

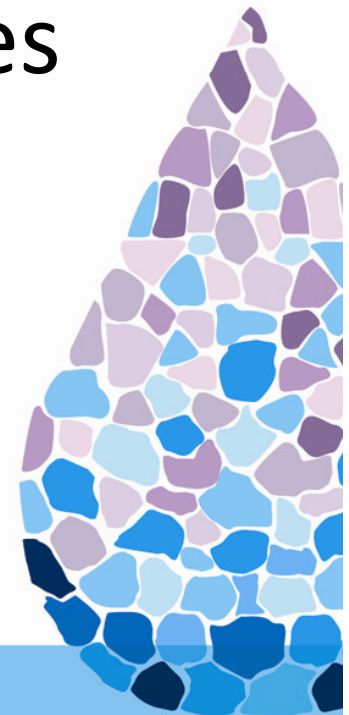
# An approach to the analysis of the critical control points of the Costa Brava water reclamation facilities

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# Water recycling: a worldwide need

- Water resources worldwide facts
  - Increase in population
  - Increase in water demand
  - Decrease in available resources per capita
  - Need for water recycling
- Safety procedures needed to keep risks under control
- Hazard Analysis and Critical Control Points (HACCP) methodology to be used in treatment for adequate public health protection

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# Costa Brava

- Touristic area in NE Spain, 200 km-coastline
- Resident population ~ 250,000 inhabitants vs. peak summer population ~ 1,000,000 inhabitants
- Limitation in available water resources (climate, small aquifers and rivers)
- In recent decades, increase in water demand, both potable and non-potable



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# Consorci Costa Brava

- Water utility formed in 1971 – 27 coastal municipalities
- Main activities:
  - Wholesale **drinking water** purveyor to **16 cities**, 5 external to CCB, **17.1 hm<sup>3</sup>/year** (2010)
  - Operation of **18 WWTP** servicing **31 cities**, 4 external to CCB, **34.1 hm<sup>3</sup>/year** (2010)
  - Operation of **14 water reclamation plants** (WRP) for a great variety of non-potable uses, **6.4 hm<sup>3</sup>/year** (2010)
- Design, construction, operation and maintenance of facilities funded by Catalan Water Agency (ACA) – regional water authority

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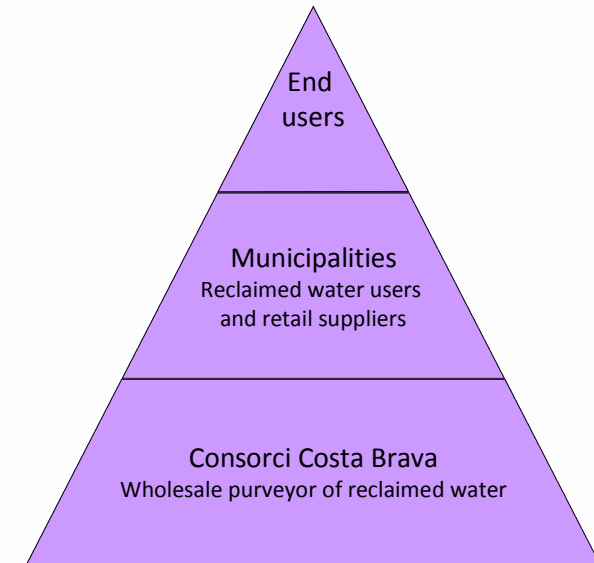
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# Municipal reclaimed water networks

- Aimed at saving drinking water in Port de la Selva (local aquifer) (2010) and both drinking water and energy in Tossa de Mar and Lloret de Mar (distant aquifer + desalination) (both 2007)
- Reclaimed water uses:
  - Present-day: portion of the municipal non-potable water demand (mostly, irrigation of public gardens, municipal services)
  - Mid-term aim: irrigation of private gardens
- Main efforts towards the control of microbiological risks for public health protection
- Real-time control of reclaimed water quality is essential – use of HACCP methodology to determine key control points



*Gravity storage tank of the Port de la Selva reclaimed water network – March 2010*

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# Tools for risk management (I)

- Goals of risk management: Identify, control and ensure risks are under control by focusing on prevention rather than on end-product testing
- HACCP methodology first developed in the 60s for the food industry. Science-based method composed of 7 steps (Codex Alimentarius, 2003) also included on ISO 22000 standard (2005) :
  - Hazard identification
  - Determination of critical control points (CCPs)
  - Establishment of critical limit(s) for the required parameter(s)
  - Monitoring of parameters in the CCPs
  - Establishment of corrective actions when critical limits are not met
  - Verification of the effect of corrective actions
  - Report procedures, actions and records

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# Tools for risk management (II)

- WHO Guidelines for drinking-water quality include Water Safety Plans (WSP), largely based on the concept of multiple barrier and on the HACCP system.
- Similar approach to be applied in the reclamation treatments, for a better risk control and subsequent health protection
- Monitoring needed at two different levels:
  - **Critical Control Point(s) (CCPs):** step(s) of the process at which control shall be applied and that is (are) essential to prevent, eliminate or reduce hazards to acceptable level
  - **Attention Point(s) (APs):** step(s) of the process where monitoring is needed to provide information for the adequate treatment, but that are not the key ones in the overall performance of the system

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# Reclamation treatments in Costa Brava

- Types of reclamation treatments
  - Disinfection (chlorine) (1 plant)
  - Combined disinfection, UV + chlorine (1 plant)
  - Sand filtration and combined disinfection (1 plant)
  - Coagulation-flocculation, double step filtration, combined disinfection (6 plants)
  - Coagulation-flocculation, sedimentation, filtration and combined disinfection (3 plants)
  - Microfiltration and reverse osmosis (1 pilot plant)
  - Constructed wetland system (1 plant)
- Operated according to established protocols
- Priority is given to the reliability of the microbial disinfection process



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# CCPs and APs in Costa Brava reclamation treatments (I)

**Table 4.** Attention Control Points (AP) and Critical Control Points (CCP) in the different elements of the several types of reclamation treatment trains in the Costa Brava.

| Attention and Critical Control Points | Treatment     |               |               |               |               |               |               |
|---------------------------------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|
|                                       | 1             | 2             | 3             | 4             | 5             | 6             | 7             |
| Secondary effluent                    | APse<br>CCPse | APse<br>CCPse | APse<br>CCPse | APse<br>CCPse | APse<br>CCPse | APse<br>CCPse | APse<br>CCPse |
| Coagulation                           |               |               |               | APcg          | APcg          |               |               |
| Flocculation                          |               |               |               | APfl          | APfl          |               |               |
| Sedimentation                         |               |               |               | -             | -             |               |               |
| Filtration                            |               |               | APfi          | APfi          | APfi          |               |               |
| UV disinfection                       |               |               | CCPuv         | CCPuv         | CCPuv         |               |               |
| Chlorination                          | CCPcl         | CCPcl         | CCPcl         | CCPcl         | CCPcl         |               |               |
| Microfiltration                       |               |               |               |               |               |               |               |
| Reverse osmosis                       |               |               |               |               |               | CCPro         |               |
| Constructed wetlands                  |               |               |               |               |               |               | APcw          |
| Reclaimed water                       |               |               |               |               |               |               | CCPrw         |

- 1 - Disinfection (chlorine) (ch) (1 plant)
- 2 - Combined disinfection, UV (uv) + chlorine (ch) (1 plant)
- 3 - Sand filtration and combined disinfection (1 plant)
- 4 - Coagulation-flocculation, double step filtration, combined disinfection (6 plants)
- 5 - Coagulation-flocculation, sedimentation, filtration and combined disinfection (3 plants)
- 6 - Microfiltration and reverse osmosis (1 pilot plant)
- 7 - Constructed wetland system (cw) (1 plant)

*For the compliance of Spanish regulations -RD 1620/2007-*

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# CCPs and APs in Costa Brava reclamation treatments (II)

*For the compliance of Spanish regulations -RD 1620/2007-*

- **Secondary effluent** (both AP and CCP):
  - AP: essential for establishing the operational parameters of the reclamation treatment.
  - CCP: when key parameters are above threshold level, water should not be allowed to enter the reclamation treatment.
- **Coagulation and flocculation** (APs): inadequate doses may be detrimental for the required quality, but still a certain loss would be tolerable if standards are met.
- **Filtration** (AP): same as above, to small losses of filter performance.
- **UV disinfection** (CCP): essential for the production of safe reclaimed water. Online monitoring needed for the protection of public health.
- **Chlorination** (CCP): same as above, either alone or as a polishing step after UV light.
- **Microfiltration** (CCP): essential both when working alone or in combination with a RO system. Performance parameters and/or online measurements needed to command decisive actions.
- **Reverse Osmosis** (CCP): Used for challenging uses (direct and indirect potable reuse), monitoring is required because of the impact on public health of non-adequate performance. Online measurements needed for its real-time detection, so decisive actions can be taken.
- **Reclaimed water** (CCP): Delivery to user/s should only be done upon compliance of quality parameters and it shall be halted if otherwise. Online monitoring essential for public health protection.
- **Constructed wetland system** (AP): Usually no action can be taken in such a facility to change the operating procedures. Information given by measurements will only be used for the recording of its performance.

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# Operation of Tossa de Mar WRP

- Capacity: 35 m<sup>3</sup>/h. Coagulation-flocculation, sedimentation, sand filtration, combined disinfection (UV + chlorine), storage (700 m<sup>3</sup>) and re-chlorination.
- Three CCPs with essential parameters monitored continuously:
  - **Online turbidity measurement in the secondary effluent:** Values above 15 NTU for more than 30 consecutive minutes will automatically shut down the inlet of secondary effluent into the reclamation plant.
  - **Online measurement of UV intensity:** Key parameter related to the performance of the equipment and to reliability of disinfection. A decrease from 100% level during 10 consecutive minutes will shut down the treatment and raise a failure alarm.
  - **Online measurement of redox potential values in reclaimed water:** Chlorination to produce redox potential values > 260 mV after UV dosage produces no detectable *E. coli* in 100 mL. If this value cannot be met for more than 10 minutes, reclamation plant will automatically shut down.

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# International experience - Australia

- Australian guidelines for water recycling (2006) propose a similar framework of risk management based on HACCP and WSP
- HACCP and WSP requirements are currently implemented in Australian water reclamation facilities
- Authorities rely on the risk management plan to allow supply of reclaimed water
- Monitored parameters are chosen depending on the intended use of the reclaimed water
- Western Corridor Recycled Water project: successful implementation of reuse at a regional scale with exhaustive monitoring of reclaimed water and risk management system

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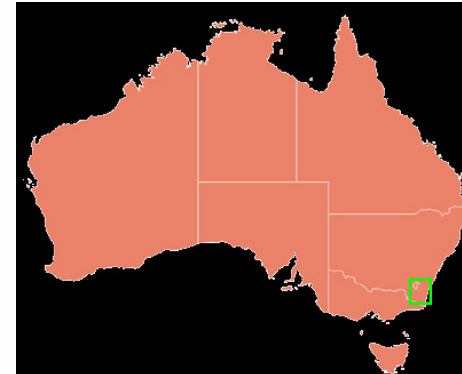
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# An Australian example : The Rosehill recycled water scheme

- Capacity: 20 000 m<sup>3</sup>/day, 3 reservoirs, 20 km of pipelines. Reclaimed water for industrial and commercial customers.
- Regulated by Water Industry Competition Act (WICA) that requires implementation of a HACCP system
- Process steps: Ultrafiltration, reverse osmosis, strong acid cation exchange, degasification, chlorination and pH correction
- Selected CCPs and parameters monitored are:
  - UF system → Pressure decay test
  - RO system → Log reduction in electrical conductivity
  - Chlorination tank → pH (environmental purpose)
  - Outlet of chlorination tank → Free residual chlorine



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# Conclusions

- Reclaimed water: dependable resource worldwide
- Development of water recycling in Costa Brava has led to municipal distribution networks in 3 municipalities
- Real-time control of reclaimed water quality is essential (HACCP). Priority: control of microbiological risks.
- Analysis of critical control points (CCPs) and attention points (APs) in Costa Brava reclamation facilities:
  - CCPs: secondary effluent, disinfection (UV and chlorine), reclaimed water
  - APs: secondary effluent, auxiliary treatments
- Australia:
  - HACCP and WSP requirements are currently implemented in Australian water reclamation facilities
  - Authorities rely on the risk management plan to allow supply of reclaimed water to customers

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