Projet MARECLEAN

MARECLEAN CORE CONCEPT

LIVRABLE D 5.3
CONCEPT MARECLEAN TRANSPOSABLE

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1. Introduction

This report summarises the methodology that can be used for protecting coastal waters affected by microbiological pollution, as a result of the MARECLEAN project. It is the outcome of the task 5.3.

5.3 Definition of reference cases, of the MARECLEAN core concept and of generic implementation tools

IRH, TME and AESN define 4 reference cases covering the most favourable contexts for the application of the method. These reference cases are theoretical, but possibly associated with real situations. They are described in detail with respect to quantitative elements and organisational context. An overview of their statistical significance in the various countries is given.

IRH, AESN, TME, CGE and SAUR adapt and formulate the MARECLEAN core concept for fitting best these reference cases. The limits of applicability are identified. AESN comments on its limits for implementing the EU Directives.
IRH, Météo France, IFREMER, SMBCG, SMPC and AESN shortly describe the generic implementation tools available for implementation. This covers at least: climate alerts, transfer modelling, structuring of risk evaluation, use of risk evaluation for consensus building, active flow management solutions, adapted hydraulic engineering, on the base of the demonstration and of related experiences. These approaches will take into account ongoing and potential source reduction actions whenever possible.

TME, IRH, CGE, SAUR, Météo France, IFREMER and AESN evaluate the funding required for implementation in the 4 reference cases.
IRH evaluates the discharge and impact reduction that can be expected from the method application in the reference cases.

Objective of the MARECLEAN method
The MARECLEAN method aims at minimising the expense for improving the microbiological quality of coastal waters. It is best applicable to a set of adjacent bathing waters or shellfish raising areas subject to similar influences, in the case of multiple potential sources.

Deliverables of method application

- Ranking of preventive actions on pollution sources according to their cost efficiency.
- Identification of areas of concern for which detailed studies are needed.
- Evaluation of economic benefit to be expected from preventive action.
- Application of specific prevention systems to selected sources.

2. Method steps

2.1. Risk assessment

1. Define **impact locations** in the polluted area. Typically, these are the regulatory control points, but others can be selected.
2. Build a marine dispersion model for calculating the concentrations at sea caused by terrestrial and marine sources. The area should reach at least 20 km around each impact location. Calculation of currents accounts for the effects of tide, regional flow and wind. An exponential decay rate (marine T_{90}) describes the inactivation of micro-organisms.
   The model can be based on a 2D mesh grid. In simple cases an empiric analytical model can be used instead. Very complex situations may require a 3D mesh grid.
   It should accept as input either instantaneous loads of pollution released at specific locations, or time varying discharges, or a combination of both.
   The main output needed are maps of maximum concentrations reached in given conditions. Additional useful results include particle trajectories and concentration time series.
3. Delineate the **coastal watersheds** (i.e. up to 30 km upstream from the sea, or more) of all outlets potentially contributing to the pollution at impact points. At least all outlets located within a distance of 10 km from an impact location should be considered. Divide the watersheds in sub-watersheds sized 5 to 30 km^2 according to the accuracy of available data.
4. Gather or measure a set of **synchronous data**, possibly time series running over 24 to 72 hours starting at a rainfall event, including:
   - sea water quality (E. coli, enterococci, salinity)
   - pollution and water flow at the outlets,
   - pollution flows originating from slowly varying sources e.g. the discharge of wastewater treatment plants,
   - tide magnitude, wind direction and velocity, hourly rainfall intensity over the watersheds (preferably space resolved).
5. Build a GIS database covering land and sea for storage and display of these data and of modelling results.
6. Build a pollution flow model for simulating the transfer of pollution from all sources within the watershed to the sea. The output are time series at a resolution of 6 hours or shorter.
   The model calculates the transit time between any portion of the watersheds and the sea according to topography and to rainfall history, and applies an exponential decay to the pollution loads transiting in the rivers under a plug flow hypothesis (riverine T_{90} decay rate). Whenever possible use the same calibration constants throughout the study area.
   Calibrate the velocity model by using the rainfall and the water flow data.
7. Build a pollution source model for both E. coli and enterococci. Sources are defined by type (WWTP, other dry weather urban flows, combined sewer overflows, rainwater drainage, bathing and nautical activities, wash out of pastures, wild birds, specific point sources, …) within each sub-watershed. The magnitude of sources is derived by simple equations from the following data:
   - unit daily production (literature),
   - spatial information such as Corine Land Cover, publicly available statistical data, …
   - seasonal variations of tourism, pasturing cattle, …
   - rainfall data, tide, and other short term phenomena if relevant.

   Only a few calibration constants should be used for the whole set of equations.
8. Calibrate the source model and the riverine T_{90}, against the pollution flow data.
9. Simulate impacts at sea for unit pollution loads under diverse dispersion scenarios (e.g. tide and wind) for each of the outlets. Define the critical load at each outlet as the minimal pollution release that can generate a pollution concentration above the impact level at one or more impact locations.
10. Back-propagate the critical load along the river network to the sub-watersheds, for ranking individual pollution sources according to their maximum potential impact.

Iterations between modelling and measuring improve the overall approach versus a merely linear scheme.

2.2. Selection of preventive solutions

A number of existing technologies can be used for recovering an adequate seawater quality. MARECLEAN developed two methodologies for ranking their application according to the cost/benefit ratio.

The critical load method
In each sub-watershed the ratio of local emissions to the critical load is a measure of the importance of acting at this location.
This ratio can guide the allocation of resources for a given type of measures over the whole watershed. It is less effective in comparing different types of measures because it does not take into account the differences in impact frequency related to different sources with different time variations.

The impact model method
This method requires a simulation of concentrations statistics at impact locations over several years considered as the reference period. Full or partial action scenarios are designed and simulated over the period by modifying the source model parameters and/or the transfer model parameters.
The residual impact for each action scenario over the reference period is derived from the concentration statistics. These residual impacts enable the calculation of cost/benefit ratios for the scenarios.
Only this method enables to capture the full potential for cost reduction by the MARECLEAN method. Such an approach is required when establishing a global budget for water quality recovery.

2.3. Active urban water management during rain events

The overflow of combined sewers and of lift stations are the most frequent mechanisms of pollution release during rainy periods.

The critical load method can set the priorities for repairing defaulting lift stations. A critical default duration can be defined for each lift station according to its size and location. Action has to proceed by order of increasing critical default duration. This approach is especially helpful when no operator monitors continuously the water level in the lift stations.

In complex sewer systems the storage capability offered by the ducts and basins is not fully used when pumps are driven according to local water level observations, as is standard practice. A can be achieved when the sewer network is managed as a whole.
Centralised real time sewer network management provides a better protection by using efficiently available capacities. It consists of simulating the overflows in real time for different pumping scenarios, starting from the present water levels and from immediate rainfall forecast. The update of pumping orders should occur at least every 15 minutes.
The system can be further improved by considering different sensitivities for different discharge points.

2.4. Active management of bathing waters closure and re-opening

Seawater quality modelling enables to close preventively the relevant bathing waters after a rainfall or another significant pollution event. Quality monitoring results obtained with rapid analytical methods can be interpreted in the light of recovery trends predicted by modelling.
Such operational use of modelling and measuring enables to improve and update the understanding of pollution sources and transfer, with benefits for the implementation of preventive actions.

2.5. Economic evaluation of pollution costs

See relevant documents prepared by TME for the methodology (Cf Annex 1).

Traditional preventive action has been oriented towards a better treatment of urban wastewater (collection, storage of excess volumes, disinfection …) and to rainwater networks management (correction of wrong connections). The importance of other sources may be underestimated, while some of the traditional actions involve very high costs.
The gain of applying risk assessment is highest when low cost actions (e.g. riverbank protection in pastures) prove to be most efficient for water quality recovery.

3. Limits of MARECLEAN method application

The general principle of risk assessment for improving microbial water quality remains valid in most circumstances. However, some contexts force to abandon certain steps and possibilities.

- The work proceeds difficultly in the absence of a watershed authority in charge of the study and of a recognised economic stake.
- A very diverse landscape (topography, land occupation …) within the global watershed lessens the relevance of model calibration and obliges to acquire more data for characterising the various contexts.
- Large rivers extending far upstream of the coast cannot be modelled in the same way as coastal streams. Dedicated monitoring is needed for an effective description of their pollution load.
- Global study areas below 20 km^2 or above 5000 km^2 seem out of range for the methodology.
- Good quality rainfall data (e.g. radar map series) are essential.
- Major cities can make larger budgets available per km^2 watershed or per km coast. Therefore detailed models with a precise outcome can replace the simplified models. This may avoid some detailed studies for the detailed design of solutions.

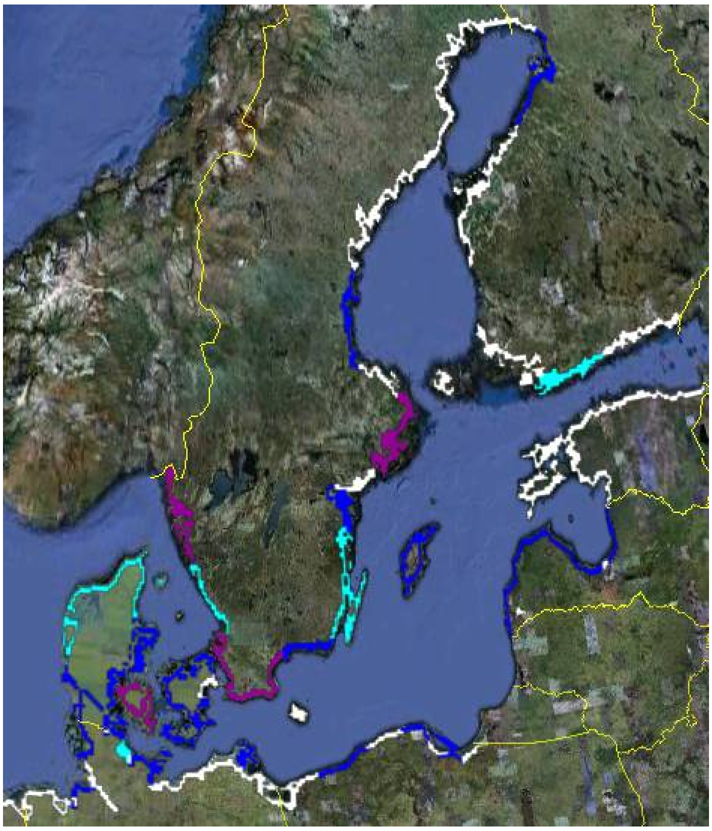
4. Areas of potential application for the MARECLEAN method

The most promising areas appear to be the semi-rural and rural coasts of the Atlantic and North Sea, but interesting opportunities exist in the Mediterranean area.

The following maps show the landscape of some European coasts. The underlying data originates from Corine Land Cover and from the Water Information System for Europe (bathing sites).

Number of coastal bathing areas per NUTS 3 territory
In France the NUTS3level is the "department".

- more than 100 bathing area in the NUTS 3
- from 50 to 100 bathing areas in the NUTS 3
- from 20 to 50 bathing areas in the NUTS 3
- less than 20 bathing areas in the NUTS 3



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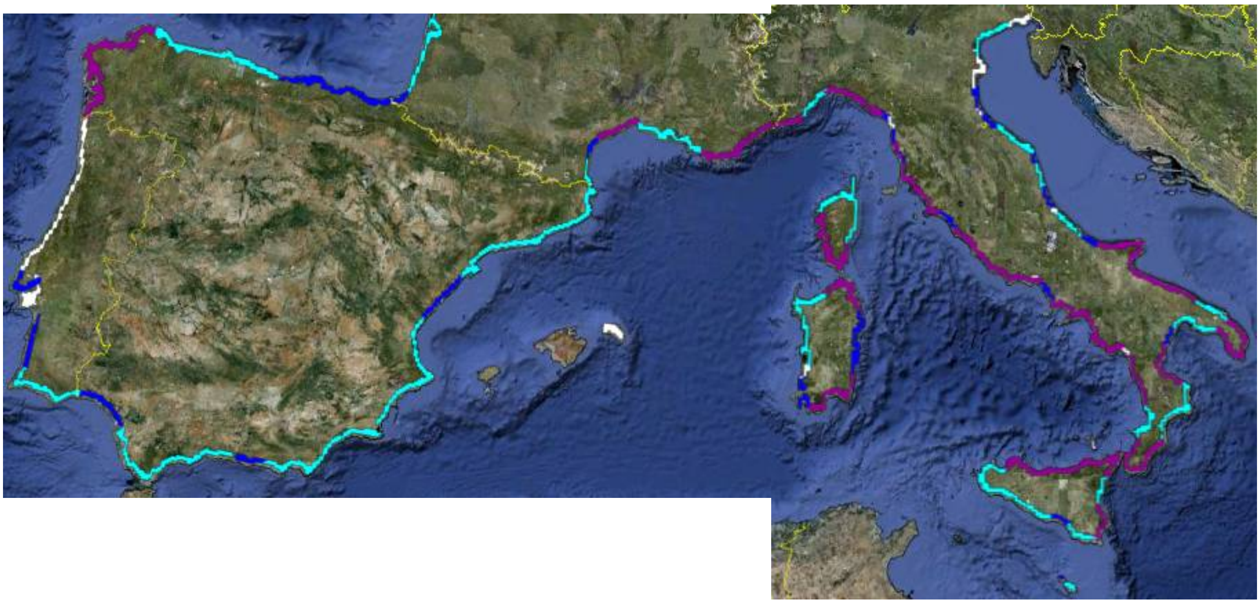
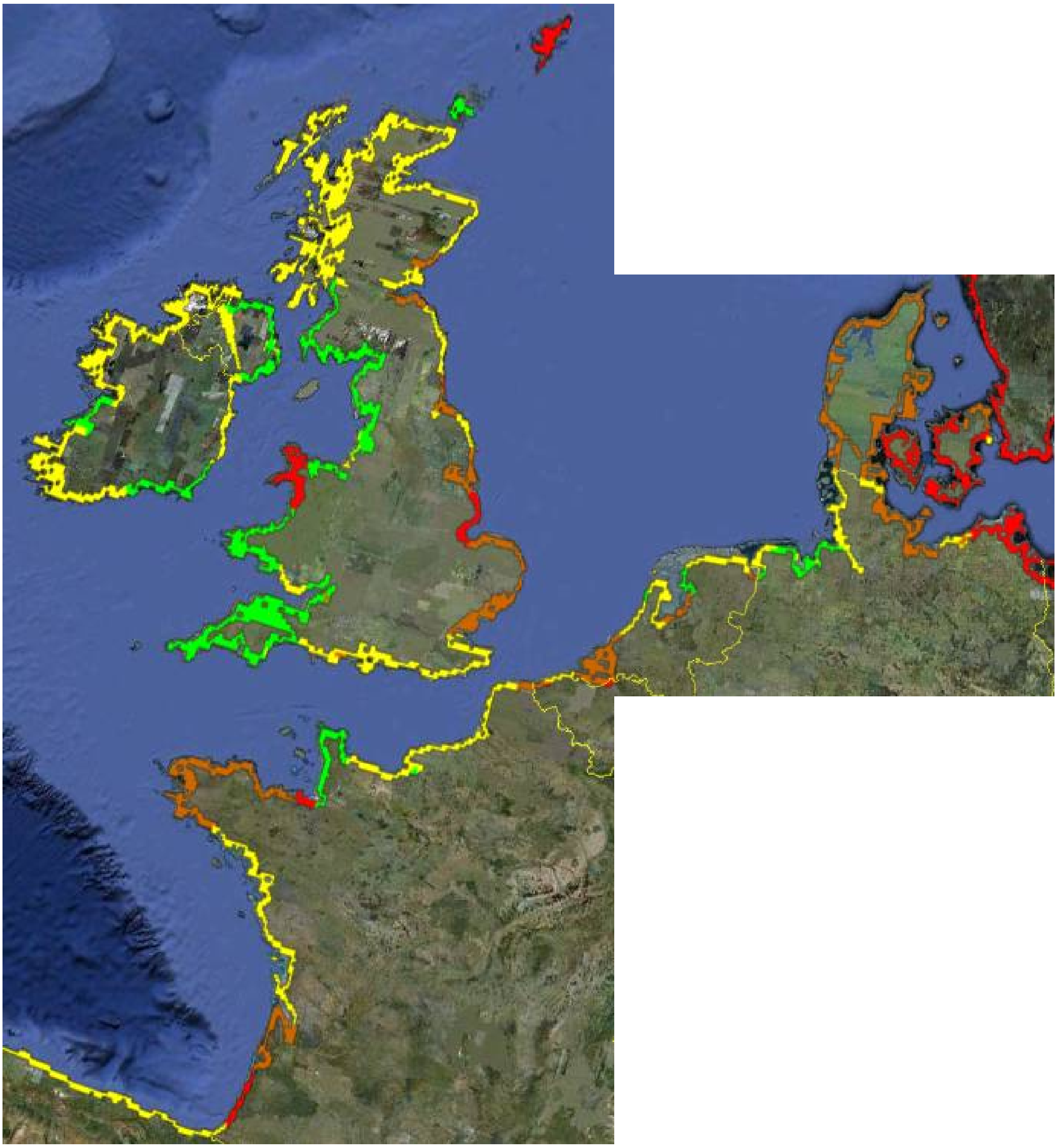


Level of pasture land cover in the coastal 10 km strip per NUTS 3 territory

- less than 1 % pasture cover
- from 1 to 10 % pasture cover
- from 10 to 50 % pasture cover
- more than 50 % pasture cover

Level of pasture land cover in the coastal 10 km strip per NUTS 3 territory

- less than 1 % pasture cover
- from 1 to 10 % pasture cover
- from 10 to 50 % pasture cover
- more than 50 % pasture cover

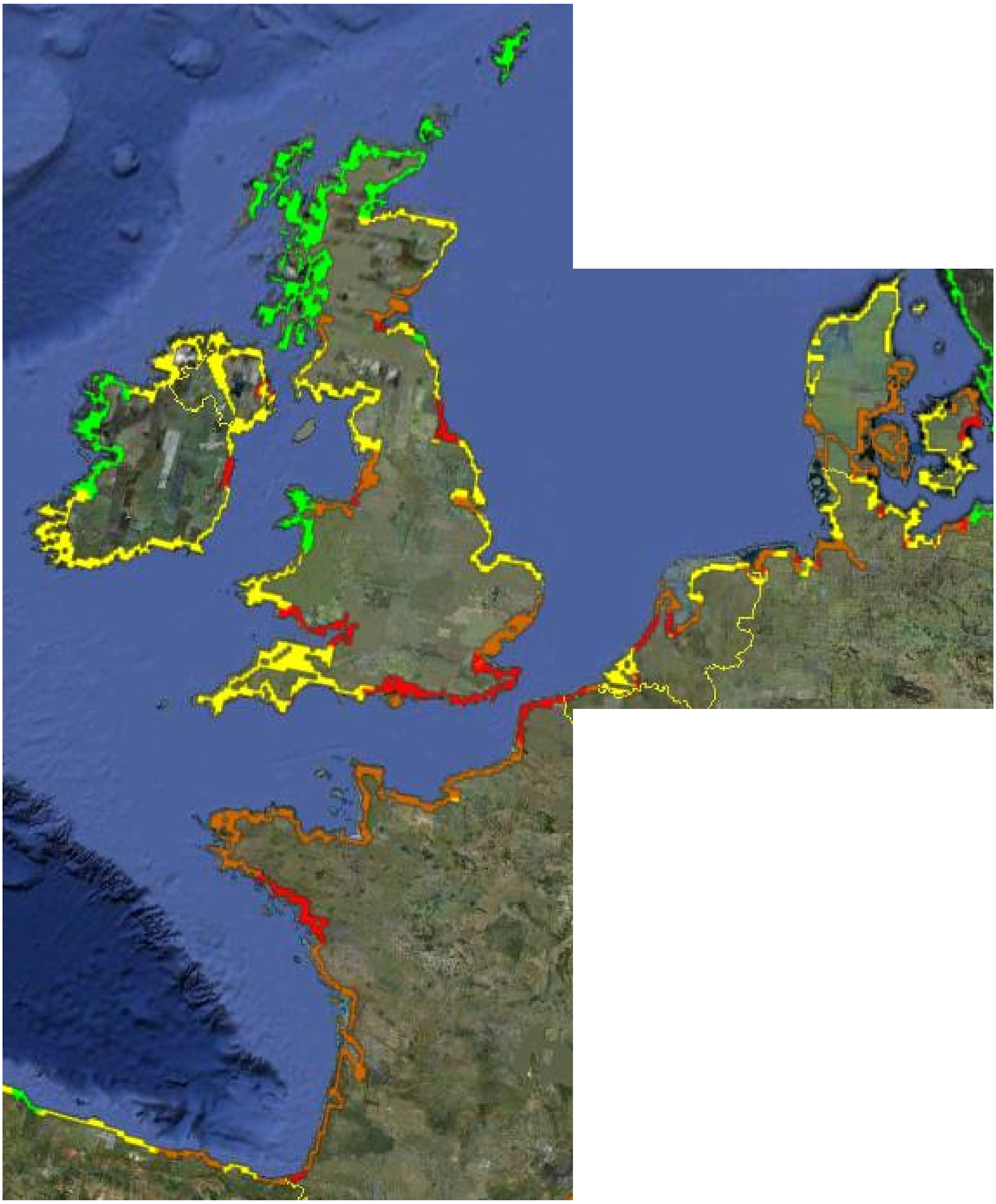


Level of urban land cover in the coastal 10 km strip per NUTS 3 territory

- more than 10 % urban cover
- from 5 to 10 % urban cover
- from 1 to 5 % urban cover
- less than 1 % urban cover

Level of urban land cover in the coastal 10 km strip per NUTS 3 territory

- more than 10 % urban cover
- from 5 to 10 % urban cover
- from 1 to 5 % urban cover
- less than 1 % urban cover



Annex 1 : GENERAL APPLICABLE METHOD TO ASSESS COSTS AND BENEFITS TO COMBAT COASTAL WATER POLLUTION

Jochem Jantzen, TME
Date: 4 October 2009

Introduction

The lessons learned from the application of Cost Benefit analysis in the project area, can serve as starting point for setting up a general applicable method to assess costs and benefits to combat coastal water pollution.

We propose, in stead of defining and assessing 4 reference cases, a general applicable approach, which includes all relevant parameters that can be taken on board when analysing the costs and benefits of the Mareclean approach in a specific regional context.

This memo contains an overview of these parameters and some indication of values.

Costs:

Costs can be linked with:
- Sewerage system (point pollution)
- Diffuse pollution from agriculture (livestock), pets and natural causes (birds, wild animals)
- Treatment costs for shellfish
- “Study costs”

Sewerage:
Options to reduce pollution from the sewer system:
- Extend storage capacity[1]
- Shift from mixed to separate system (rainwater not mixed with raw sewage from households)[2]
- Active management:[3]
  - Better use of existing storage capacity (by pumping)
  - Direct overflow to point that affect less the coastal water quality (by pumping)
- Individual treatment in stead of sewerage (advanced septic tanks, reed filters)

The costs to implement such measures depend (largely) on:
- Existing infrastructure
  - Pumping stations at the right (desired place)
  - State of maintenance (% of malfunction)
  - Single (mixed) or separated sewerage
  - Treatment capacity and type of treatment for secondary waste water (run off from streets etc.)
- Unit costs
  - To a certain extent, unit costs should be more or less equal, although larger scales may give cost advantages (but in public management often the opposite is the case)[4]
- Local situation
  - The local climatological situation

- o Is there space for creating storage capacity or need space be created at costly places

Diffuse pollution:
Options to reduce diffuse pollution from agriculture:
- Avoid animals to drink from streams/artificial ditches by fencing and creating drinking places for livestock

Options to reduce diffuse pollution from pets (dogs, cats, etc.).
- Mandatory cleaning by pet owners (dispose excrements in waste-bins)

Options to reduce diffuse pollution from birds (and other wild animals)
- Improve waste management near beaches (avoid that food waste is accessible for birds)
- Noise to scare birds

The costs of measures for agriculture depend on:
- Length of fencing needed (which depends on meadows with livestock near coastal streams, vulnerable zone (20km from coast?) and providing drinking places
- Unit costs of fencing and drinking places (# of cattle affected) [5]

The costs of measures for pets depend on:
- Costs of public information,
- Costs of enforcement regulations
- Level of fines
- Mentality of (mainly) dog-owners

The costs of improved waste management near beaches depend on:
- Mentality of bathing and other guests
- Availability of waste bins which don't allow birds to enter (and steel food)
- Cleaning frequency and costs of cleaning services]
- Costs of enforcement
- Level of fines (does revenue cover the costs of enforcement)
- Willingness of local authorities to improve waste management

Treatment costs for shellfish:
The costs of measures for treatment of shellfish depend on:
- Share of the total production in coastal water classified as B (or lower)
- Number of producers and their annual production capacity (scale of production)
- Unit costs of treatment (either depending on tons of production or on number of producers)[6]

Study costs
To apply the Mareclean approach it is necessary to set up an information and alert system, as to guide regional authorities and others involved in taking the right decisions timely. The example of the Mareclean project can be used as a proxy.

Avoided damages and Benefits:

Avoided damages/benefits can be linked with:
- Income from tourism linked with the availability of (clean) beaches
- Income from shell fish harvesting

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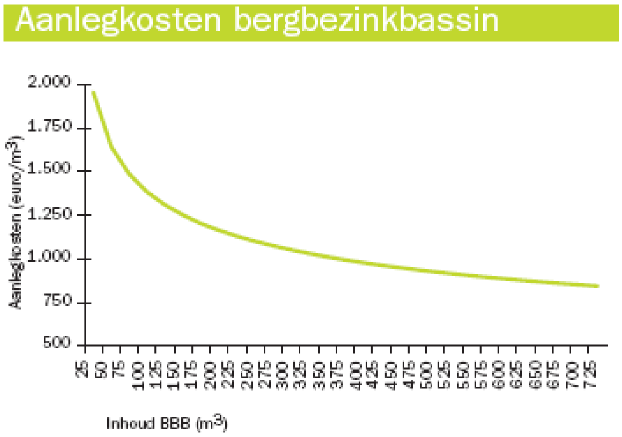
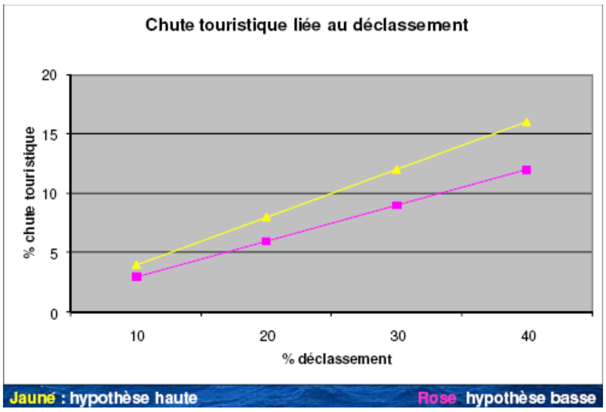
Tourism
The avoided damages for tourism depend on:
- (Annual) direct and indirect income from tourism in the region. This can be estimated from:
  - tourist overnight stays in various accommodations (hotels, camp-sites, second homes, other)
  - tourist direct (lodging) and indirect expenditures (food, leisure activities, construction sector, etc.)
- Share of beaches that will be declassified (closed) or (better) share of beach guest negatively affected by closure of beaches (as some beaches are more popular than others)
- Anticipated drop in (income from) tourism (may be linear with drop in tourist visits/overnight stays)[7]

Shellfish
The avoided damages for shellfish harvesting depend on:
- (Annual) direct and indirect income from shellfish in the region. This can be estimated from:
  - annual (multi annual average) harvest of shellfish (oysters and mussels) in tonnes
  - average prices for oysters and mussels[8]
  - (indirect) income from retail
- Share of harvest in coastal water classified as “B” or lower

Regional information needed

To assess both costs and benefits, certain data depend on the regional context.





Kosten aanleg en vervanging

Aanlegkosten per woning	1997	2002	2005
Gemengde stelsels	2.800	3.500	3.500
Verbeterd gemengde stelsels	3.200	3.900	4.000
Gescheiden stelsels	3.500	4.400	4.500
Verbeterd gescheiden stelsels	4.200	5.200	5.200
Drukriolering	6.700	7.800	8.300

Vervangingskosten per woning	1997	2002	2005
Gemengde stelsels	5.500	6.700	6.700
Verbeterd gemengde stelsels	6.000	7.400	7.400
Gescheiden stelsels	7.700	9.500	9.500
Verbeterd gescheiden stelsels	9.000	11.100	11.100
Drukriolering	8.500	10.100	10.700

Bron: Stichting RIONED, Leidraad Riolering

Dispositifs :

- Clôtures :
  - Rang de ronce – Coût : 4.40 € HT / ml
  - Clôture électrique – Coût : 2.30 € HT/ml
- Passerelles de franchissement :
  - Matériau : bois – Coût : 1200 € HT / Plus efficace que le passage à gué
- Points d'abreuvements :
  - Aménagement au cours d'eau
    - Peu d'entretien / Adaptabilité / Précaution : calage
    - Coût : 850 € HT
  - Pompe à nez
    - Aucun contact direct avec l'eau / Contrainte : maintenance régulière
    - Coût : 420 € HT
  - Bac
    - Aucun contact avec l'eau
    - Contrainte : pente minimale
    - Coût : 400 € HT

End notes:

1 See RIONED
2 See RIONED, additional costs of separate sewers
3 Experience of Mareclean project can be used here (check with Pottecher (and SAUR and Veolia) to figure out how costs are depending on other factors (# of inhabitants, length of sewerage, etc. to formalise cost estimates.
4 Information from the Safege study can be used as a first proxy
5 See presentation Dieudonne SMBCG: 3.11_SMBCG_Pollutions diffuses-entretien et aménagement de rivières_PPT.pdf
6 Use can be made of unit costs from AESN jul 2004 (as used in CBA report TME)
7 it assumes drop of 30-40% in tourism if all beaches in a region are closed! See: Duchemin: 1.3_AESN_Assainissement-pollutions diffuses_coûts nécessaires à l'amelioration de la qualité des eaux de baignade_PPT.pdf
8 These prices differ considerably between member states. Also margins of regional traders and retail should be taken into account (as they contribute to regional income). See Eurostat data on Oysters and Mussels (website?)