SWITCH4FOOD

"Services for Water and InTegrated teCHniques for FOODindustry"

Water management assessment methodology

European Commission
Enterprise and Industry

ainia
centro tecnológico

financed by:

Water Management Assessment Methodology is an outcome of SWITCH4FOOD Project (www.s4food.eu) financed by the Executive Agency for Competitiviness & Innovation (EACI) under the "Competitiveness and Innovation Programme" (CIP). Agreement Nº: EEN/SPA/09/ENV/250426-SWITCH4FOOD

Water Management Assessment Methodology (2011) has been produced by ainia centro tecnológico (www.ainia.es)

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Introduction

Water is a valuable and limited resource with a key role in food industry as it is a basic raw material in the elaboration of a vast amount of products of very diverse nature. Also it is a tool for a great number of production and auxiliary operations.

Water consumption and waste water discharge involves a number of questions regarding technology, social, economic and environmental issues that affect long term sustainability of food industry activities. According to the European Reference Document of Best Available Techniques in the Food, Drink and Milk water is the most important environmental aspect of food industry and is deeply connected to companies' competitiveness in aspects as:

- Excess of water consumption in process operations and over generation of waste water due to lack of monitoring
- Loss of valuable materials at in-process streams
- High costs of investment and maintenance of waste water treatment facilities.
- Cost related to waste water discharge taxes.

Nevertheless many companies often are not aware of the amount of water consumed and the costs associated to water management (including wastewater treatment and discharge) and low attention has been paid to identifying opportunities of optimisation (practices and technologies) in order to reduce both water supply and effluent discharge costs. Performing a water management assessment will result in:

- Gaining a greater understanding of the water and wastewater management processes on site.
- Understanding water and wastewater costs.
- Identifying opportunities to reduce water use, waste water and their costs.
- Establishing a continuous improvement of water management processes.

This methodology for the assessment of water management in food processing industries is a tool to gather all the dispersed information that already exists in the company actually needed to perform the assessment, set the baseline and search for applicable solutions. The depth and complexity of the assessment depends on the particular situation and characteristics of each company. Nevertheless, depending on the available resources external help may be needed in this process specially at identifying options for improvement from the information gathered. In any case, the company itself should be the main actor of any kind of assessment performed within its facilities, practices and processes and lead the assessment process, as nobody as them, will know all the particularities of their production and auxiliary processes and operations, the characteristics of the facilities, current practices and associated costs to it all.

Water flow within the company has a money flow associated. The methodology tries to outline the economic implication associated with water management. Awareness of the real state of the issue (real costs and environmental regulations compliance) and commitment to take measures to improve are the necessary basements upon which such an enterprise must rely.

The first improvement in the water management scheme in the company will be to identify if some of the basic information to perform a sound water management assessment can't be obtained. In such a case measures to improve the availability of the information, monitoring and/or register of some data, inputs and outputs, practices and operations will become the first improvements to carry out in the path for optimisation of the water management system.

Table templates are shown along with the text and real case studies are provided at the end of the document to assist to perform a water management assessment. The case studies show just part of more complex assessments but may be quite helpful to understand the assessment methodology, especially regarding the water balance and evaluation of the information generated by a water balance.

Water consumption and wastewater production in food processing industry

Food processing industry is a major water consumer as an ingredient, cleaning agent, transport medium, cooling, heating for heat treatments, etc. That great consumption involves a large quantity of wastewater generation. In this way, most inlet water is poured as wastewater after use, excepting when it is added as a product or mostly evaporated. Indeed, wastewater generation is the main environmental issue of food sector.

Food processing industry effluents are classified in the following groups according to their source:

- **Process water:** waters that take part in production processes**.** They are usually in contact with raw materials, final product or by-products. In the food processing factories water is commonly used not only in raw materials conditioning operations (washing, blanching, etc) but also in heating treatments for preserving as vapour or hot water, unfinished products transport, etc.



a) Cleaning and post harvest treatment of oranges; b) Artichoke soaking; c) Sardine brining

- **Equipment or facilities cleaning water:** these unit operations are essential in food processing industry, as they are necessary for preserving manufactured food healthiness. Cleaning is a main source of water consumption an wastewater generation in food factories.



a) Cleaning of wine tanks; b) Cleaning of yogurt vessel; c) Wash down of table olive lines

- **Utility water** (cooling waters, drains from boilers, heat exchanger regeneration, etc.). These waters are usually less loaded than the previous ones and they should be optimized trough a proper maintenance of facilities and wastewater reuse whenever possible.

- **Sanitary waters** (used in staff toilets, showers, washbasins, etc). They are similar to household waters.

Process waters and cleaning waters are the most important streams. They are typically characterized by their organic matter load and suspended solids with different pollutants coming from raw materials (dissolved salts, oils and fats, phenols, nitrates, phosphates, potassium, etc. depending on the industry type, from chemical products involved in manufacturing processes (acids, alkalis, brines, etc…) or cleaning products.

Utility waters are characterized by high temperature (cooling waters and boiler drains), high dissolved salts rates and/or acids or alkalis (bleaching regeneration) and eventually chemical additives traces.

There are huge differences in consumption, quantity, and load among the different food sub-sectors but in general, common characteristics can be observed in the high organic load rates expressed in COD or BOD terms. Food wastewaters contain an organic load between 10-100 times higher than the urban wastewaters with both COD and BOD high rates.

Untreated waste water from: a) Cow slaughterhouse (COD≈2.200 mgO2/L); b) Cured ham factory (COD ≈ 2.600 mgO2/L); c) Fried corn factory (COD≈6500 mgO2/L); d) concentrated orange juice factory (COD≈13000 mg O2/L); e) chicken slaughter house (COD≈1800 mg/L); f) Pastry factory (COD≈6000 mg O2/L)

In many food sectors manufacturing is developed in periods (e.g. tinned food processing, olive processing, winemaking, beet sugar processing, etc) causing seasonal effluents of different kind throughout the year. In addition to the seasonal effluent variations, food industry wastewaters usually have a wide daily variability during work time. There is a discontinuous wastewater generation owing to the batch operation processes and the intermittent cleaning character of the majority of cleaning operations. This issue must be considered in the onsite wastewater treatment facilities design.

In the same food sub-sector, even among factories with similar technologies, water consumptions and wastewater volumes can diverge dramatically according to water management. Water management itself depends on price and availability, staff concern and internal measures adopted for avoiding waste.

It is important to consider the convenience of corporations having devices and control systems for measuring water consumption and wastewater volume production. Moreover, it is necessary to posses the proper equipment for periodical integrated sampling during the working day.

The utilization of the described equipment along with quantitative analytical methods allow for assessing the main effluent parameters (pH, COD, SS) and will offer valuable information relative to effluent characteristics, time evolution, wasted volume, treatment systems effectiveness, as well as, if the corporation has taken minimisation actions it will be possible to determine the improvements achieved this way.

Approaches

There are different strategies to diminish the environmental impact of food processing companies in relation to water relater issues. The strategies can be classified as follows (fig 1):

- **PREVENTIVE strategies:** as its name suggest, they refer to those strategies whose principal aim is minimizing water consumption and wastewater both generated and discharged.

- **CORRECTIVE strategies:** as its name suggest, these strategies include those that are applied after wastewater generation, that is, strategies aimed to wastewater treatment, previous to their final sewage disposal.

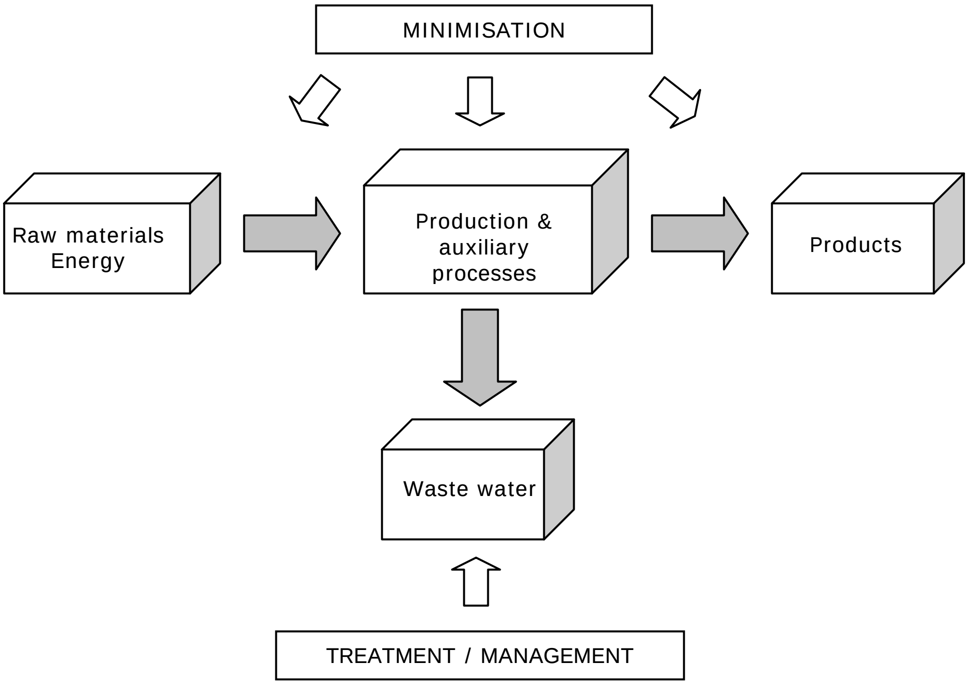


Fig 1. Principal strategies sketch (prevention /treatment) aimed to reduce wastewater generation.

Preventive strategies

The minimization as a concept is a philosophy of work aimed at the reduction of the environmental impact of a company through actions to prevent, reuse and/or recover. The techniques used to implement strategies for minimization can be divided into three groups:

- ***Prevention techniques:*** Those techniques are oriented to wastewater reduction at source (water volume and/or pollution load) from changes in raw materials in the production, modification of production processes based on change of procedures, equipment, replacing equipment and utilities, etc…

- ***Onsite recycling techniques:*** as its name suggests are techniques based on the reuse of the various streams of water within the company (but complying with quality and hygiene standards), or based in the recovery of wastewaters as by-products…

- ***Offsite recycling techniques:*** Those are based on recovering effluents through sale to other corporations or external management, etc.

Preventive strategies have mainly two advantages: reduction of pollution and savings in various areas such as a decrease in water consumption, a reduction in discharge taxes and the reduction in the amount of wastewater that need a treatment before being discharged, as well as, in general, a reduction in the complexity and size of the corrective treatments finally needed.

Corrective strategies

After the implementation of the prevention strategies, when necessary, further corrective actions to achieve the necessary quality of wastewater before its discharge into sewer systems may be needed, so that sewage regulations are accomplished. Several operations and unit processes may be considered depending on to the characteristics of the wastewaters and different combinations of these unit processes may be necessary. Thus an end of pipe waste water treatment system may have some of the following steps:

- ***Screening*** units for thick particulate solids removal in water (mesh, screens) aimed to avoid seals in subsequent treatment units and remove the abrasive effects on pumps and valves placed along the upstream treatment system. First, coarse screens are installed to retain larger solids, and then place a fine solids separation system for solids in suspension of small particle size. The passage of coarse screen depends on the rough solid waste that is present in discharges of each company. Regarding to the fine solids separation system a light between 0,25 and 1 mm is recommended. The most commonly used fine solids separation systems are rotary drum screens and step screens, both with self-cleaning systems to prevent their obstruction. These systems must be equipped with solids collecting devices for recovering the solids if possible as by-products. Moreover, they should carry a drainage system to evacuate the water contained in these materials and make their management easier due to their lower moisture content.

- ***Homogenization*** units for balancing the dumping, avoiding in this way flow and load peaks. This kind of unit should be stirred and aerated to maintain aerobic conditions and avoid sedimentation. In this way, aeration prevents bad smells and in some cases may achieve interesting COD removal yields even making unnecessary downstream treatment steps. The need for this type of unit arises from the heterogeneity of products dealt with by companies throughout a day and the variability of the analytical characteristics of discharges that arise from this diversity of products and operations. A tank of homogenization also provides security deposit against accidental spills that may occur in the industry, because that prevents them reaching the final point of discharge.

- ***Neutralization*** systems: which is the addition of acids and bases to neutralize wastewaters with extreme pHs. It is appropriate to promote the mixture of acid and basic streams to reduce costs of reagents, where both acid and basic wastewaters are produced within the same installation.

- **Fats or/and suspended solids removal** units. There are basically two types depending on whether are based on processes of flotation or sedimentation, usually aided by the addition of flocculants and coagulating chemicals. These systems of treatment are commonly called physicochemical treatments.

- ***Biological treatments***. The basis of a biological treatment is to accelerate the biological process that would be found in nature, i.e. degradation by certain microorganisms (bacteria, fungi, algae, etc.) of matter dissolved in water. Such a process can occur under aerobic or anaerobic conditions. Biological treatments consist of two types of different units: biological reactors and final clarification units.

- ***Tertiary treatment/water regeneration***. Technologies for wastewater regeneration for reuse purposes are available. These involve technologies such as membranes, UV disinfection, ozonation, etc.

- ***Sludge treatment.*** Decantation and/or flotation units which may have a certain treatment system, generate a high amount of solids, sludge or mud, that need special treatment to reduce its volume, weight and characteristics prior to external management and disposal. Sludge treatments have different units: thickening units, sludge stabilization and dehydration.

a) Rotary screen in a chicken slaughterhouse; b) Floatation unit for grease removal in a meat products factory; c and d) Homogenisation tank and biological reactor in a fried corn factory; e) biological reactor and decanter in a pre-cooked meals company; f) filter press for sludge dewatering in a soft drinks company

Water management methodology assessment

1. Company Commitment on water management

- allocate human resources
- allocate capital resources

2. Preliminary overall review

- Review legal compliance
- Overall water balance
- Overall water management costs
- Identify information gaps
- First glance observations

3. Water balance

- qualitative review
- quantitative review
- pareto analysis (set priorities)
- set baseline scenario through performance indicators

4. Identification of Tecnnology/practice options

- BATs
- BEPs
- Clean technologies
- Water and wastewater technologies
- Bench scale studies
- R&D projects
- List of options

5. Action plan

- Evaluate options
- Set indicators and targets
    - total water consumed
    - cleaning water consumed
    - cooling water consumed
    - wastewater consumed
- Select actions

6. Implementation

Monitoring, reviewing and disseminating (staff involvement)

- Follow up of performance indicators, e.g:
- Benchmarking
- Costs

7. Continuous improving

1. Company Commitment on water management

Establish a water management team. Involve key staff members who may influence or have an understanding of how water is used at your company. This will enable to identify and implement water-saving measures, thus, you should consider staff such as:

- Senior management
- Production managers
- Maintenance staff
- Accounting staff
- General staff

Once a preliminary overall is performed produce a statement of commitment on water management improvement and make it visible within the company.

Capital investments will be needed at some stage but this should be largely justified once the assessment process is concluded.

2. Preliminary overall review

Start checking your legal compliance (permits and discharge limits), then prepare a global water balance, focus on identifying all costs in connection to water use and wastewater treatment and disposal, outline information gaps and get a list of first glance observation and ideas on the issue.

To identify what savings can be achieved at your site, it is essential to understand where and how water is used and how much it costs. Deep analysis of such will be made later on, but a preliminary assessment allowing for rough numbers on water consumption and wastewater generation focusing, so far, on costs will raise real awareness of the economic relevance of the issue and will allow for allocation of resources for the whole improvement process.

The preliminary review will, also, help to identify and outline all those existing information gaps on water management so actions to obtain such a measure will be one of the first outcome of the preliminary evaluation.

To the possible extent, with the information available in the company, the global assessment of the use of water shall be established along with the annual global cost associated to water use and wastewater disposal. This action allows visualizing the economic impact dimension within the corporative activities and establishing a few primary indicators of behaviour for efficient use of water. They shall be monitored over time as proof of the effectiveness of the improvement measures to be taken in the future.

Your baseline water use is the amount of water you currently use on site. This information helps to determine what potential savings can be achieved in the timeframe identified. It also helps you to measure your performance. Savings can be easily identified by comparing your water use each year with your baseline water use.

To determine your baseline scheme water use, you will need your site’s water bills for the previous 12 to 36 months. When reviewing your site’s water use history, ensure the data represents normal operating conditions, i.e. there were no shutdowns or refurbishments during the period. If there has been a variation from normal conditions during the period, please include a description or reason for this and the estimated impact on water use.

A general visit to the company's facilities including production lines and auxiliary processes with the aim of observing water use and interchange of ideas with different staff on the issue and ask on opinions on potential water savings will be useful at this stage.

A global flow chart of water inputs and outputs is showed in figure 3. A template to gather cost information and estimate water related costs along with water use and discharge observations is presented below in order to produce the preliminary assessment.

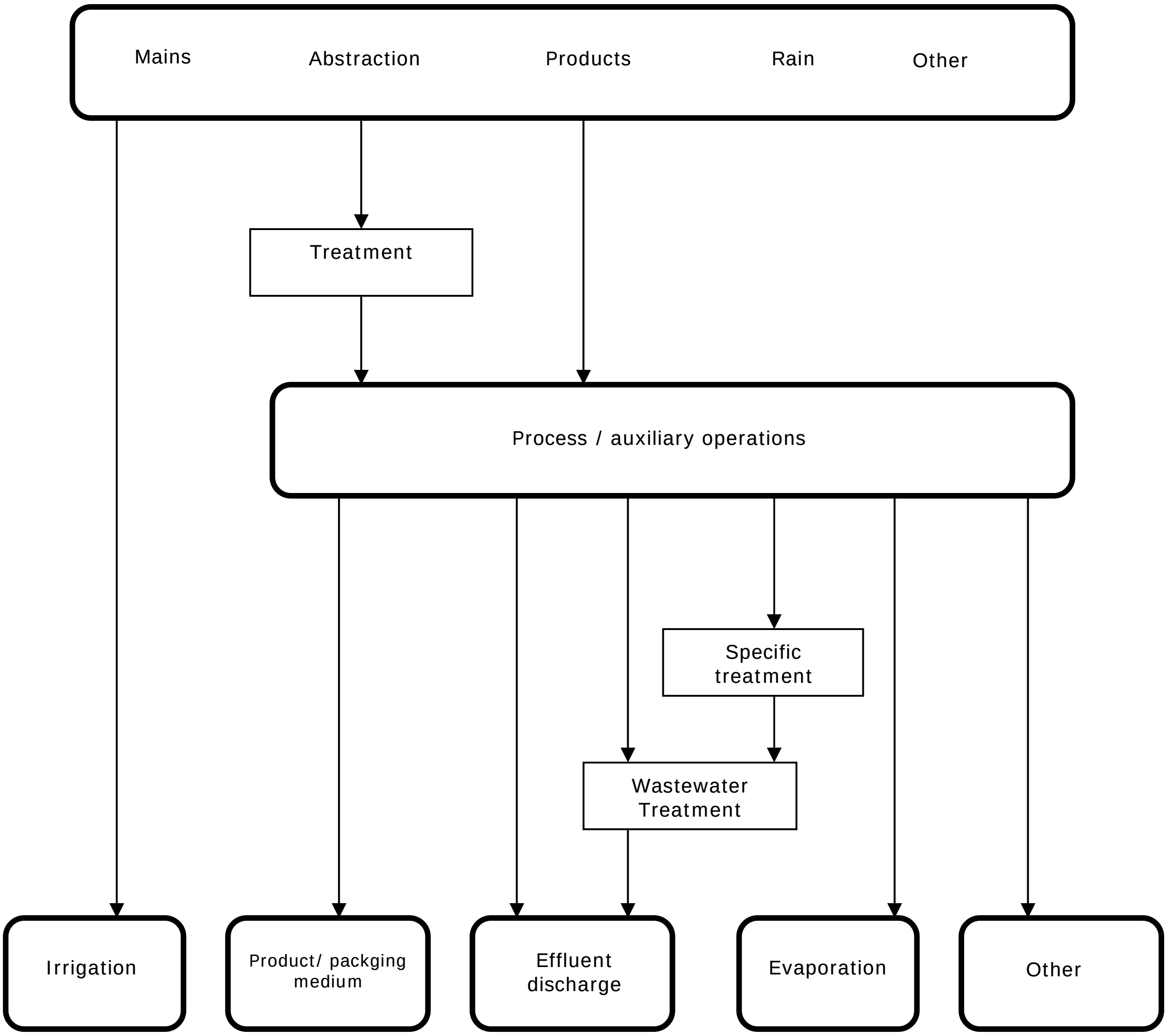


Fig 2. General water flow chart

PRELIMINARY REVIEW	
General water balance	
Inputs	**Water volume (m^3)**
Abstraction	
Tap water	
Water from products	
Rain	
Other	
Total water in	
Outputs	
Evaporation	
Water in the product/packaging medium	
Waste streams external management	
Effluent to sewer system	
Other	
Total water out	

Water management annual cost	
Year: **Total water consumption:_______ m3**	
Item	**Annual cost (€)**
Cost of Water supply	
tap water	
Abstraction of Ground water water	
licenses	
process water treatment (chemicals, energy, maintenance…)	
analysis	
energy (pumping, heating)	
other (e.g. rain water)	
Cost of waste water management	
external management of liquid wastes	
effluent treatment	
sludge disposal	
chemicals	
energy	
effluent discharge tax	
analysis	
other	
raw material lost in effluent	
licenses	
other	
TOTAL:	

PRELIMINARY REVIEW
On site observations and comments on water use
E. g. make general visit to the company's facilities including production lines and auxiliary processes: - observe and write down water use, effluents, etc - interchange of ideas with different staff on the issue - ask on opinions on potential water savings, that will be useful at this stage
Establish some basic indicators
E.g: - m3 water consumed per unit product - m3 wastewater discharged per unit of product - cost of water management: euros/m3 of water consumed - % of water management costs in relation to general costs

Notice that discharge taxes are often included in the water supply bill. Such a tax is local regulation dependant are different complex formula to allow for volume and load correction factors are used. Get the method your local authority uses to calculate your tax and test how improvements in consumption or wastewater quality would impact on your bill.

Ensure your staff is aware of the total cost of water to your company and make indicators public.

3. Water balance

A site water balance is necessary to determine how much water is actually used in each area of your business. A site water audit or sub-metering will be useful in accurately determining the water use in each area. Knowing how much water you are using and where it goes are the first steps towards being able to control and reduce the amount of water you need. Then field work will be necessary to quantify the contribution of each in process waste water stream and finally classify processes and streams according of its particular impact in terms of water consumption, pollution strength and type of pollution.

Such information will be the basis to identify later on improvement options regarding practices and technologies. It will outline those processes may suffer an improvement process and will show where we have to focus our efforts for cost effective actions.

A water balance is a numerical account of where water enters and leaves your site and where it is used within the business. It lists the amounts of water used by each main process. It can be kept quite simple or be made very detailed, depending on your situation and needs. It should produce a flux diagram identifying qualitatively and quantitatively all the inputs and outputs in connexion to water in each of the operation processes and auxiliary operations.

Regular surveys will keep water and effluent systems in order. Checks should be carried out on a monthly basis, at least until full control of water use has been established, when an annual survey may be sufficient. Surveys typically reveal leaks; incorrectly set, poorly maintained or broken equipment; unidentified connections; redundant lines; unknown or unauthorised usage or discharge and clean water discharges to effluent streams.

The steps are:

- List of production processes and operations and auxiliary processes and operations
- Production of production flow charts
- Identify water consumption points and waste water production points
- Qualitative analysis and balance of each process and auxiliary operation and select those significant for quantitative balances and selection of critical control points for water quality
- List of potential relevant in process effluents and consumption points
- Quantification: volume, flow and sampling campaign
- Add numbers to the list and flow chart
- Classify as a function of contribution to overall water consumption or/and contribution to overall waste water volume or/and contribution to wastewater pollution (or other of interest) and hence identify most relevant streams
- Identification of sewage system

Depending on the complexity of your company you may join or shortcut some of the steps. Let's comment step by step.

List of production processes and operations and auxiliary processes and operations

Start by reviewing your production and auxiliary processes (PP and Aux) and identifying unit operations. Often some operations are shared by several processes. You quality department should have already this kind of information.

Code	Processes
PP1	**Production process 1**
…..	…..
PPn	**Production process n**
AUX1	**Auxiliary Process 1**
….	….
AUXn	**Auxiliary Process n**

+

Code	Operations	Processes
OP1	Operation Process 1	Indicate in which processes this operation is included
OP2	Operation Process 2	
…	…	…
OPi	Operation Process i	

In some cases where the activities are not too wide and complex a single table may do

Code	Processes/Operations
PP1	**Production process 1**
PP1-O1	Production Process 1-Operation Process 1
PP1-O2	
PP1-Oi	Production Process 1-Operation Process i
…..	…..
PPn	**Production process n**
PPn-O1	Production Process n-Operation Process 1
PPn-O2	
…	…
PPn-Oi	Production Process n-Operation Process i
AUX1	**Auxiliary Process 1**
AUX1-O1	Auxiliary Process 1-Auxiliary Operation 1
AUX1-O2	Auxiliary Process 1-Auxiliary Operation 2
….	….
AUX1-Oi	Auxiliary Process 1-Auxiliary Operation i
….	….
AUX1	**Auxiliary Process 1**
AUX1-O1	Auxiliary Process 1-Auxiliary Operation 1
AUX1-O2	Auxiliary Process 1-Auxiliary Operation 2
….	….
AUX1-Oi	Auxiliary Process 1-Auxiliary Operation i

Flow charts and identify water consumption points and waste water production points

Produce a flow chart (or several in necessary) and identify where the water comes from and goes to, so that you can link origin and destination of water at each point. It is useful to differentiate continuous discharges from batch discharges. Among the auxiliary processes include wastewater treatment, external management of liquid wastes, etc.

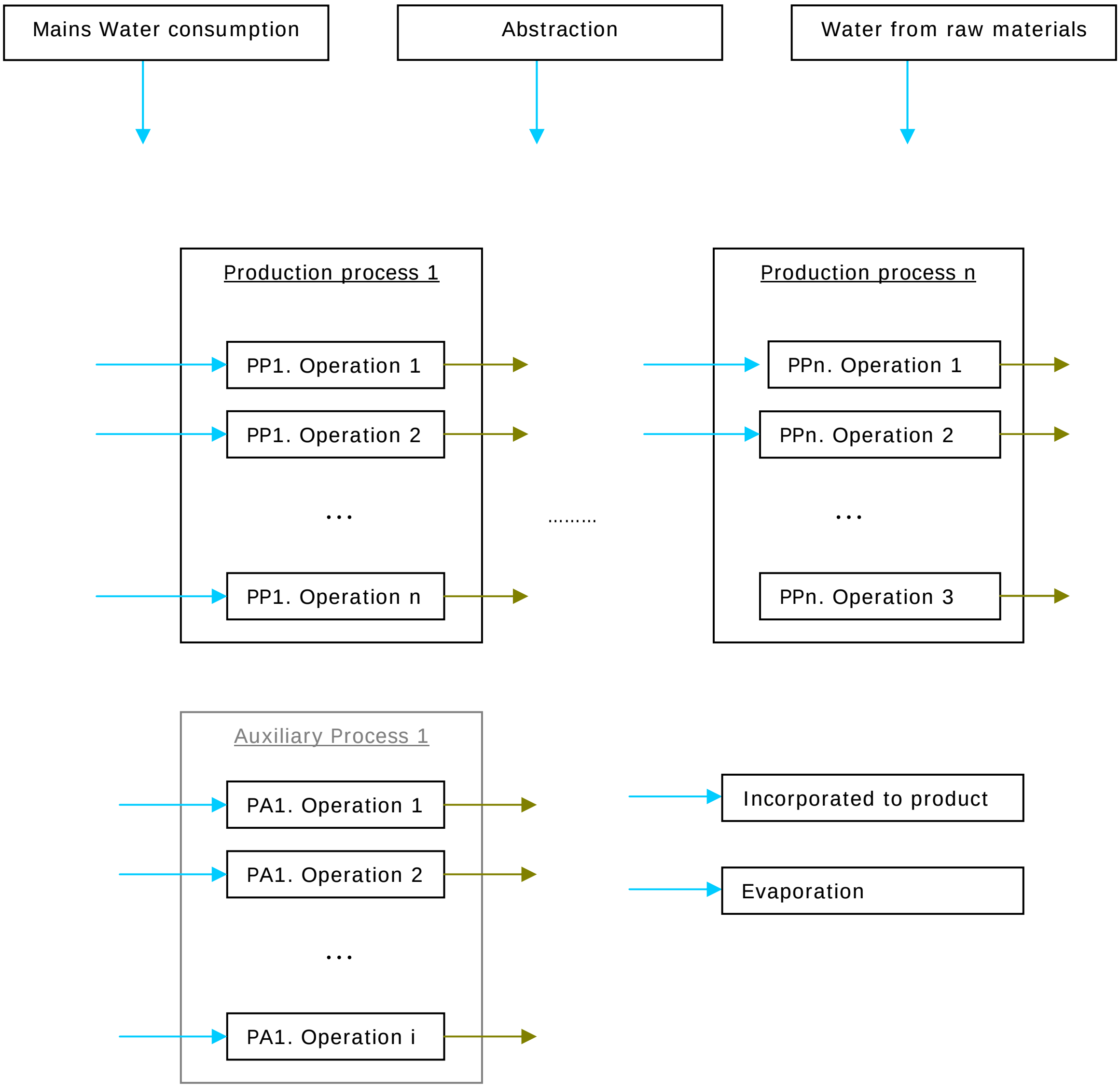
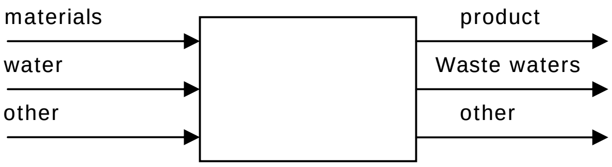


Fig 3. Water Flow chart

Qualitative analysis and balance of each process and auxiliary operation and select those significant for later quantitative balances

Make a qualitative analysis of each process and or operation, with a description of the operation, the equipment needed, the staff involved and describe the water consumption regime and nature of the wastewaters generated and other data of interest.

Process x Operation y:
Flow chart: 
Technical Description:
Environmental aspects:

You may add the consumptions and internal discharges at your operation list or produce a particular list along with comments.

Water consumption points		
Code	Observation	Operation
Waste Water production points		
Code	Observation	Operation

Quantification: volume, flow and sampling campaign

Once water using areas have been identified, the actual water used can be measured through sub-metering. Sub-metering high water demanding areas (such as cooling towers, production process, irrigation, showers etc) will help you gain a better understanding of each area and identify savings opportunities. This can be done manually (involve staff members to read the main meter at night and first thing in the morning, to check for leaks) or automatically via data loggers to record water use information in real time.

In order to study the treatment of final waste waters consists on a characterisation that represents the mean pollution conditions of the stream and also defines its variability with time. Such variations in volume and pollution occur during a single day as different operations that produce different type of effluents happen throughout the day contributing to the overall effluent, but also variation may have a weekly, monthly or season dependent pattern. Production campaigns have to be carefully considered when planning action for water management improvements. In parallel in order to identify good practices and minimisation options deep knowledge of the characteristics and flow patters of in-process effluents has to be obtained.

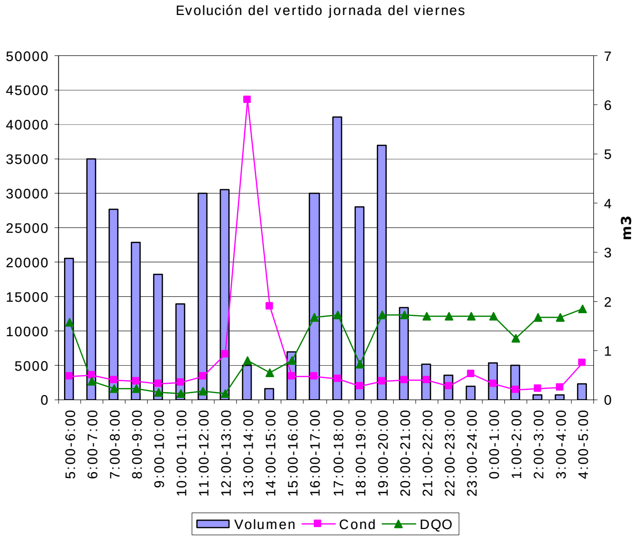


Fig 4. a) Automatic samplers and flow measuring equipment. b) Example of volume, conductivity and COD profiles

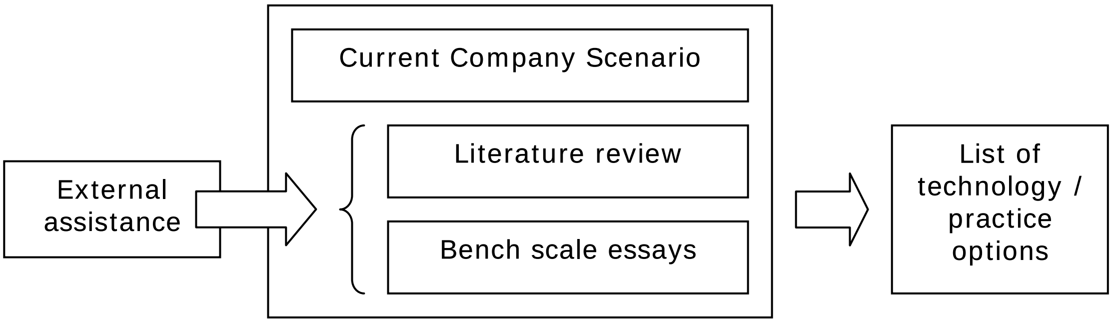
Thus, the characterisation study has to include pollution and hydraulic patterns identification of overall and in-process effluents. In order to identify the contribution of each consumption point and effluent a sampling and characterisation programme should be established including:

- o Flow metering and volume estimations
- o Sampling and analytical characterisation

Once the characterisation programme is finished add numbers to the operations list and flow chart and classify the operations or streams as a function of the contribution to overall water consumption or/and contribution to overall waste water volume or/and contribution to wastewater pollution (or other of interest). Now you have the information to focus on the main causes of excess water use or water pollution. A pareto analysis is a simple and effective technique to show where to target actions. pareto principle: also known as the 80-20 rule) states that 80% of the effects are due to 20% of the causes.

4. Identification of technology/practice options

Now that you understand the site's water use and the current cost of water management you have the basis you need in order to identify potential action for improvement and decide targets.



Considering your current processes, practices and your global environmental performance, particular actions from both prevention and end of tube approaches should be identified.

External assistance may be necessary at this stage to evaluate the current scenario of the company so that appropriate technology and management solutions to particular issues may be identified and evaluated.

A deep review of information in connection with your particular case should be performed and a selection of options for improvement should be produced. Extensive available literature exists on:

- Best Available Techniques
- Best Environmental Practices
- Clean technologies
- Water and wastewater technologies

The characterization performed of the final and partial waste water streams allow us to produce an initial identification of strategies, actions and treatments to improve the environmental performance in terms of water consumption, waste water volume, pollution and energy associated with water management. Nevertheless, additional bench scale or pilot scale essays may be necessary to evaluate the efficiency of potential technologies that may be employed and decide whether such technologies could be a sound option.

Fig 5. Pilot essays of different technologies for waste water treatment

Based on information obtained in the preceding paragraphs shall be defined possible strategies for better management of wastewater generated in the industry. Thus shall be identification of options for improvement in terms of consumption or pollution load reduction at source, treatment of waste water, etc.

- Results of the various tests conducted in laboratory, qualitative interpretation of the same
- Identification of possible strategies to be followed in order to achieve a significant improvement of wastewater characteristics by selecting the technique or the most appropriate combination of these.
- Description of the different commercial options available for their implementation and comparative analysis of the same.
- Possible actions for minimization of flow rates and charges in production line.
- Effluents segregation possibilities depending on its nature and specific treatments as well as potential treatments to end of line as a whole.
- Improvements in work procedures and practices with impact on water consumption and generation of waste measures
- Possible end of line corrections
- Possible BATs applicable to the company that are not yet being implemented
- Possibility of changes in installation
- Possible internal reuse of flows

LIST OF OPTIONS		
Stream	**Action description**	**Objective**

5. Action plan

set targets

Setting water reduction targets or pollution reduction targets will help drive the implementation of water optimisation actions in your business. Targets need to include a realistic timeframe and the base year from which improvements will be measured.

select actions

Focus on the main causes of excess water use or water pollution according to the pareto analysis. When selecting your options be coherent with your targets. Analyse your options for economic feasibility that is, evaluate your options in terms of expect benefit and costs. You will need to gather budgets from different providers. List your selected options, allocate resources (human and money and set target dates for completion.

ACTION PLAN					
Action	**Description**	**Benefit**	**Satff involved**	**Cost**	**Date for completion**
1	e.g. Recovery and reuse of product rinse waters for truck cleaning	Reduction in water consumption and effluent production			
2	e.g. Conductivity and pH control loops in CIP systems	Reduction in water consumption and chemicals consumption			
...	...	...			...
n	e.g. Optimisation of flocculant used at coagulation-floculation step in waste water treatment	Reduction of costs of waste water treatment			

6. Implementation

Implement your selected actions as scheduled in the action plan. Training of staff may be needed.

Once actions have been implemented it is important to measure and monitor the performance regularly. Monitoring of water use and wastewater generation has to be performed and performance indicators obtained. Carry out regular inspections and surveys and inform staff of the progress and results.

Water use is directly related to business activities. A Core Business Indicator (or water use indicator) is a measure of activity that takes into account core business operations specific to the site – for example how much water is used per tonne of product manufactured on site.

It is important to consider how variables such as production rates, number of staff/contractors or the number of customers affect water use when determining water-saving targets.

Determining a Core Business Indicator allows measurable targets for water reduction on the site to be set, regardless of these variables, and enables comparison of water use across years. It is a good idea to use the same indicator that your business uses to assess business efficiency when calculating your Core Business Indicator. graphing this information is a useful way of viewing the changes in water-use efficiency over time.

Comparing your Core Business Indicator to the best practice standards for your industry will assist in measuring how efficiently your site is operating. Understanding current best practice will also help you determine realistic water and money-saving targets.

- performance indicators
    - total water consumed
    - process water consumed
    - cleaning water consumed
    - cooling water consumed
    - wastewater produced
- water cost indicators

Benchmarking is the process of comparing the cost, cycle time, productivity, or quality of a specific process or method to one that is widely considered to be an industry standard or best practice. Essentially, benchmarking provides a snapshot of the performance of your business and helps you understand where you are in relation to a particular standard. Internal benchmarking is a comparison between similar operations within your own organisation. External benchmarking is a comparison with best practice achieved by others in the industry.
Benchmarking can be used by a business as an indication of how it is performing in terms of water consumption and effluent generation (ie product loss) compared with the rest of its sector.

7. Continuous improving

The water balance and performance indicators should be reviewed regularly, for example yearly. And new targets should be set after each revision.

Communication of the progress achieved to al staff is important to keep them motivated.

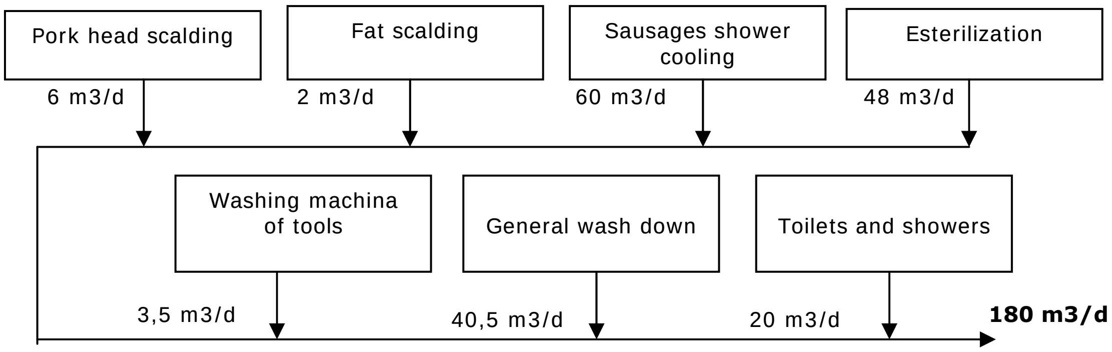
Study case 1
Company sector: Meat products (pâté, mortadella, sausages, and other pig products)

Code	Production Processes list (PP)
PP1	Manufacture of pasteurized sausages
PP2	Manufacture of sterilized sausages
PP3	Manufacture of cold cuts of pork head
PP4	Manufacture of galantines without decoration and sausages in bulk
PP5	Manufacture of galantines decorated after cooking
PP6	Manufacture of sterilized liver pâtés
PP7	Manufacture of sterilized fish pâtés
PP8	Manufacture of decorated pâté of liver in bulk before cooking
PP9	Manufacture of decorated bulk liver pâtés after firing
PP10	Manufacture of sliced liver pâtés
PP11	Cream manufacture
PP12	Manufacture of bulk fish pâtés

The different production processes include operations that are shared by different production processes according to:

Code	Process operation list	PP
1	Reception: meat, fish, raw materials and ingredients	1,2,3,4,5,6,7,8,9,10,11,12
2	Freezing/refrigeration storage	1,2,3,4,5,6,7,8,9,10,11,12
3	Preparation and weigh of meats or liver	1,2,3,4,5,6,8,9,10,11
3	Fish preparation	12
4	Blanching	4,6,8,9,10
5	Kneading and maceration of filling	1,2,5
6	Brine preparation	2,3
7	spices and additives weigh	1,2,3,4,5,6,9,10,11
8	Brining by immersion	3
9	Pot boiling	3
10	Mincing	9,10
11	Emulsify in cutter	1,2,4,5,6,7,8,9,10,11,12
12	Hot kneading	3,9,10,11
13	Kneading by vacuum	1,2,4,5
14	Drawing by vacuum and closed with clamp	5
15	Drawing and hot molding	3
16	Stuffed in gut	1,2,4
17	Mold dosing	8,9,10,11,12
18	Standing in cooling	8,
19	Boiling/blanching	3
20	Pasteurization (and smoking) in oven	1,2,4,5, 12
21	Shower	1,4
22	Fast cooling	1,2,3,4,5,12
23	Packaging in bags	5
24	Remove from mould	3
25	Remove from mould + decoration	5
26	Preparation of jelly	5,8,12[a]
27	Decoration	8,9,10,12b
28	Heat-sealed	8,11,12b
29	Peeling or cutting	1,2,4
30	Packaging by vacuum	1,3,4,5,9,10,12 a
31	Packaging in glass jar	2,6,7
32	Post pasteurization and cooling	1,2,4
33	Baking in oven	8,9,10
34	Sterilization in autoclave	2,6,7
35	Cooling at room temperature	6,7
36	Slicing	10
37	Labeling and box packaging	1,2,3,4,5,6,7,8,9,10,11,12
38	Refrigerated storage	1,2,3,4,5,6,8,9,10,11,12
39	Expedition	1,2,3,4,5,6,7,8,9,10,11,12

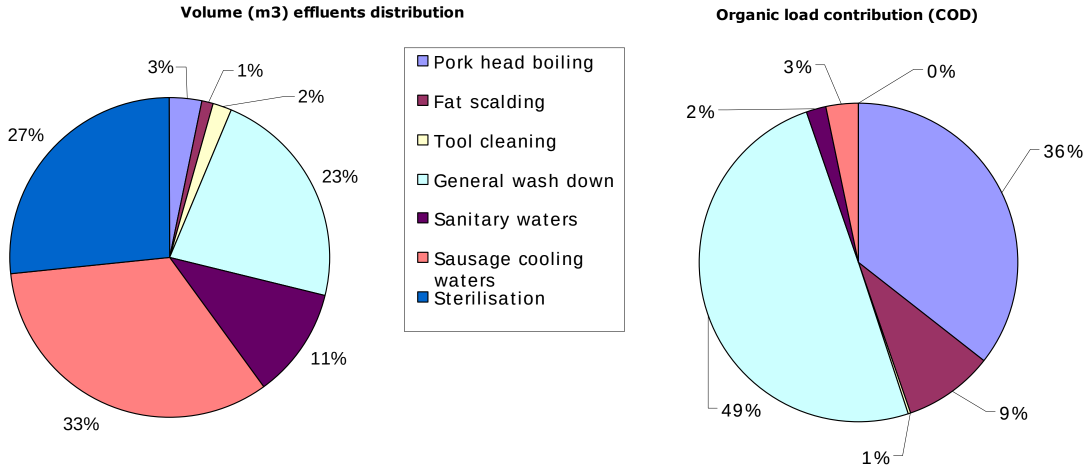
The operations with a greater impact in terms of waste water generation were identified and analysed and are shown in the following flow chart and tables:



Process operation	**Effluent** (m3/day)	**Characteristics**
Pork head cooking	6	Emptying of the cooking liquid. High salinity, high content of fat, solids and organic matter.
Fat scalding	2	Emptying of the cooking liquid. High salinity. High content of fat, solids and organic matter
Sterilization	48	Emptying of the sterilizer and after the end of the cycle. Low pollution levels.
Cool water shower	60	Discharge to drains of water from cooling of sausages. Low-medium pollution level.
Peeling-cutting	Low volume	Continuous spills from working tables. Low pollution.
General wash down	40	Frequent operations of cleaning with detergents of production equipment and surrounding areas. Highly polluted with fats and organic load.
Tool Cleaning	3,5	Overflow of the cleaning machine, daily emptying of wash water. Pollution from detergents, oils and fats and moderate organic load.
Sanitary waters	20	Low load similar to household
Global Discharge	**180**	**Mixture of all partial effluents. Moderate salinity, fats and oils, high organic load, high solids loading.**

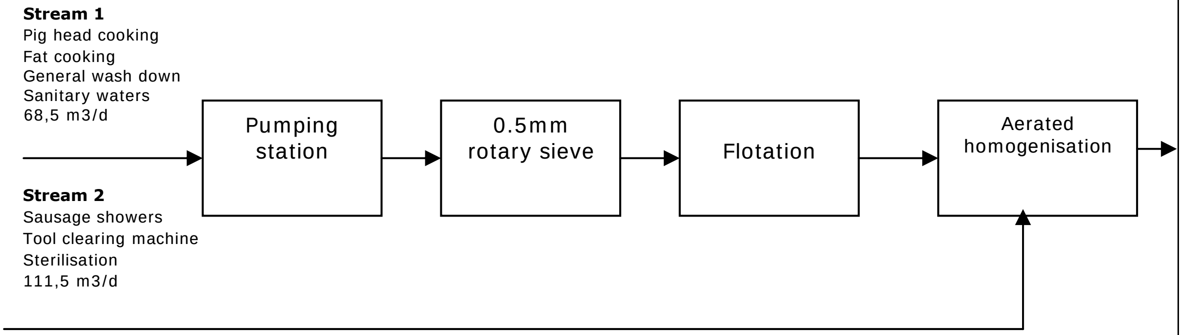
Wastewater stream	**Volume** m^3/d	**pH**	**Conductivity** $\mu S/cm^2$	**COD** mgO_2/l	**SS** mg/l	**Oils&fats** mg/l	**Organic load** Kg COD
Pork head boiling	6	6,85	35000	29500	-	9,7%	177
Fat scalding	2	6,5	17000	22500	-	15,6%	45
Tool cleaning	3,5	9,1	973	746	400	90	2,611
General wash down	40,5	-	-	6083	-	-	246,349
Sanitary water	20	7	-	500	220	100	10
Cool water shower	60	7,65	1706	274	43	10	16,44
Sterilization	48	8,1	801	10	0	0	0,48
Global effluent	**180**	**6,9**	**2564**	**2766**	**916**	**476**	**497,88**
Effluent Limits	**-**	**-**	**3000**	**1000**	**500**	**100**	**-**

The contribution of each stream to the overall effluent in terms of volume and organic load is analysed in the following graphs:



List of options
Implement dry clean-up operations: cleaning operations generate the main load contribution to the global effluent. Changes should be made to reduce the amount of organic matter that is dragged up to the drains. A dry cleaning of surfaces of soils and equipment prior to cleaning with water should be made when possible. Pressure water should be used after sweeping and disposal of waste in containers.
Solids separation in sinks: prevent particulate matter from entering the drains by placing solid separation devices in sinks.
Installation of metal trays for spills collection: It is convenient the installation of metal trays under transport tapes, dosing and operations where spills of product occur, in order to reduce the area affected by spills and splashes, facilitate the separation of dry spilled materials and reduce clean-up water needs.
Removal of fat in cooking operations: operations of cooking are one of the main sources of load organic, and especially of fats. A layer of fat is formed on surface which could be separated into a container prior to emptying of the boiling pans. Given that discharges from the emptying of cooking operations represent a volume of about 8 m3/d (about 4% of the total volume) but bring about 45% of the pollution load, it would be advisable to study the cost of its management separately as waste at least, as a urgent measure during the period that adequate purification facilities are not available.
Streams segregation: in order to allow a more rational treatment of effluents, the separation of effluents depending on specific characteristics of pollution is interesting. In the company, there are a series of pollution free streams that may be discharged without treatment.

End of pipe treatment



Implementation action plan	
Action	Date for completion
Training of staff on good environmental practices	Month 1
Dry cleaning implementation	Month 1
Solid separation in sinks	Month 1
Trays for spills and overflows	Month 1
Wastewater treatment project	Month 1-2-3
Separation of fats in scalding operations	Month 3
Cleaning of the grease trap	Month 3 and month 4
Elimination of open cauldron cooking and implementation of new cooking system	Month 6
Wastewater treatment construction	Month 4-5-6
Wastewater treatment start up	Month 7

Implementation and monitoring									
Date	**pH**	**Cond**	**SS**	**BOD5**	**COD**	**O&F**	**TKN**	**P**	**Toxicity**
Before the study									
Month -5	7,10	1838	1340	3120	3408	504,6		61.08	82
Period of implementation of upstream measures									
Month 1. A		1119	356		1119	146			
Month 1.M		910	314		535	145			
Month 2. A	6,81	1241	497	858	1138	209	38	7,2	7,98
Month 2.B	7,02	875	226	320	395	107	25	3,9	3,5
Month 2.C	6,92	1213	428	370	453	123	38	6,7	10,59
Month 2.D	6,85	961	1238	330	464	129	31	8,1	31,44
Month 3.A	6,50	1200	990	1212	1302	810	86	6,7	13,51
Month 3.B	6,47	1896	666	1864	1616	216	59	34,8	14,88
Month 3.C	6,46	8160	190	728	972	10	41	5,7	2
Month 4.A	6,91	1647	396	660	777	120	8,7	3,9	5,2
Month 4.B	6,73	2540	610	699	900	534	31	9,8	7,1
Month 5.A	6,74	1217	754	1250	1857	241	39	6,6	9,7
Month 5.B	7,11	1613	242	680	723	210	34	7,6	3,72
Month 5.C	6,45	1875	390	681	924	250	47	9,3	2
Month 5.D	7,31	908	156	240	281	23	15	1,2	2
Month 5.E	7,72	1262	159	325	390	10	22	4,2	3,73
Period after start up of wastewater treatment facilities									
Month 6. A	7,33	2820	397	360	807	395	92	14,2	2
Month 6.B	7,73	3300	382	210	668	10	94	28,4	2
Month 6.C	7,75	3160	259	310	668	10	82,2	20,1	2
Month 11.A		2830					66		
Month 11.B		2350					45		
Month 11.C		2370					38		
limits	5,5-9	3000	500	500	1000	100	80	30	15

Finally the company implemented the actions achieving the accomplishment of the limits with a combination of good environmental practices, minimisation measures and end of pipe actions. Thus it was not necessary the construction of a biological treatment as it might be foreseen just considering the characteristics of the final wastewater at the beginning of the study what leads to important cost savings in investment and maintenance.

Study case 2
Company dedicated to elaboration of canned sardines and anchovies

Auxiliary operations

Auxiliary operations are activities and operations which, despite not being processes of the manufacturing process in itself, are necessary for the general operation of the factory. They are related to productive processes in greater or lesser extent. In this case we have:

Auxilary operations	
Process	**Code**
Brine preparation	OA1
Washing of barrels from the anchovy line	OA2
Tools washing used in the line of sardine	OA3
Grills washing	OA4
Office	OA5
Sanitary (toilets, showers, etc)	OA6
General cleaning of equipment and facilities	OA7
Waste water treatment facilities	OA8

Production processes (PP)

The existing production lines, depending on the nature of the final product are:

Production processes (PP)	
Process	**Code**
Semi-tinned anchovies production	PP1
Tinned sardines production	PP2

Sections (S)

Each of the production processes includes a number of sections, in turn, each section includes several operations, e.g.:

Semi-tinned anchovy production(PP1)

Half tinned anchovy production(PP1)	
Section	**Code**
Reception	PP1-S1
Pre-elaboration	PP1-S2
Maturation	PP1-S3
Kneading	PP1-S4
Cutting and spinned	PP1-S5
Packing	PP1-S6
Cooled preservation	PP1-S7

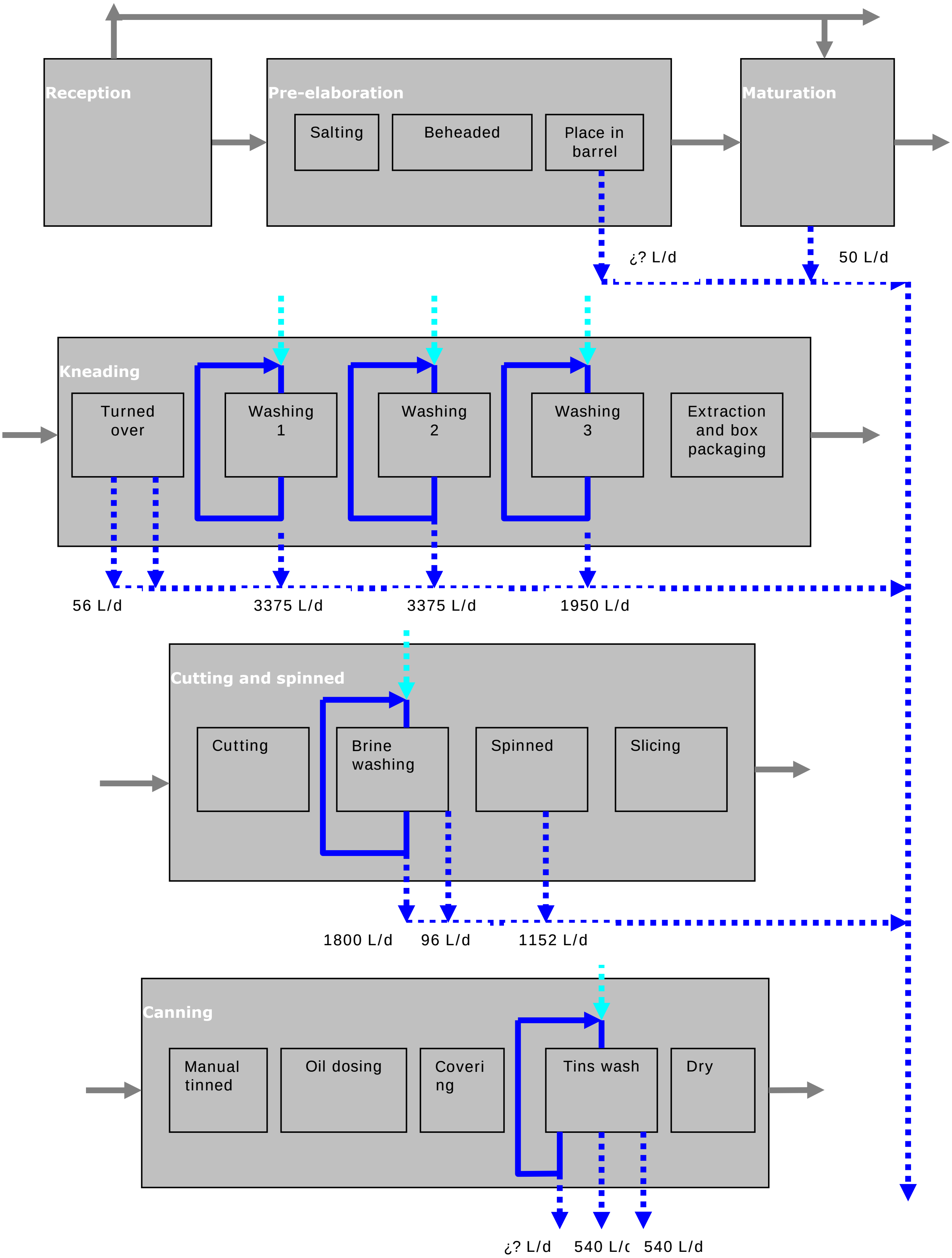
Production of canned sardines (PP2)

Production of canned sardines(PP2)	
Section	**Code**
Reception	PP2-S1
Conditioning	PP2-S2
Initial tinned	PP2-S3
Boiling	PP2-S4
Final tinned	PP2-S5
Sterilization	PP2-S6
Final washing	PP2-S7

Section: Kneading (PP1-S4)

Kneading (PP1-S4)	
Stage	**Code**
Barrels turn over	PP1-S4-E1
Cool water washing	PP1-S4-E2
Hot water washing	PP1-S4-E3
Cool water washing	PP1-S4-E4
Extraction and packing in boxes	PP1-S4-E5

A flow diagram of PP1 is presented below; similarly flow charts may be produced of the other PP or a general flow chart covering groups of PP and auxiliary processes.



After identification of the different streams a list of them should be produced, for example the table below shows the different in-process effluents for PP2:

PP2. PROCESS WASTE GENERATED IN THE LINE OF SARDINE	
Waste code	**Source**
PP2-S1-E2-V1	Discharge of sardine thawing
PP2-S2-E1-V1	Brine machine draining
PP2-S2-E2-V1	Disposal of spills on sardine conveyor belts in the tables of gutting
PP2-S2-E2-V2	Water of thrust for the advancement of sardines in conveyor belt.
PP2-S3-E1-V1	Emptying of the channels of boards of canned sardines
PP2-S3-E3-V1	Turned over of grills of sardine cans spill
PP2-S4-E1-V1	Discharge of liquid from cooking
PP2-S5-E1-V1	Emptying of the cans water tanks washing with detergent
PP2-S5-E3-V2	Overflow of the deposit of water washing sardine cans before sterilization
PP2-S6-E1-V1	Discharge of the sterilizer of tinned sardines
PP2-S7-E1-V1	Final washing of cans of sardines with detergents
PP2-S7-E1-V2	Final rinsing with water of sardine cans

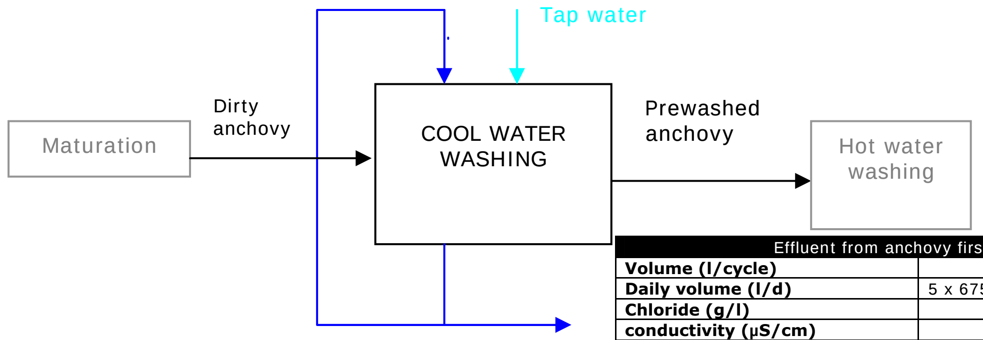
Each of the operations may be analysed regarding a technical description and identification of inputs and outputs and finally perform, when needed, flow estimates or measures and sampling and characterisation of waste streams, e.g.:

- ***Cool water washing (PP1-S4-E2)***

Technical description: anchovies, separated from the barrels for maturation are fed to a washing with shower. In this first washing the anchovies are fully covered with wet salt stuck to the skin as well as fats and scales. This first washing separates the thicker dirt. Washing water circulates in a closed circuit being pumped from a tub beneath the shower through which pass, by conveyor, anchovies and thus water from washing that will progressively contaminating with fats are picking up, salt and solids. The replacement of the washing water is made several times per shift. The tank has a capacity of 675 liters and, in general, is replaced about 5 times a day.

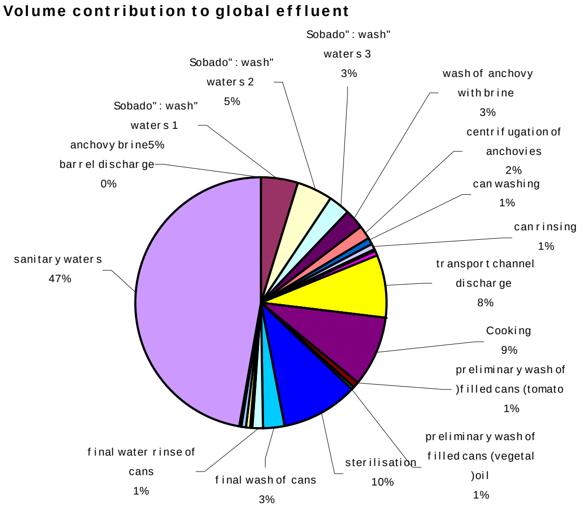
Enviromental issues:

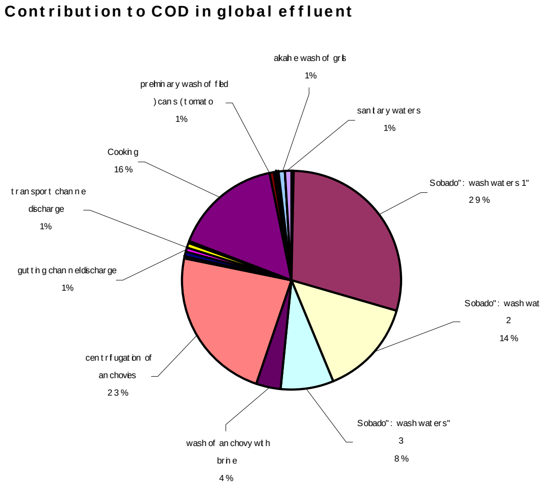
Effluent (PP1-S4-E2-V1): the discharge of water from washing, contaminated by salt, fat and suspended and sedimentable matter is carried out.
Flow chart:

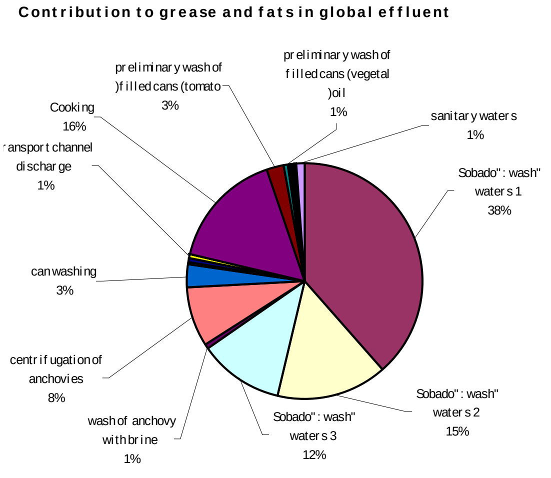


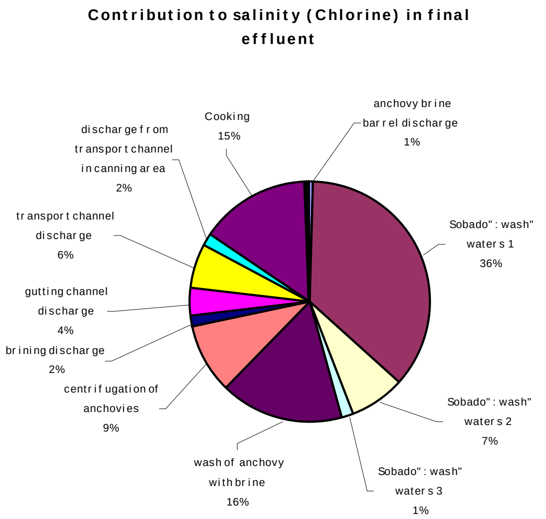
Effluent from anchovy first washing	
Volume (l/cycle)	675
Daily volume (l/d)	5 x 675 = 3375
Chloride (g/l)	164
conductivity (µS/cm)	166500
Sedimentable matter(ml/l)	stable
Suspended solids(mg/l)	88000
COD (mg O2/l)	175800
BOD5 (mg O2/l)	58846
Oils and fats (mg/l)	37230

When analysing quantitative results on particular operations, after discarding those whose contribution was found to be less than 1% we have:

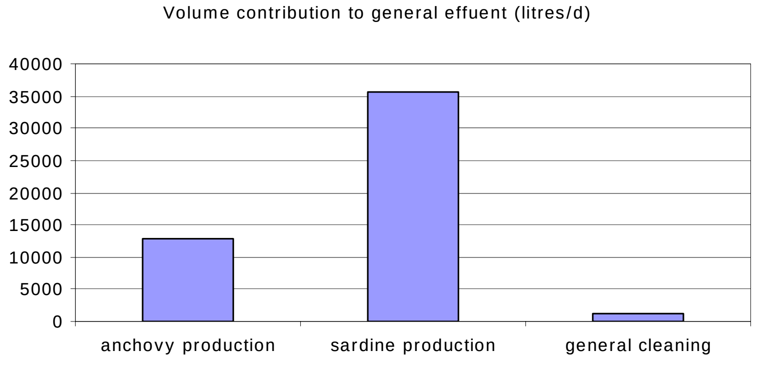


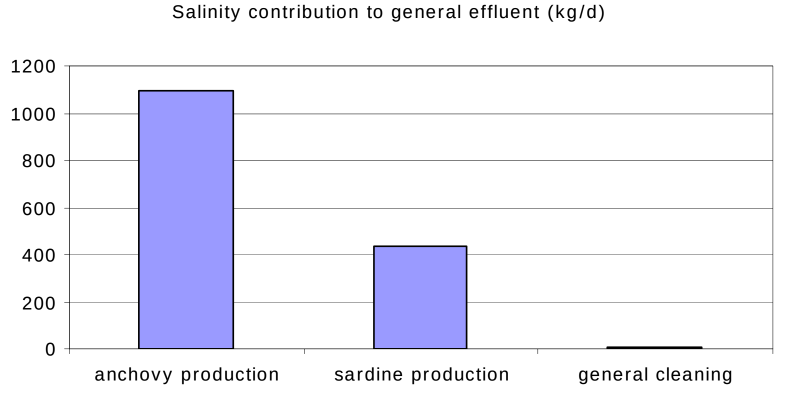


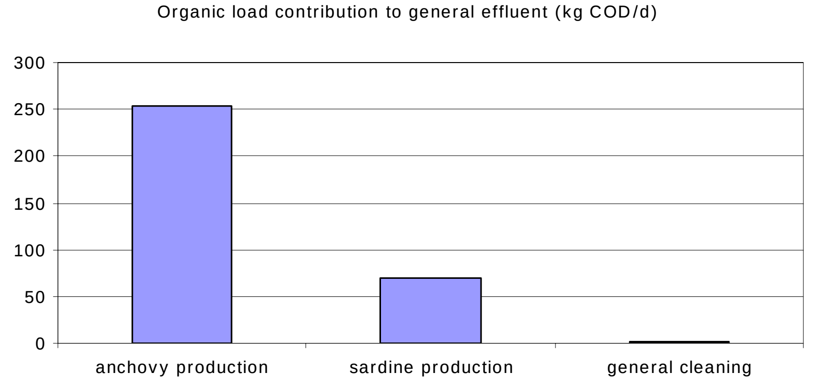




Quantification of the different streams (in process and global effluent) in terms of volume and pollution allows us to identify where to focus efforts, thus in this particular case it was found that PP1 represents around 30% of the total wastewater volume but brings around 70% of total pollution. Furthermore section PP1-S4 represents 70 % of effluent volume, 60% of salinity, 85% of fats and 65 % of organic load of PP1 environmental impact.







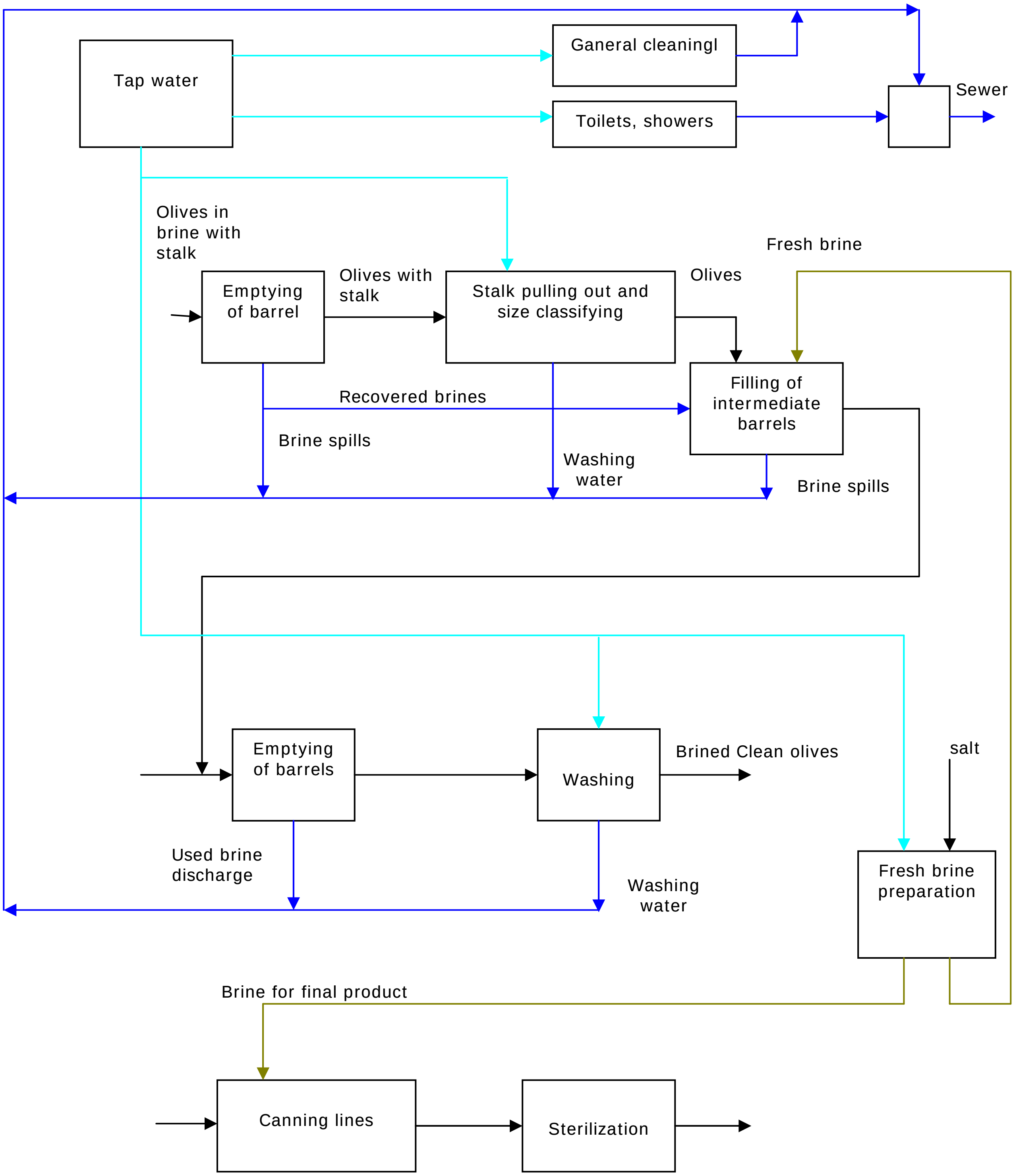
Considering all the information obtained along with the characterisation of global effluent and additional lab scale essays several measures and options where identified regarding processes, auxiliary operations and end of pipe measures. For example in relation to measures for PP1 the following list was produced (similarly regarding PP2):

OPTIONS FOR ANCHOVY PRODUCTION PROCESS. PP1.			
Efluent code	**Source**	**Action**	**Aim**
PP1-S2-E3-V1	Brine overflow in anchovy barrel before ripening	Overflow collection system	Avoid spillage on soils, reduce cleaning needs
PP-1-S3-E1-V1	Brine overflow n anchovy barrel during ripening	Overflow collection system	Avoid spillage on soils, reduce cleaning needs
PP1-S4-E1-V1	Discharge of the fluid (brine) for conservation and maturation of the anchovies. Once the process of maturation during the barrels flip prior to the operation of kneading is completed	Modify system of dumping. Making tipping system in dry screening that separates the wet salt of anchovy	Elimination of dumping pp-S4-E2-V1. Decrease in the subsequent cleaning. Decrease in saline load.
PP1-S4-E1-V2	Discharge of washing of salt covering the anchovies after producing the maturing barrels sift.		
PP1-S4-E2-V1	Discharge of water from the deposit of the first washing of anchovy's kneading.	Actions to consider: a) Installation of trays for spills, continuous filtering of wash water collection, removing supernatant fat in situ. Installation of punched baskets out of the drains.I b) Installation of three-phase decanter: water, fats and solids. Installation of punched baskets out of the drains.	Make the Kneading waters life longer and thus reduce consumption and loads. Recovering fats and possible use.
PP2-S4-E3-V1	Discharge of water from the tank of the second washing of anchovy's kneading.		
PP2-S4-E4-V1	Discharge of water from the deposit of the third washing of anchovies kneading.		
PP1-S5-E2-V1	Discharge of water from the deposit of the washing of anchovies with brine after the cut.	Replace washed with brine by washing with water. Install perforated basket in drainage.	Decrease saline load, reduce organic load
PP-S5-E2-V2	Discharge of the spill from tailings of brine in the desk after washing	Place recovery pipe of the spill to washing	Remove this stream from effluent. Decrease consumption of brine needs.

Estimated effect on / **Action**	**volume comsumpt ion/vefflu ent**	**Organic load**	**Brine load**	**Fats load**
Overflow collection in barrels	↓			
Dry separation of salt in sift	↓		↓	
Kneading water regeneration system	↓	↓		↓
Replacement of washing with brine by washing with water			↓	
Recovery of the spill on table work anchovy	↓	↓	↓	↓
Transport sardine thrust Recirculation system by Water	↓			
Spills recovery of brine in brining machine and boards of gutting and canned	↓	↓	↓	↓
Spill recovery flip grills	↓	↓	↓	↓
Installation of coarse screen baskets in several drainages.		↓		

Study case 3
Company dedicated to table olive canning

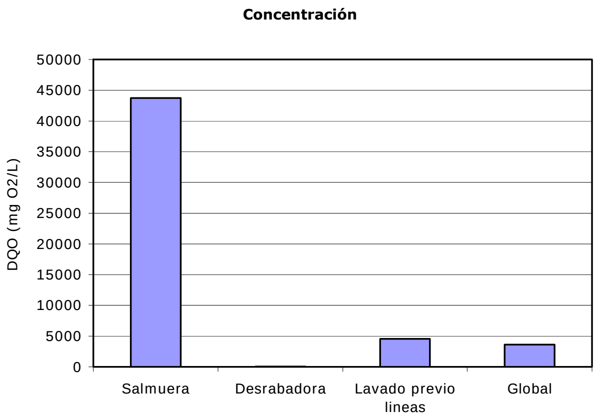
Flow chart

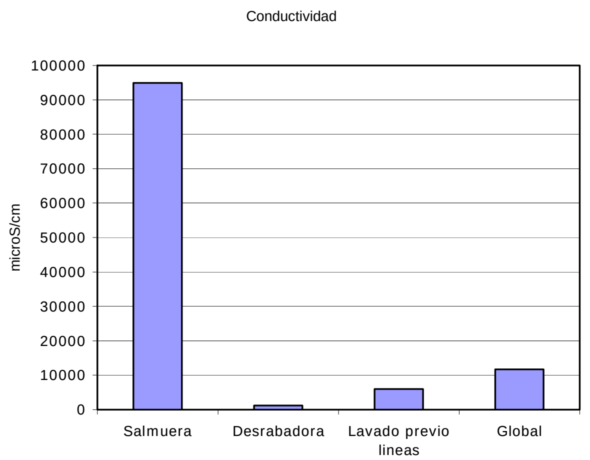


List and characteristics of main in-process effluents and global effluent

Operation	Wastewater characteristics
Emptying of olive brining barrels	High salinity
Olive washing in canning lines	Moderate salinity; moderate organic load
Washing in stalk pulling out machine	Low organic load
Sanitary waters	Like urban wastewater
General wash down	Moderate organic load

Contribution of streams to global effluent





LIST OF OPTIONS AND ACTION PLAN
Minimization measures taken:
✓ Segregation of the dumping of used brine
✓ Recirculation of water from the desrabadora
✓ Installation of water recirculation in washing lines
✓ Staff good practices **(dry clearing)**
Treatment mesures taken:
✓ Treatment by simple methods: – Fine screening – Aireated homogeneization

Performance monitoring

Parameter	Initial single sample	integrated simple befote minimisation	integrated simple after minimisation imiplementation	integrated simple alter minimisation + end of pipe treatment	% Reduction with minimisation measures	% Reduction with de minimisation + end of pipe treatment
pH (U. de pH)	4,4	4,52	5,48	7,5	-	-
Cond. (µS/cm)	18100	11720	4140	4140	65%	65%
SST (ppm)	276	240	187	86	22%	64%
COD (ppm)	6190	3630	1075	445	70,4%	88%
BOD5 (ppm)	3700	1720	862	-	50%	-
TKN (ppm)	81	56	28	-	50%	-
P (ppm)	32	16,6	3,5	-	79%	-
Toxicity (U.T.)	69	37,87	4,71	-	87,6%	-

Annex

Templates for preliminary water management assessment

Water management assessment

Company name

Contact person in the company:
Position:
phone: **email:**

Decription of industrial activity

Main product production per year: **units:**

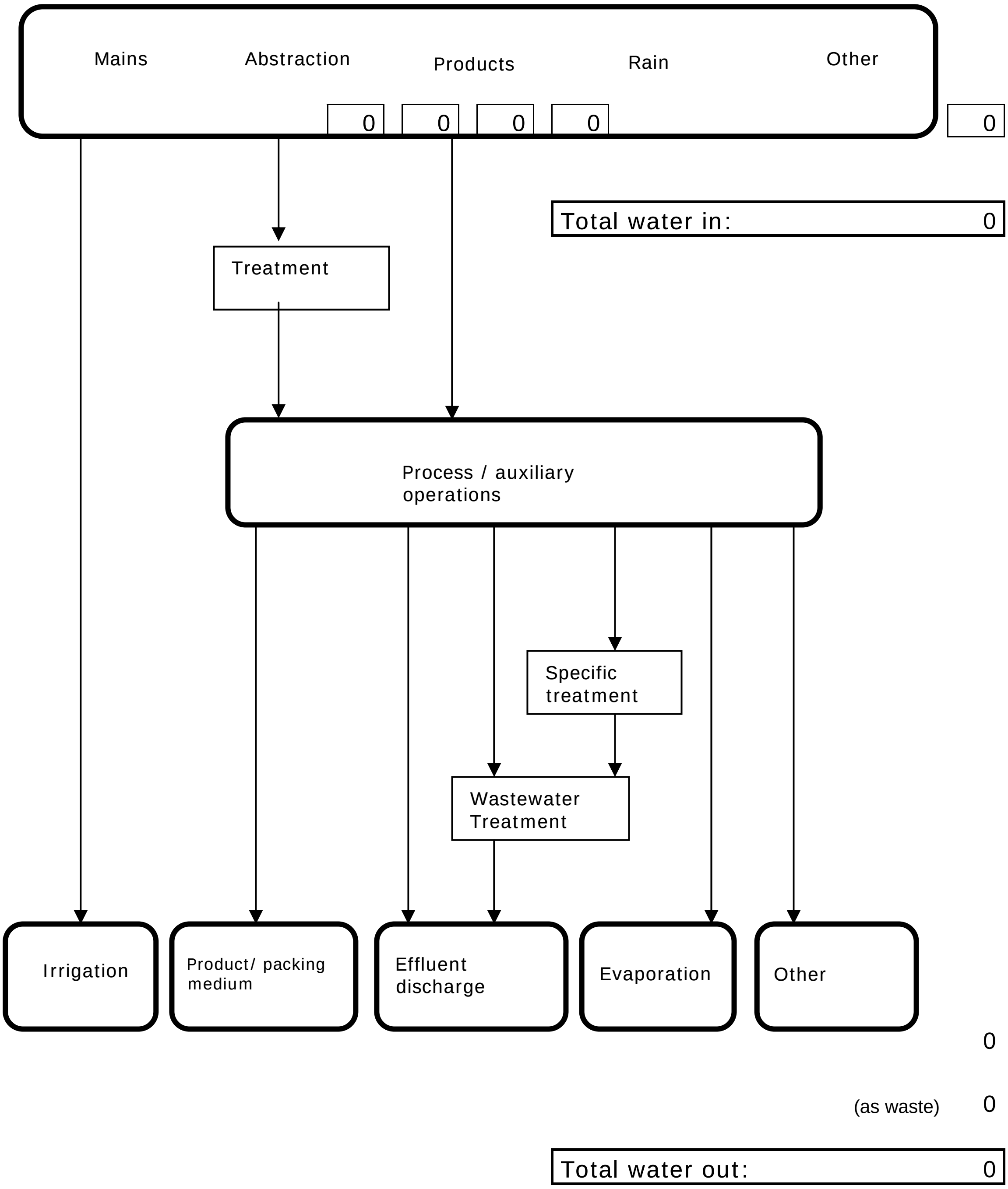
Develeoped by:

ainia
centro tecnológico

PRELIMINARY REVIEW Check on legal compliance
Main water and wastewater regulations of application to the company
Main water related legal requirements to comply with

PRELIMINARY REVIEW	
General water balance	
Inputs	**Water volume (m^3)**
Abstraction	0
Tap water	0
Water from products	0
Rain	0
Other	0
Total water in	**0**
Outputs	
Evaporation	0
Water in the product/packaging medium	0
Waste streams external management	0
Effluent discharge to sewer system	0
Irrigation	0
Other	0
Total water out	**0**
Water management annual cost	
Year: **Total water consumption (m3)**	**0**
Item	**Annual cost (€)**
Cost of Water supply	0
tap water	0
Abstraction of Ground water water	0
licenses	0
process water treatment (chemicals, energy, maintenance...)	0
analysis	0
energy (pumping, heating)	0
other (e.g. rain water)	0
Cost of waste water management	0
external management of liquid wastes	0
effluent treatment	0
sludge disposal	0
chemicals	0
energy	0
effluent discharge tax	0
analysis	0
Licenses	0
other	0
raw material lost in effluent	0
other	0
TOTAL:	**0**

PRELIMINARY REVIEW
General water flow chart



PRELIMINARY REVIEW
On site observations and comments on water use

E. g. make general visit to the company's facilities including production lines and auxiliary processes:

- observe and write down water use, effluents, etc
- interchange of ideas with different staff on the issue
- ask on opinions on potential water savings, that will be useful at this stage

Establish some basic indicators

- m3 water consumed per unit product	
- m3 wastewater discharged per unit of product	
- cost of water management: euros/m3 of water consumed	
- % of water management costs in relation to general costs	

PRELIMINARY REVIEW
Conclusions

Legal requierments

Water consumption levels and indicators

Wastewater production and indicators

Cost of water management

First sight observatios, opinions of staff

Information gaps

Actions to be taken