ENVIRONMENTAL ASSESSMENT OF ROAD MATERIALS INCLUDING MARINE DREDGED SEDIMENTS FROM DUNKIRK HARBOR (North Sea, France)

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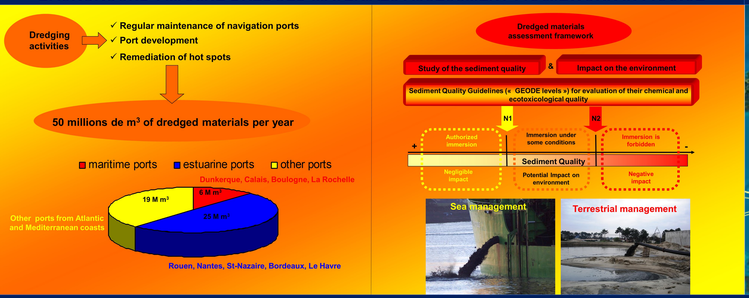
BACKGROUND : MARINE DREDGED MATERIALS ASSESSMENT FRAMEWORK IN FRANCE



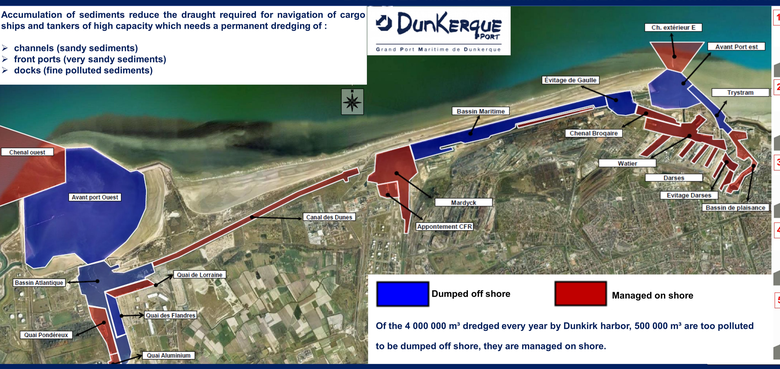
DUNKIRK HARBOR IN THE NORTHERN FRANCE

Dunkirk Harbor is located on the North Sea shore with a coast line length of more than 15 km. It is the third biggest coastal sea port in France.

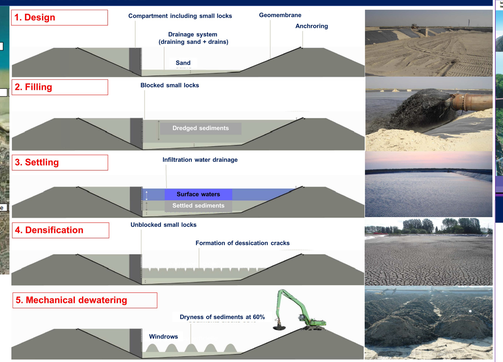
DREDGED MATERIALS MANAGEMENT BY DUNKIRK HARBOR AUTHORITIES

Accumulation of sediments reduce the draught required for navigation of cargo ships and tankers of high capacity which needs a permanent dredging of :

- channels (sandy sediments)
- front ports (very sandy sediments)
- docks (fine polluted sediments)



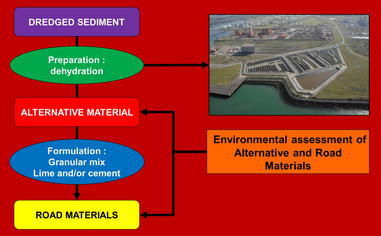
Of the 4 000 000 m³ dredged every year by Dunkirk harbor, 500 000 m³ are too polluted to be dumped off shore, they are managed on shore.



OBJECTIVE OF THE STUDY

The goal of this study is to assessing the environmental acceptability of dredged materials from Dunkirk Harbor produced after dewatering process and intended for road construction usage.

Prior this environmental assessment study, COLAS and EQIOM companies checked at industrial scale that the dredged sediment proposed for usage in road construction fulfills a useful function, i.e. its structural and geotechnical characteristics are suitable for its intended usage and comply with current construction specification standards for concrete road and base course.



Environmental assessment of Alternative and Road Materials

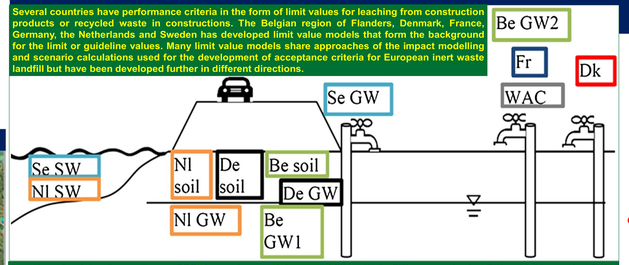
Concrete roads including 20% of sediments

Base course including 50% of sediments

CHEMICAL PARAMETERS		TOTAL CONTENT IN SEDIMENT	Level N1	Level N2
METALS	As	13.2 ± 1.3	25	50
	Cd	1.4 ± 0.1	1.2	2.4
	Cr	44.8 ± 2.5	90	180
	Cu	40 ± 3	45	90
	Hg	0.48 ± 0.10	0.4	0.8
	Ni	12.8 ± 1	37	74
	Pb	215 ± 29	100	200
	Zn	398 ± 34	276	552
PAHs	Naphtalene	0.1 ± 0.02	0.16	1.13
	Acenaphtylene	<0.1	0.015	0.26
	Acenaphtene	<0.005	0.04	0.34
	Fluorene	0.054 ± 0.011	0.02	0.26
	Phénanthrene	0.317 ± 0.063	0.24	0.87
	Anthracene	0.069 ± 0.014	0.085	0.59
	Fluoranthene	0.404 ± 0.081	0.6	2.85
	Pyrene	0.531 ± 0.106	0.5	1.5
	Benzo(a) Anthracene	0.317 ± 0.063	0.26	0.93
	Chrysene	0.327 ± 0.065	0.38	1.59
	Benzo (b) Fluoranthene	0.400 ± 0.080	0.4	0.9
	Benzo (k) Fluoranthene	0.225 ± 0.045	0.2	0.4
	Benzo (a) Pyrene	0.412 ± 0.082	0.43	1.015
	Dibenzo (a, h) anthracene	0.022 ± 0.004	0.06	0.16
	Benzo (ghi) Perylene	0.318 ± 0.064	1.7	5.65
	Indeno (1, 2, 3-cd) Pyrene	0.282 ± 0.056	1.7	5.65
PCBs	28	<0.01	0.005	0.01
	52	<0.01	0.005	0.01
	101	0.015 ± 0.003	0.01	0.02
	118	0.012 ± 0.002	0.01	0.02
	138	0.021 ± 0.004	0.02	0.04
	153	0.028 ± 0.006	0.02	0.04
	180	0.018 ± 0.004	0.01	0.02

ENVIRONMENTAL LIMIT VALUE MODELS IN EUROPEAN COUNTRIES

Several countries have performance criteria in the form of limit values for leaching from construction products or recycled waste in constructions. The Belgian region of Flanders, Denmark, France, Germany, the Netherlands and Sweden has developed limit value models that form the background for the limit or guideline values. Many limit value models share approaches of the impact modelling and scenario calculations used for the development of acceptance criteria for European inert waste landfill but have been developed further in different directions.

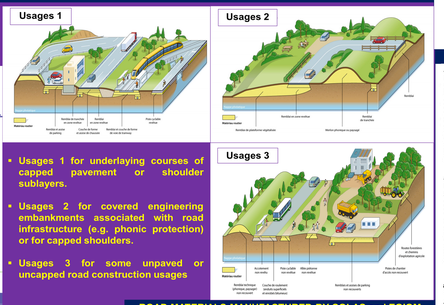


Location of points of compliance (POC) for environmental acceptability criteria GW = groundwater, DW = drinking water, SW = surface water. The squares represent the approximate location of POCs in different limit value models; Be = Belgium (Flanders), De = Germany, Dk = Denmark, Nl = the Netherlands, Se = Sweden. WAC = waste acceptancecriteria inert waste landfill.

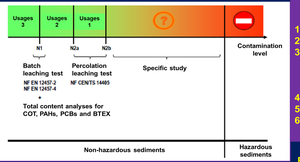
ACCEPTABILITY OF ALTERNATIVE MATERIALS IN ROAD CONSTRUCTION : GUIDELINES APPLIED IN FRANCE

French guidelines are reported in a methodolological guide entitled : «Acceptability of Alternative Materials in Road Construction – Environmental Assessment »

- Usages 1 for underlaying courses of capped pavement or shoulder sublayers.
- Usages 2 for covered engineering embankments associated with road infrastructure (e.g. phonic protection) or for capped shoulders.
- Usages 3 for some unpaved or uncapped road construction usages



THE PRINCIPLE OF THE METHODOLOGY FOR ENVIRONMENTAL ASSESSMENT



ROAD MATERIALS MANUFACTURED BY COLAS and EQIOM

6 formulations were subjected to environmental assessment :

1. Control Concrete Road : (CCR)
2. Sediment Concrete Road 1 : (SCR1)
3. Sediment Concrete Road 2 : (SCR2)

Concrete roads including 20% of dredged sediment

4. Road base course 1 : (RBC 1)
5. Road base course 2 : (RBC 2)
6. Road base course 3 : (RBC 3)

Base course materials including 50% of dredged sediment and various hydraulic binders

ENVIRONMENTAL ASSESSMENT USING BATCH LEACHING TEST PROCEDURE ACCORDING TO THE NF EN 12457-2 AS REQUIRED IN THE FIRST LEVEL OF THE METHODOLOGY

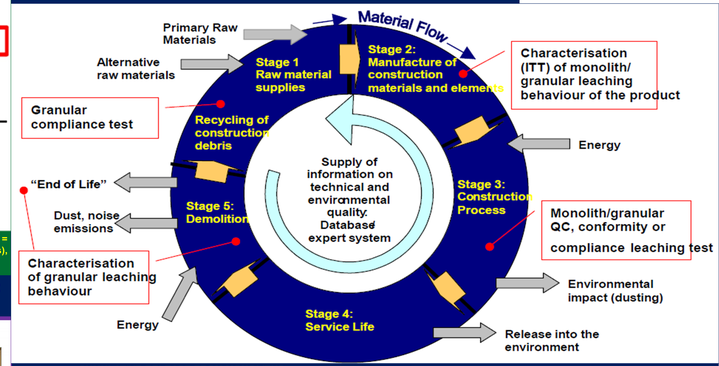
RESULTS OF ENVIRONMENTAL ASSESSMENT FOR THE FIRST LEVEL OF THE METHODOLOGY

- Alternative material = Dredged sediment :
  Not comply all parameters because residual salts not allowed to satisfy chlorides, sulphates and soluble fraction levels.
- Road materials = Concrete road and road base course :
  They not comply for fluorides due to chemical composition of hydraulic binders.
- Manufactured road materials are suitable to use in maritime works since salts are generally not considered as contaminants.

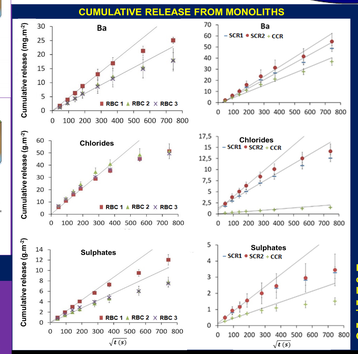
CONCLUDING REMARKS : These data about environmental performances of road construction materials including marine dredged sediments are the first to be published and may serve as a basis for identifying the amounts of hazardous substances that such construction products may release in waters. They are of great interest for potential users of secondary raw materials and required for CE-marking procedure of construction products.

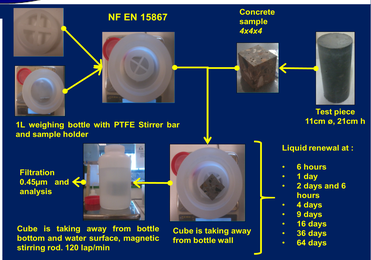
TIERED ENVIRONMENTAL APPROACH LINKED TO CONSTRUCTION PRODUCTS REGULATION (CPR) IN NETHERLANDS

GROUP 1



CUMULATIVE RELEASE FROM MONOLITHS





Leaching tests results highlight that highly soluble chemicals such as Ba, chlorides and sulphates are systematically detected in all road material leachates while some other elements (such as copper, vanadium, and zinc) may occur only punctually in the monolithic dynamic leaching test.
The amounts of chemical substances released at 64 days from all road materials are lower than limit values proposed by Netherlands in their Soil Quality Decree (2008) for monolithic construction materials.

Chemical parameters	Cumulative release at 64 days (mg.m⁻²) Road Base Course RBC1	RBC2	RBC3	Concrete Roads SCR1	SCR2	CCR	Limit values from Soil Quality Decree (2008) in Netherlands
As	< 0.7	< 0.7	< 0.7	< 0.4	< 0.4	< 0.4	260
Ba	25.1 ± 1.1	18.2 ± 3.5	17.8 ± 3	48.8 ± 1.6	54.9 ± 5.8	36.8 ± 2.2	1,500
Cd	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	3.8
Co	< 0.1	< 0.1	< 0.1	< 0.5	< 0.5	< 0.5	60
Cr	< 0.07	< 0.07	< 0.07	< 0.06	< 0.06	< 0.06	120
Cu	7.1 ± 0.4	4.6 ± 3.1	4.0 ± 1.5	2.3 ± 0.5	4.4 ± 0.4	0.3	98
Hg	< 0.005	< 0.005	< 0.005	< 0.4	< 0.4	< 0.4	1.4
Mo	< 0.5	< 0.5	< 0.5	< 0.3	< 0.3	< 0.3	144
Ni	< 0.3	< 0.3	< 0.3	< 0.2	< 0.2	< 0.2	81
Pb	< 0.7	< 0.7	< 0.7	< 0.5	< 0.5	< 0.5	400
Sb	< 1.6	< 1.6	< 1.6	< 0.5	< 0.5	< 0.5	8.7
Se	< 0.7	< 0.7	< 0.7	< 0.7	< 0.7	< 0.7	4.8
Sn	< 0.6	< 0.6	< 0.6	< 0.6	< 0.6	< 0.6	50
V	< 0.1	< 0.1	< 0.1	2.6 ± 0.1	2.8 ± 0.6	1.0 ± 0.1	320
Zn	< 0.3	< 0.3	< 0.3	< 0.2	< 0.2	< 0.2	800
Fluorides	< 320	< 320	< 320	< 320	< 320	< 320	2,500
Chlorides	51,432 ± 703	51,280 ± 767	49,510 ± 168	12,566 ± 518	13,925 ± 927	1,459 ± 102	110,000
Sulphates	12,030 ± 709	7,749 ± 748	7,489 ± 389	3,284 ± 118	3,449 ± 668	1,511 ± 65	165,000

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