to manage it. Here are some methods you can use.

Metering

Metering the water supply to specific processes provides excellent data. Particularly useful locations for meters include supply hoses to the filleting process and, for some shellfish, the supply to the peeling/shucking process.

Spot measurements

There are many fish processing operations where the water supply or effluent discharge is easily accessible. Spot measurements of the flows here using a bucket and a stopwatch can provide sufficient data.

Equipment specifications

Information about equipment size and design is often useful. For example, if the volume of a tank and the frequency with which it is filled and emptied are known, then the water consumption can be calculated.

Meters help to manage water use effectively

Fish processor, F Smales & Son (Fish Merchants) Ltd in Hull, has installed meters on a number of individual processes, including the fish washing equipment, the defrosting cabinet and the filleting lines. Regular readings are taken and used to monitor progress and set targets.

Metering water use during filleting

section 4

Production data

The quantity of water used in products can often be estimated directly from production data. For example, the amount of water needed in batter manufacture can be calculated from the quantity of batter produced and the typical percentage water content.

Rules of thumb

Using 'rules of thumb' is the least accurate method of quantifying water and effluent flows. However, it is useful for initially estimating the amount of domestic sewage leaving the site. Typical values for domestic water consumption are shown in Table 3.

Site facilities	Water use (litres/person/day)
Toilets and hand washing only[4]	25
With canteen	40
With canteen and showers	75

Table 3 Typical domestic water use at industrial sites

Good Practice Guide (GG152) *Tracking Water Use to Cut Costs* contains more detailed information about quantifying water use and effluent flows, including estimating non-process uses.

[4] For the food and drink industry, the figure for water used in toilets and hand washing could be at least twice that quoted due to the legal requirements regarding hygiene.

4.1.4 Recording and analysing data

Once you have identified and quantified your water and effluent flows, use Worksheet 1 in Appendix 1 to record and analyse your data as in the worked example.

The overall flows and the sum of the component flows should agree to within 10%. If they do not, first check that all processes and streams have been included. If they have, then you may need to recalibrate your water meters or check for leaks.

> **Tip**
>
> To reduce the risk of errors in your calculations, use the same units for your flows, eg litres or m^3, depending on their size.
>
> *Water volume conversion*
>
> 1 m^3 = 1 000 litres = 220 gallons.
>
> To convert gallons to m^3, multiply by 0.0045.

4.2 SURVEYING EFFLUENT STRENGTH

You now know how much water your site uses and the volume of effluent discharged. To calculate future trade effluent charges (see Appendix 2), you also need to take into account the strength of each effluent. This information will also help you to identify ways of reducing your costs. Sewage treatment works generally make intermittent spot checks on your effluent quality.

Regular sampling improves effluent management

Fish processor, F Smales & Son (Fish Merchants) Ltd, monitors the site's effluent using a sampler which measures the flow rate and takes samples at set intervals. The samples are taken to a local laboratory for analysis.

Smales' waste Champion checking the effluent sampler

Carrying out your own monitoring programme will:

- provide more detailed information on the effluent generated by individual processes;
- give you a more representative value for the effluent's average quality.

The first step is to measure how much COD[5] and suspended solids[6] are present in the effluent from each process operation. Table 4 shows some typical costs for analysis by an external laboratory. Your budget may limit the number of samples you can take - but the more the better.

For free advice on effluent sampling and analysis, contact the Environment and Energy Helpline on freephone 0800 585794.

Test	Typical cost (£/sample)
Biochemical oxygen demand (BOD)[7]	10
Chemical oxygen demand (COD)	10
Suspended solids (SS)	7

Table 4 Typical analysis costs (1998 prices)

section 4

Tip

Concentrate on the effluents that appear to contain the most fish waste or have the darkest colour.

4.3 CALCULATING YOUR WATER AND EFFLUENT COSTS

You should now know the average COD and suspended solids concentration of each effluent (Ot and St respectively in the Mogden Formula).

- Use Worksheet 2 in Appendix 1 to calculate the charges for biological treatment and solids removal for each effluent. Values for other parameters used in the Mogden Formula can be obtained from your effluent bills. Use the worked example shown in Worksheet 2 to help you.
- Use Worksheet 3 and the information gathered in Worksheets 1 and 2 to calculate the total water and effluent costs for each process over the same period of time, eg day, month or year. A worked example of Worksheet 3 is provided.

5 The oxygen equivalent of the oxidisable organic matter is measured using a strong chemical oxidising agent in an acidic medium. Units for COD are usually mg/litre.

6 Suspended solids concentration (in mg/litre) is determined by filtering a known volume of effluent through a previously weighed 0.45 µm filter paper, drying the filter paper at 105°C for one hour and reweighing. Alternatively, a known volume of effluent is centrifuged, drying the tube at 105°C and weighing the dried pellet.

7 A measure of the dissolved oxygen used by micro-organisms in the receiving waters in the biochemical oxidation of organic matter. BOD (in mg/litre) is usually measured over a five-day test period.

5 TARGETING SAVINGS OPPORTUNITIES

Use Worksheet 3 (see Appendix 1) to identify which processes at your site make the greatest contribution to the site's water and effluent costs and thus where priority action should be taken. This will allow you to focus resources on the areas with the greatest potential for cost savings.

An alternative to looking directly at the figures in Worksheet 3 is to highlight the priority areas by presenting the information in a graph. Fig 2 shows a graph plotted using the cost figures from the worked example in Worksheet 3. The graph shows very clearly that, in this example, the highest costs are due to enrobing. Table 5 summarises the cost data used to plot the graph.

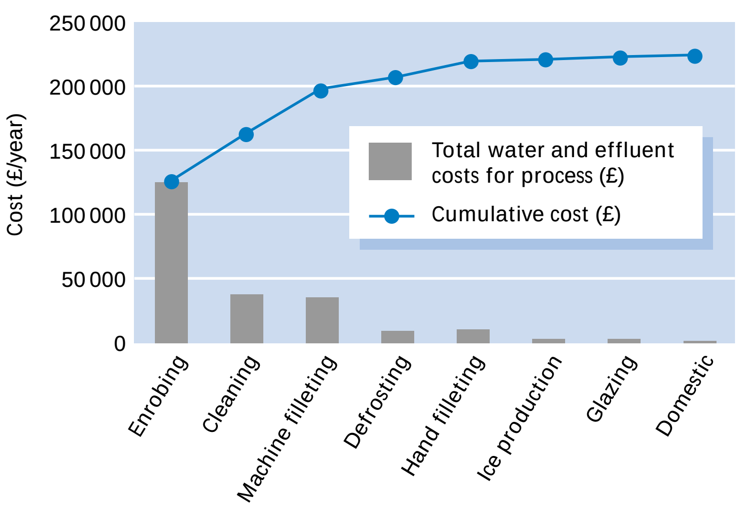


Fig 2 Graphical representation of the combined water and effluent costs for the worked example in Worksheet 3 (see Appendix 1)

Process operation/area	Ranking	Total water and effluent costs (£)	Cumulative cost (£)
Enrobing	1	125 728	125 728
Cleaning	2	37 320	163 048
Machine filleting	3	35 017	198 065
Defrosting	4	8 500	206 565
Hand filleting	5	8 957	215 522
Ice production	6	1 536	217 058
Glazing	7	1 229	218 287
Domestic	8	360	218 647

Table 5 Summary of the total cost data from the worked example in Worksheet 3

You should now have the information you need to plan an improvement programme with realistic targets for reductions in:

- water consumption;
- effluent organic load;
- effluent solids content;
- site water and effluent costs.

> **Tip**
>
> Once you have established your priorities for action, choose solutions with the shortest payback. Section 6 describes a range of no-cost and low-cost measures applicable to many sites.
>
> Involve staff in identifying opportunities to reduce water use and effluent production.

6 NO-COST AND LOW-COST TECHNIQUES TO REDUCE WATER USE AND EFFLUENT

Although processing steps and issues vary between sites, there are many simple measures to reduce water use and effluent that are applicable to most sectors of the fish processing industry. This Section explains the reasons for high water consumption and effluent production in the processing stages common to most sectors of the industry and describes no-cost and low-cost measures to reduce waste.

The areas covered are:

- primary processing, ie cutting operations such as heading, gutting, filleting, skinning, trimming, shucking, peeling and picking;
- secondary processing, ie value added operations such as freezing, brining, smoking, marinating, canning, deboning and enrobing;
- defrosting;
- cleaning of equipment, work surfaces and floors to maintain the hygienic environment required in fish processing;
- equipment maintenance to prevent leaks;
- the design and use of catch baskets;
- the design of drainage systems in processing areas.

Measures to reduce water use and effluent generation that may involve a higher capital cost are described in Section 7. General water saving measures applicable to industrial and commercial sites are described in Good Practice Guide (GG67) *Cost-effective Water Saving Devices and Practices*. GG67 is available free of charge through the Environment and Energy Helpline on freephone 0800 585794.

Intermittent filling reduces costs by 78%

Research by the Sea Fish Industry Authority showed that filleters using continuously running water consumed about 11 m^3 of water/tonne of white fish fillets. However, consumption fell to 4 m^3 of water/tonne when tubs were filled only as required.

Changing from a continuous flow rate of 22 litres/minute per bench to intermittent filling would typically reduce water and effluent costs from £6.08/tonne of white fish fillets to £1.31/tonne. This represents a reduction of 78%.

6.1 COMMON PROBLEMS AND THEIR SOLUTIONS

Most cost-saving opportunities in the fish processing industry arise by addressing the problems of:

- Excessive water use and consequent generation of large volumes of effluent.
- Fish waste in contact with water leading to a high COD and suspended solids content in the effluent and thus a high treatment charge. Fish guts, in particular, increase effluent COD.

Some common problems and their solutions are listed in Table 6 overleaf.

Common problems	Solution
Excessive use of water:	
Water running when not required	Switch off the water until needed
Excessively high flow rates	Control the flow rate
Leaks	Simple maintenance
High effluent strength due to fish waste in contact with water:	
Waste left in water for a long time	Separate fish waste from water as soon as possible
Waste reaches the floor and is disposed of to the drainage system	Contain waste to keep it off the floor, eg using catch baskets (see photo below)
	Do not hose waste into the drain

Table 6 Common water and effluent problems and their solutions

Catch basket to collect waste falling off the bench

section 6

6.2 REDUCING WASTE IN PRIMARY PROCESSING

There are many opportunities to reduce both water consumption and effluent strength in primary processing through changes to operating practices and improved controls.

6.2.1 Water running when not required

Water supplies are often left running unnecessarily, eg during breaks, thus incurring excessive water and effluent costs. The potential for waste is greatest in areas with high water consumption such as processing machines.

Fitting a solenoid valve reduces water use by around 40%

At fish processor F Smales & Son (Fish Merchants) Ltd, water used to run continuously onto the conveyor belt during the pre-wash stage of the filleting process. Excessive water consumption was confirmed when meters were installed to monitor water use. Smales has fitted solenoid valves to the water supply to switch it off when the conveyor belt is not being used. This measure has reduced water use during pre-washing by approximately 40%.

Tip

Make operators aware of:

- how much water is wasted and effluent generated;
- the costs involved.

Make manual valves for turning off water supplies easily accessible to operators.

Use automatic shut-off valves. Solenoid valves for smaller pipe sizes cost £100 - £200.

Install equipment in which water runs only when necessary.

Review your processes to:

- Check that all water use is necessary.
- Identify possible changes to operating practices that would produce significant cost savings. For example, what kind of filleting process do you use? Could this be changed at low cost to reduce water and effluent costs?

New skinning machine incorporates water control

White fish processor Arthur Bacon installed a new skinning machine 18 months ago. Water flow is pedal-operated so that the supply can be controlled easily according to need.

Pedal-operated skinning machine at Arthur Bacon

section 6

6.2.2 Water set at excessively high flow rates

The rate at which water flows to mechanical processing equipment is generally set manually and is often higher than necessary. Manufacturers' instructions - as used by many fish processing companies - often specify rates that exceed actual requirements.

Tip

Determine the optimum rate, ie the one that uses the minimum quantity of water while maintaining a high quality product.

Maintain a constant flow rate by installing flow regulators. Flow regulators reduce water use in processes using continuously running water and, depending on the size of the pipe, cost about £10 each. Prevent tampering, eg by fitting them at a high level.

For variable flow rates, use a manual flow control valve set to the optimum rate. Lock the valve so that it is only accessible by the operator and other designated personnel.

For more information about flow rate controls, see Good Practice Guide (GG67) *Cost-effective Water Saving Devices and Practices,* available free of charge through the Environment and Energy Helpline on freephone 0800 585794.

Typical flow regulators

Flow regulators produce significant cost savings

White fish processor, G W Latus, has installed flow regulators on the water pipes supplying its filleting benches. Previously, flow rates varied between the benches from 2 litres/minute to 15 litres/minute, with an average use of 13 litres/minute. Flow regulators have reduced flow rates to a consistent 8 litres/minute at each work station. Cost savings of £3 200/year have been achieved and are expected to increase in the future to £5 400/year (including effluent charges). Working conditions and productivity have not been affected by the change.

6.2.3 Ineffective sprays

Most sectors in fish processing use sprays. Sprays are often not aimed directly at the process area and manually controlled flow rates are higher than necessary.

Tip

To optimise water use during spraying:

- Use high pressure, low volume spray heads.
- Ensure that the spray head is directed onto the appropriate section of the process.
- Provide an accessible control for switching off the system. In mechanised processes, install automatic controls.
- Carry out trials to determine the optimum settings and design of the spray. For example, replacing 'crushed pipe' nozzles with a newer design in machines processing pelagic fish has been shown to reduce water use by 50%.

New nozzle design reduces water use by 50%

New nozzle designs are used on mechanised systems in several Scandinavian countries. A herring company changed the nozzles on the feeder box in its sorting process to a smaller system using 65 litres/minute. This change reduced water use by 50%. A valve was also attached to the water supply so that this could be varied if larger quantities were required occasionally to remove scale. Such nozzles are being evaluated in Ireland.

6.2.4 Poor connection of flexible hosing

Large quantities of flexible hosing are used in primary processing. This is easily ruptured and is often not connected effectively, leading to losses of vast amounts of water due to leakage.

Tip

Check regularly for leaks.

Include checks on flexible hosing connections and the state of the hosing in your preventive maintenance programme (see Section 6.8).

Significant cost savings from repairing leaks

A white fish company achieved savings of over 20% by repairing the leaks in the flexible hosing connecting the water supply to a manual filleting process area.

6.2.5 Organic waste in water

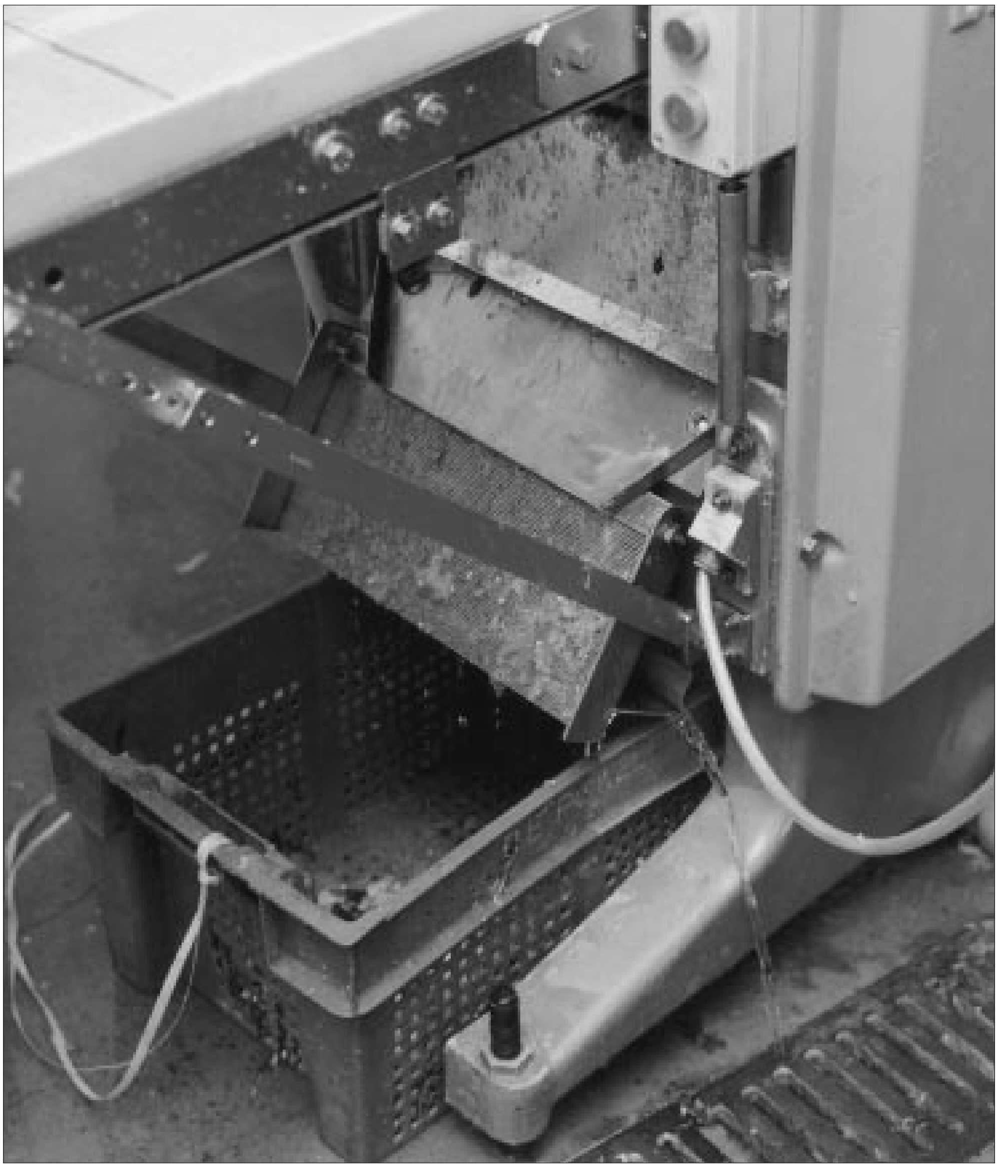
Organic waste from cutting operations is often left soaking in water for long periods of time. Problem areas include waste transport and catch baskets.

Tip

Avoid transporting organic waste using water flumes.

Introduce dry transportation of offal after filleting and gutting in pelagic fish processing. A fine mesh conveyor belt allows early separation of water from the waste and, although it does not reduce water consumption, it can lower the COD of the effluent by 40%.

Modify your systems to reduce water entering the catch basket. For example, the waste chute system on processing machines can be modified so that the water is separated from the skins before they reach the catch basket. Avoid leaving water running through catch baskets as this washes out additional organic material and thus increases the strength of the effluent. The photo below shows a catch basket with a deflection plate to force water away from the basket; also see Section 6.6.



Catch basket with deflection plate

6.2.6 Waste on the floor

Throughout the fish processing industry, waste commonly falls onto the floor and is then washed into the drain, producing a high strength effluent; also see Section 6.5.1.

> Tip
>
> To prevent waste reaching the floor:
>
> - check that equipment, eg conveyor belts, is aligned properly so that there are no gaps through which waste can fall;
> - ensure that catch baskets and containers are adequate and in place.

6.3 REDUCING WASTE IN SECONDARY PROCESSING

The materials involved in secondary processing can increase the strength of effluent from this area significantly. Cleaning and lost product are the main sources of high strength effluent. For example, enrobing batter has a high COD (around 71 000 mg/litre) and its presence in effluent has a significant impact on trade effluent charges. The cost will vary between water companies, but as shown in the worked example in Worksheet 2 (see Appendix 1), it could be in the region of £35/m^3.

Water is often used as a raw material in secondary processing, eg as ice or in batter. Check that the water company has made an allowance for water used in product when calculating the volume of effluent that you discharge. You should know how much water is used in product from your water and effluent balance (see Section 4.1).

> **Allowing for ice in product reduces trade effluent charges**
>
> A white fish company could currently reduce its trade effluent charges by £200/year if an allowance was made by the water company for ice in product. When charges based on the quantity and strength of the effluent are introduced, this saving could increase to over £12 000/year.

A number of simple improvements are described below which reduce the quantity and strength of effluent from secondary processing.

6.3.1 Avoid excessive water use

Excessive use of water for secondary processing leads to the production of high volume, low strength effluent. Taking action to reduce effluent volumes will reduce trade effluent charges (see Appendix 2).

> Tip
>
> Check for excessive use of water, particularly in manual systems.

6.3.2 Plan production

Excess quantities of batter, crumbs, etc at the end of production are generally disposed of via the drain. Production planning prevents manufacture of excess amounts, saving raw materials and reducing disposal costs.

> Tip
>
> Use a simple checklist to monitor processing requirements and establish optimum quantities of batter, crumbs, etc.
>
> Train staff about the production plan and set up lines of communication between those managing production and shop-floor staff.

6.3.3 Improve pipe cleaning

Cleaning pipework with water produces high strength effluent and results in lost product.

Tip

Before using water, first clear the line with low pressure air (if available) or a pigging system. This will reduce the quantity and strength of the effluent.

Where possible, re-use recovered product, eg batter.

For more information, see Good Practice Guide (GG154) *Reducing the Cost of Cleaning in the Food and Drink Industry*. GG154 is available free of charge through the Environment and Energy Helpline on freephone 0800 585794.

6.3.4 Introduce containment

Lack of containment leads to waste falling onto the floor and then being washed down the drain, thus increasing the strength of the effluent.

Tip

Ensure spillage trays/troughs are provided and located in appropriate areas to contain spills.

If large amounts of waste are collected, consider returning it to the blending vessel. Check your food hygiene regulations first.

If waste does reach the floor, sweep it up and put it in containers for scrap rather than washing it down the drain.

6.4 REDUCING WASTE DURING DEFROSTING

Several methods of defrosting are used in the fish processing industry. In most cases, defrosters use large quantities of water.

6.4.1 Fish waste in water

Defrosting with water produces high strength effluents due to contamination by blood, slime and debris.

Tip

Consider changing to a system that does not use water. For example, defroster designs are available that thaw in air (see Section 7.1).

When defrosting, ensure that fish are on bars above boxes so that when they defrost they fall into the boxes and not onto the floor. This will not only reduce effluent strength, but will also improve hygiene standards.

New defrosting system reduces water use by 80%

White fish and dogfish processor, Richard Coulbeck Ltd of Grimsby, changed its defrosting system to reduce water use. Previously, the Company had water running continuously through tubs. The new sprinkler system has reduced water supply costs from £100/day to £20/day.

6.4.2 Inefficient thawing

Inefficient thawing increases the quantity of water required to perform a given duty. Causes include low temperatures and poor circulation of water in water bath defrosters.

Tip

Improve water circulation around the frozen fish by:

- adding a pump/mixer;
- attaching a diffuser nozzle;
- splitting the water supply to create smaller jets of higher pressure water.

Do not load fish too high in tubs. This can cause water to overflow rather than circulate around the fish.

Consider using warm water to defrost the fish, particularly in winter. The temperature of the water should not exceed 15°C.

Consider a system that uses warm water baths sparged with air to improve circulation. Although water consumption is significantly less, this option may only be feasible for larger companies due to the associated air and pumping costs.

6.4.3 Excessive use of sprays

With spray systems, the spray can be left running - particularly overnight - after the fish have defrosted. Apart from the excessive use of water, the fish temperature may become too high. Another problem is that more sprays than necessary are used when only a few fish are being defrosted.

Tip

Use a control system to switch off the water supply once the fish are defrosted. For example, the water supply could be shut off by a valve controlled according to the temperature measured by probes inserted into selected fish.

Put valves on individual spray lines so that only those required are turned on.

6.5 REDUCING WASTE DURING CLEANING

Thorough cleaning is essential to maintain the hygienic environment required in the fish processing industry. Both the method and frequency of cleaning vary from site to site. Water use is considerable and high strength effluents are often produced.

According to research from Scandinavia, cleaning accounts for 30% of water use for flatfish/white fish processing and 20% of water use for herring filleting. About 70% of cleaning water is used during initial hosing of equipment and floors. Significant savings can be achieved at this stage.

Good Practice Guide (GG154) *Reducing the Cost of Cleaning in the Food and Drink Industry* describes how to work out the true costs of cleaning and offers advice on how to control these costs. GG154 is available free of charge through the Environment and Energy Helpline on freephone 0800 585794.

6.5.1 Clearing waste with water

Using hoses and pressure washers to wash waste off the floor and work surfaces wastes a large amount of water. Water and debris are often washed down the drain, producing high strength effluent.

It is estimated that initial dry collection of offal can reduce water consumption for hosing by about 40%.

Tip

Sweep and collect waste wherever possible. Place all waste from the floor in fishmeal containers. This will achieve extra revenue rather than incur costs. Use a rubber blade-type cleaner to clean the floor (avoid sponges as they harbour germs).

Avoid pressure hosing waste into the drain. This increases the suspended solids in the final effluent, particularly if there is no further method of collection before discharge to sewer.

Do not remove catch baskets or drain covers in order to release debris to drain.

Avoid using hoses on filleting benches and meat extraction tables to get rid of debris. Benches and tables should be brushed clean and then washed with water from buckets.

Drain covers help to reduce effluent strength

Marr Foods Ltd[8] has installed fine mesh covers on its drains to prevent waste being swept down the drain. Instead, the waste is collected and put in waste bins. Marr Foods Ltd deals with white fish, pelagic fish, trout, salmon, prawns and tuna.

Try not to let waste get on the floor, but if it does, sweep it up

[8] The Company is featured in Good Practice Case Study (GC202) *Cutting Water and Effluent Costs in Fish Processing*, available free of charge through the Environment and Energy Helpline on freephone 0800 585794.

6.5.2 Excessive quantities of water and cleaning chemicals

Take action to avoid excessive use of water and cleaning chemicals, ie detergents for general cleaning and degreasing and disinfectants to kill bacteria.

Tip

Do not use large quantities of cleaning chemicals as this necessitates large volumes of rinse water.

Control quantities of cleaning chemicals using a dosing system.

Consider the benefits of using alternative cleaning chemicals.

Fit hoses with trigger action spray nozzles.

Monitor water use by attaching a small flow meter to the pipeline supplying the hoses. Ask cleaning staff to take readings.

6.5.3 Cleaning schedules

Badly organised or non-existent cleaning schedules may result in areas not being cleaned at all or excessively.

If organic waste is not cleared frequently, it will break down thus increasing the risk of it passing through catch baskets and drain covers.

Tip

Clear the floors frequently to prevent breakdown of waste.

Designate responsibility for cleaning specific work station areas throughout the day. Explain what must be cleaned, how and when.

Keep cleaning equipment close to work stations and easily accessible.

6.6 EFFECTIVE CATCH BASKET DESIGN AND MANAGEMENT

Catch baskets are essential for preventing waste reaching the floor and subsequently being washed down the drain. However, they are not always used to good effect. This may be due to poor design, removal to allow easy disposal of waste via the drain, or infrequent emptying. If waste is allowed to accumulate in the catch basket, it will degrade producing a higher strength effluent and a potential hygiene problem.

Tip

Ensure that catch baskets are well-designed. They should:

- fit securely in the holder;
- have an aperture size smaller than that of the drain cover (this will ensure containment of fine solids);
- have sufficient holes for good drainage;
- be small enough for easy handling.

Empty catch baskets frequently (at least twice per day) to prevent blockage and minimise effluent strength.

Designate responsibility for emptying catch baskets.

Don't forget to ensure that catch baskets are emptied

A shellfish company had effective catch baskets with small apertures in all processing areas, but unfortunately had not allocated specific personnel to empty them.

6.7 KEEPING WASTE OUT OF DRAINS

There are generally drainage channels or a number of smaller drainage points in processing areas. Although every effort must be made to prevent waste falling onto the floor, any waste that does reach the floor should be kept out of the drains. Keeping waste out of the drains will reduce effluent strength and thus trade effluent charges.

Tip

Use drain covers with a slot small enough to retain large solids.

Ensure that the drain covers cannot be lifted easily. Making it difficult to lift the cover will avoid drains being used as a quick disposal route. Drains can also be locked in position.

Set up a programme to check that the drains are clean and that drain covers are clear and clean.

6.8 THE IMPORTANCE OF MAINTENANCE

Water is often wasted and product lost to drain due to lack of equipment maintenance. Problem areas include:

- ruptured or badly connected flexible hosing;
- leaking rigid pipes;
- leaking flanges;
- leaks from worn pump and valve seals.

Typical water losses from an open tap and from leaking valves, joints on pipes, seals in pumps, and hoses are given in Good Practice Guide (GG67) *Cost-effective Water Saving Devices and Practices*. GG67 is available free of charge through the Environment and Energy Helpline on freephone 0800 585794. For example, at 1996 prices, two drops/second from a single open tap represents an annual water and effluent cost of £6 - £13. Similarly, a 5 mm diameter stream from an open tap represents an annual water and effluent cost of £325 - £705.

Tip

Implement a preventive maintenance programme to reduce losses due to leakage, etc. For example, use a simple checklist with the equipment listed along with the date for checking for wear and replacement of parts.

7.1 ADVANCED TECHNIQUES

More advanced techniques are available for achieving cost savings for those companies that:

- have already implemented no-cost and low-cost measures to reduce waste;
- want to upgrade their process.

Table 7 lists some suggestions for reducing water and effluent costs. For current information on technological advances in the fish processing industry, contact the SFIA.[9]

Technique	Notes
Dry filleting	Consists of a pre-wash followed by work stations with individual sprays. Marr Foods Ltd currently saves £1 890/year using this system and expects to save even more when higher trade effluent charges are introduced. Some large supermarkets require their suppliers to use dry filleting techniques.
Hand filleting modifications	These include: ■ modifying the filleting bench to incorporate a catch tray and thus prevent loss of solids to drain; ■ improving the water supply to filleting benches to eliminate use of a tub.
Vacuum removal of viscera	The equipment involves a vacuum installation with a sucking nozzle. Effluent strength is reduced significantly by sucking out the fatty viscera before they blend with the water. It is particularly effective in mechanised cutting operations in the pelagic fish sector.
Different types of skinning machine	Choose a machine that suits your production requirements. Some machines use less water than others. For example, one machine costs £1.92/hour in water and effluent charges for processing compared to another which costs £1.49/hour. The cheaper machine is generally used for smaller-scale operations.
Recycling equipment cooling water	One company changed the water system on the skinning machine compressors. Originally water ran continuously to drain, but now there is a closed loop circuit with a chiller to maintain a consistent temperature. There is no contact between cooling water and product. Savings of £2 500/year have been achieved in reduced water and effluent charges, at a cost of £8 300.
Mechanised defrosting	A temperate air defroster at F Smales & Son Ltd, with a capacity of 4 tonnes/batch, has operating costs of £1.93/tonne of white fish. This compares with costs of £7.82/tonne for a relatively inefficient water spray system.
Frying	Techniques exist for re-using oil rather than disposing of it to landfill. For more information, contact the Environment and Energy Helpline on freephone 0800 585794.
Mechanical glazing units	Several companies use mechanical glazing units with a recirculatory water bath. This ensures that water is topped up only when necessary.

Table 7 Advanced techniques for reducing water and effluent costs

For information and free advice on general waste minimisation techniques, contact the Environment and Energy Helpline on freephone 0800 585794.

[9] Sea Fish Industry Authority, c/o Seafish Technology, Seafish House, St. Andrew's Dock, Hull HU3 4QE. Tel: 01482 327837. Fax: 01482 223310.

7.2 EFFLUENT TREATMENT

Reducing water use and effluent production at source will produce significant cost savings at no-cost or low-cost. However, some effluent treatment may still be required to achieve discharge consents or to reduce trade effluent charges further. Implementing a programme to reduce waste means that you may be able to select a smaller, more cost-effective effluent treatment plant.

When considering effluent treatment, it is important to:

- Take all possible steps to minimise the amount and strength of your effluent.
- Characterise your effluent to ensure that the most appropriate treatment is used.
- Carry out feasibility trials before making a final decision.
- Compare the costs of on-site treatment and final discharge with the cost of discharging to sewer as trade effluent.
- Take a strategic view. For example, is the local water company planning to upgrade its treatment works? If so, what will the impact be on your company?

A step-by-step approach to choosing the most suitable pollution control measures as part of an overall waste management strategy is described in Good Practice Guide (GG109) *Choosing Cost-effective Pollution Control*. GG109, which is available free of charge through the Environment and Energy Helpline on freephone 0800 585794, contains worksheets and matrix tables to get you started and to help you identify areas where you may need further expert advice, eg from consultants and equipment suppliers. Trade associations such as the SFIA will also be able to advise you.

7.2.1 Removing solids, fats, oils and greases

Methods suitable for removing these materials from fish processing effluents include:

- **Screening.** This is a simple, mechanical method of removing suspended solids. Various types of screen are available, including rotary and run-down screens. Rotary screens are mechanical systems whereas run-down screens are static. Some screens with small apertures are prone to blockage problems.

  Trials of rotary wedge wire screens with fish processing effluents have been performed. It is estimated that a 10 - 20% reduction in the strength of white fish effluents and a 30 - 40% reduction in the strength of herring effluents are possible.
- **Dissolved air flotation (DAF).** This technique, which is used after screening, uses fine air bubbles to float out suspended solids and oils/greases from effluents. Sludge disposal constitutes the main additional cost associated with this treatment method.

  Trials have shown that DAF can reduce the strength of fish processing effluents by 80%.
- **Sedimentation.** This method of solids removal involves gravity settlement in a settlement tank or basin and is particularly suited to particles larger than 10 mm diameter. Up to 35% of the solids present in the effluent can be removed by this technique. At sites where space is at a premium, more expensive lamella separators can be used for sedimentation.

7.2.2 Reducing BOD and COD

- **Aerobic biological treatment.** Aerobic treatment, ie treatment in the presence of oxygen, is generally suitable for effluents with a BOD/COD of less than 3 000 mg/litre. It includes activated sludge systems, high rate biological filters and rotating biological contactors. Removal efficiency is high.

- **Anaerobic biological treatment.** Anaerobic treatment, ie treatment in the absence of oxygen, is more suited to effluents with a higher BOD/COD. Various designs of anaerobic treatment reactor are available. Removal efficiency is high. Because most of the BOD is converted to methane rather than biomass, anaerobic treatment processes have significantly lower sludge disposal costs than aerobic processes.

Tip

When considering effluent treatment, ask the Environment and Energy Helpline on freephone 0800 585794 for a free copy of Good Practice Guide (GG109) *Choosing Cost-effective Pollution Control.*

Most effluent treatment methods produce sludges. The cost of sludge disposal should therefore be considered when evaluating options. Various sludge dewatering techniques are available to reduce volumes and improve handling properties.

8 CONTINUOUS IMPROVEMENT

It is important that you continue to make improvements and not just achieve cost savings for a short period of time. To do this, you need to:

- monitor water use and effluent production;
- set realistic and achievable targets for reducing water use and effluent production.

Water use and effluent generation often vary with the rate of production. Establish the effect of production on water use by monitoring levels of both. Account for and control any variations. Table 8 shows some example data from a white fish processor.

Month	Water use (m^3/month) A	Production (tonnes/month) B	Water used per unit production (m^3/tonne) C = A ÷ B
January	3 512	156	22.5
February	3 245	132	24.6
March	3 196	125	25.6
April	3 533	160	22.1
May	3 628	174	20.9
June	3 471	163	21.3
July	3 087	145	21.3
August	2 791	115	24.3
September	3 369	162	20.8
October	3 491	178	19.6
November	3 336	169	19.7
December	3 104	159	19.5

Table 8 Example monitoring data from a white fish processor

Having calculated the amount of water used per unit produced, plot a graph of water use for each month. Fig 3 shows the data from Table 8. In this example, an investigation should be undertaken to establish why there was much less water per tonne of production used in December than in March or August. Being aware of how you are doing will enable you to exercise better control.

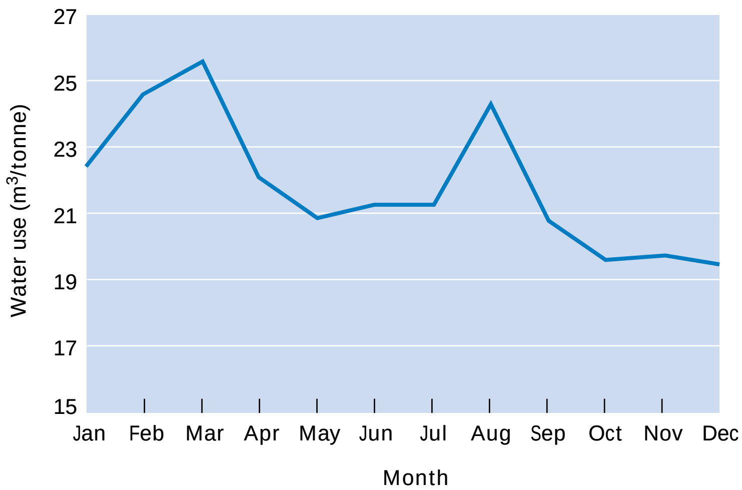


Fig 3 Variations in water use per unit of production at a white fish processor

Display your graph to keep staff informed and motivated.

Use the information from your monitoring programme to:

- **Take action.** You need to find out why variations occur and implement measures to improve performance. Plotting a graph as in Fig 3 will also help you to identify any leaks and to take immediate remedial action.
- **Set targets.** Aim to maintain the lowest water use/tonne of product achieved during the monitoring period - if you've achieved it once, you should be able to again. Once you can achieve this figure consistently, try to think of ways of doing even better.

If possible, try to monitor effluent strength as well. Where a peak occurs, find out which process was being carried out at that time and may have caused the peak. Set targets to reduce effluent strength.

Remember:

If you don't measure it, you can't manage it.

How to reduce your water and effluent costs:

- Obtain management commitment for a waste minimisation programme.
- Appoint a project Champion.
- Involve all staff in the waste minimisation programme. Make them aware of the impact of water and effluent costs on the business and the benefits of reducing these costs.
- Carry out a water and effluent balance for your site.
- Survey effluent strength.
- Use the Worksheets in Appendix 1 to identify the processes that incur the highest water and effluent costs.
- Decide your priorities and focus your efforts on these areas.
- Identify opportunities to reduce waste. Involve staff in brainstorming sessions and ask for suggestions. Check with your local Environmental Health Department that food hygiene standards will not be breached.
- Implement no-cost and low-cost measures to reduce water use and effluent production. (Measures that reduce the strength of your trade effluent generally produce the greatest savings.)
- Consider the need for other solutions, eg advanced techniques and end-of-pipe treatment.
- Monitor water use and production rates. Investigate the reasons for variations in water use/tonne of production and take remedial action.
- Set targets to reduce water use and effluent production.
- Continue your monitoring programme and feed back results to staff.
- Revise your targets to reflect changes and maintain progress.

If necessary, obtain help.
The Environment and Energy Helpline (0800 585794) can:

- Send you copies of relevant Environmental Technology Best Practice Programme publications, including the ones referred to in this Guide.
- Suggest other sources of information.
- Provide free, up-to-date information on a wide range of environmental issues, legislation, technology and equipment suppliers.
- Arrange for a specialist to visit your company if you employ fewer than 250 people, at the discretion of the Helpline Manager.

Appendix 1

BLANK AND EXAMPLE WORKSHEETS

This Appendix contains worked examples and blank versions of three worksheets as follows:

- Worksheet 1 Site water and effluent balance;
- Worksheet 2 Effluent costs for each process operation or area;
- Worksheet 3 Total site water and effluent costs.

Please photocopy the blank worksheets to use as required at your site.

If you need further advice on using these worksheets, contact the Environment and Energy Helpline on freephone 0800 585794.

Water volume conversion

1 m^3 = 1 000 litres = 220 gallons

1 UK gallon = 0.0045 m^3

WORKSHEET 1		
SITE WATER AND EFFLUENT BALANCE		
Process operation/area	**Water supplied (m^3/day, week, month, year)**	**Effluent generated (m^3/day, week, month, year)**
A Sum of all processes		
B Site total (metered/billed)		
NB A good balance has been achieved if values for A and B agree to within 10%		

Space for notes and calculations

NB 1 000 litres = 1 m^3

WORKSHEET 1		
SITE WATER AND EFFLUENT BALANCE		
Process operation/area	**Water supplied (m^3/~~day, week, month,~~ year)**	**Effluent generated (m^3/~~day, week, month,~~ year)**
Hand filleting	5 720	5 720
Machine filleting	9 200	9 200
Defrosting	7 100	7 100
Glazing	1 300	650
Enrobing	3 800	3 500
Ice production	2 200	0
Cleaning	3 650	3 650
Domestic	312.5	312.5
A Sum of all processes	33 282.5	30 132.5
B Site total (metered/billed)	36 000*	32 400*
NB A good balance has been achieved if values for A and B agree to within 10%		

Space for notes and calculations

```
Filleting benches operate for 40 hours/week
50 weeks/year.
Average measured overflow =  0.57 m3/hour
from filleting bench
Number of benches         =  5
Total overflow 5 x 0.57 =  2.85 m3/hour
∴ Water use
=  2.85 m3/hour x 40 hours/week x 50 weeks/y
=  5 700 m3/year
All water supplied is discharged as effluent


A 2.5 cm (1 inch) hose is used for cleaning
total of 4 hours/day.
Enrobing is carried out for 250 days/year.
Measured flow from hose =  3 500 litres/hour
∴ Effluent from enrobing
=  3 500 litres/hour x 4 hours/day x 250 days
=  3 500 000 litres/year  =  3 500 m3/year
Average water use for batter = 1 200 litres/day
                            =  300 000 litres/yea
                            =  300 m3/year
Total water use for enrobing = 3 800 m3/year
```

* From previous 12 months water and effluent bills

Typical domestic water use for industrial site (see Table 3)
Site has 50 employees and operates for 250 days/year
Site (no canteen or showers) = 25 litres/person/day
∴ Water supplied = 25 x 50 x 250 litres/year
= 312 500 litres/year
= 312.5 m^3/year

NB 1 000 litres = 1 m^3

WORKSHEET 2

EFFLUENT COSTS FOR EACH PROCESS OPERATION OR AREA

Process operation/area	Reception charge R pence/m^3	Primary treatment charge V pence/m^3	Average COD Ot mg/litre	Average suspended solids St mg/litre	Biological treatment charge (B_2 x Ot/Os) pence/m^3	Solids treatment charge (S x St/Ss) pence/m^3	Total charge C pence/m^3

Effluent charges are calculated from the Mogden Formula (see Appendix 2), ie $C = R + V + B_1 + (B_2 \times Ot/Os) + (S \times St/Ss)$.
Values for R, V, B_1, B_2, Os, S and Ss are set by the water company. Look on your bills or ask for details. Record the values below.

Year

		Value	Unit
R	Reception and conveyance		pence/m^3
B_1	Extra volume charge if there is biological treatment		pence/m^3
V	Volumetric treatment (primary)		pence/m^3
B_2	Biological treatment charge		pence/m^3
Os	Mean COD of sewage in the region		mg/litre
S	Treatment and disposal costs of solids removal		pence/m^3
Ss	Mean suspended solids of sewage in the region		mg/litre

WORKSHEET 2							
EFFLUENT COSTS FOR EACH PROCESS OPERATION OR AREA							
Process operation/area	**Reception charge R pence/m^3**	**Primary treatment charge V pence/m^3**	**Average COD Ot mg/litre**	**Average suspended solids St mg/litre**	**Biological treatment charge (B_2 x Ot/Os) pence/m^3**	**Solids treatment charge (S x St/Ss) pence/m^3**	**Total charge C pence/m^3**
Hand filleting	17.46	20.06	1733	311	37.73	11.53	86.78
Machine filleting	17.46	20.06	5346	4231	116.39	156.90	310.81
Defrosting	17.46	20.06	515	32	11.21	1.19	49.92
Glazing	17.46	20.06	500	30	10.89	1.11	49.52
Enrobing	17.46	20.06	71900	51600	1565.43	1913.50	3516.45
Ice production	17.46	20.06	0	0	0	0	37.52
Cleaning	17.46	20.06	25000	10000	544.31	370.83	952.66
Domestic	17.46	20.06	200	100	4.35	3.71	45.58

Effluent charges are calculated from the Mogden Formula (see Appendix 2), ie $C = R + V + B_1 + (B_2 \times Ot/Os) + (S \times St/Ss)$.
Values for R, V, B_1, B_2, Os, S and Ss are set by the water company. Look on your bills or ask for details. Record the values below.

Data from effluent sampling and analysis

Year Yorkshire Water 1997/98

		Value	**Unit**
R	Reception and conveyance	17.46	pence/m^3
B_1	Extra volume charge if there is biological treatment	0	pence/m^3
V	Volumetric treatment (primary)	20.06	pence/m^3
B_2	Biological treatment charge	20.27	pence/m^3
Os	Mean COD of sewage in the region	931	mg/litre
S	Treatment and disposal costs of solids removal	12.46	pence/m^3
Ss	Mean suspended solids of sewage in the region	336	mg/litre

WORKSHEET 3							
TOTAL SITE WATER AND EFFLUENT COSTS							
	WATER			**EFFLUENT**			
Process operation/area	*Worksheet 1* **Amount supplied m^3/day, week, month, year**	*Bills* **Unit cost pence/m^3**	**Total cost £/day, week, month, year**	*Worksheet 1* **Volume m^3/day, week, month, year**	*Worksheet 2* **Unit cost pence/m^3**	**Total cost £/day, week, month, year**	**Total water and effluent cost £/day, week, month, year**
A Sum of all processes							
B Site total							

WORKSHEET 3

TOTAL SITE WATER AND EFFLUENT COSTS

	WATER			EFFLUENT			
Process operation/area	*Worksheet 1* **Amount supplied** **m^3/~~day, week, month,~~ year**	*Bills* **Unit cost** **pence/m^3**	**Total cost** **£/~~day, week, month,~~ year**	*Worksheet 1* **Volume** **m^3/~~day, week, month,~~ year**	*Worksheet 2* **Unit cost** **pence/m^3**	**Total cost** **£/~~day, week, month,~~ year**	**Total water and effluent cost** **£/~~day, week,~~ month, year**
Hand filleting	5 720	69.8	3 993	5 720	86.78	4 964	8 957
Machine filleting	9 200	69.8	6 422	9 200	310.81	28 595	35 017
Defrosting	7 100	69.8	4 956	7 100	49.92	3 544	8 500
Glazing	1 300	69.8	907	650	49.52	322	1 229
Enrobing	3 800	69.8	2 652	3 500	3 516.45	123 076	125 728
Ice production	2 200	69.8	1 536	0	37.52	0.00	1 536
Cleaning	3 650	69.8	2 548	3 650	952.66	34 772	37 320
Domestic	312.5	69.8	218	312.5	45.58	142	360
A Sum of all processes	33 282.50		23 232	30 132.50		195 415	218 647
B Site total	36 000		25 128	32 400		209 883	235 011

From Worksheet 1

From water and effluent bills

From Worksheet 1

From Worksheet 2

appx A1

Appendix 2

CALCULATING RISING COSTS USING THE MOGDEN FORMULA

Water company charges for trade effluent discharged to sewer are based on the Mogden Formula. This formula attempts to link charges for a particular customer to the cost of treating the effluent, ie customers pay according to the volume and strength of their effluent. The extent to which the Mogden Formula is applied by a particular water company depends on the degree of treatment provided.

The Mogden Formula is expressed as follows:

$$C = \underbrace{R + V}_{\text{Primary treatment}} + B_1 + \underbrace{\left(B_2 \times \frac{Ot}{Os}\right)}_{\text{COD}} + \underbrace{\left(S \times \frac{St}{Ss}\right)}_{\text{Suspended solids}}$$

Table A1 shows example values[10] for the charges for a sewage treatment works with secondary treatment and typical values for the effluent strength from a white fish processor (see Table 2 in Section 2.3).

C	Total charge	Unit	Example values
R	Reception and conveyance	pence/m^3	11.7
B_1	Extra volume charge if there is biological treatment	pence/m^3	1.3
P or V*	Primary or volumetric treatment	pence/m^3	9.3
B_2	Biological treatment charge	pence/m^3	9.5
Ot	COD of site's trade effluent	mg/litre	2 000
Os	Mean COD of sewage in the region	mg/litre	363
S	Treatment and disposal costs of solids removal	pence/m^3	7
St	Suspended solids of site's trade effluent	mg/litre	300
Ss	Mean suspended solids of sewage in the region	mg/litre	233

* Used interchangeably depending on the water company/authority.

Table A1 Calculating trade effluent charges using the Mogden Formula: example values

The cost of treating this trade effluent at this sewage treatment works can be calculated using the Mogden Formula as follows:

$$\text{Cost} = (11.7 + 9.3) + 1.3 + \left(9.5 \times \frac{2\,000}{363}\right) + \left(7 \times \frac{300}{233}\right)$$

$$= 21.0 + 1.3 + 52.3 + 9.0$$

$$= 83.6 \text{ pence/m}^3$$

This cost can be broken down into:

reception and conveyance only = 11.7 pence/m^3

primary treatment = 21.0 pence/m^3 (reception charge included)

full biological treatment = 83.6 pence/m^3

10 North West Water 1998/99.

Upgrading of this sewage treatment works from reception and conveyance only to full biological treatment (ie as required by the Urban Waste Water Treatment Directive) would increase trade effluent charges for this white fish processor from 11.7 pence/m^3 to 83.6 pence/m^3. This represents an increase of 615%.

For further information about trade effluent charges in your area, contact your local water company (water authority in Scotland).

CALCULATING THE INCREASE IN ANNUAL COSTS

To calculate the annual trade effluent charges for full biological treatment, the site in this example is assumed to use 30 000 m^3 of water/year. The white fish processor employs 50 people, who work for 240 days/year. The water company has an allowance for domestic use of 25 litres/person/day. The volume of trade effluent is calculated by subtracting this allowance from the volume of water supplied to the site.

Water supplied to site = 30 000 m^3/year

Total domestic allowance = 300 000 litres/year = 300 m^3/year

Volume of trade effluent = 30 000 - 300 = 29 700 m^3/year

Trade effluent unit charge for full biological treatment = 83.6 pence/m^3

Total trade effluent charge = 83.6 x 29 700 ÷ 100 = £24 829/year

Trade effluent charges for reception and conveyance only = £3 475/year

Increase in trade effluent charges for full biological treatment = **£21 354/year**

This is an example only. Contact your local water company for details about future increases in trade effluent charges in your area.

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FOR FURTHER INFORMATION, PLEASE CONTACT THE ENVIRONMENT AND ENERGY HELPLINE

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