



BIOSYNERGIE

Reconciling economy and ecology



Biological treatments*

**Pollution & Prevention
treatment
sediment, soil, water**

**Industrial, urban
and natural environment**

**Patented Processes*

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Site internet : www.biosynergie.net



REFERENCES & PARTNERS



Tripartite Departmental Partnership Agreement (P.R.I.D.) (12 years) France - COP21

Contribution <http://www.plateformesolutionsclimat.org/wp-content/uploads/2015/11/BIOTRAITEMENT-COP-21-2015-11-19.pdf>



BIOSSED Project -> University of the Littoral Opal Coast (ULCO) - France



- Partner Chair ECOSED Digital 4.0 Sediment Valorization- France - <https://ecoseddigital.wp.imt.fr/sediasphalte/>
- Partner Chair CIRVAL - IMT Lille Douai Research Center- France - <https://recherche.imt-nord-europe.fr/partenaires>



- Collaboration Research Contract University of Montpellier 2 - France: A test model of nitrification-denitrification / Evolution of sludge in wastewater treatment plants
- Scientific Publications:→ World Journal of Modeling and Simulation (World Academic Union) - Water Research - Elsevier Science Direct –
- Degradation of hydrocarbons in freshwater (Rainwater from Orly ADP - 94 - France) Pr. Paule Vasseur European Laboratory of Environmental Sciences (Metz - France)
- Pharmacy thesis (University of Franche-Comté / Faculty of Medicine and Pharmacy of Besançon) – France - N°25.93.027)
- Scientific meetings – Mare Nostrum - Polytech Nice - France – Sophia Antipolis

Presentation at Nautic Paris
of processes
to the French Ministers
of the Environment



Speaker at M.I.T.
at the Oceanographic Institute of Monaco
(Massachusetts Institute of Technology).

Some references:

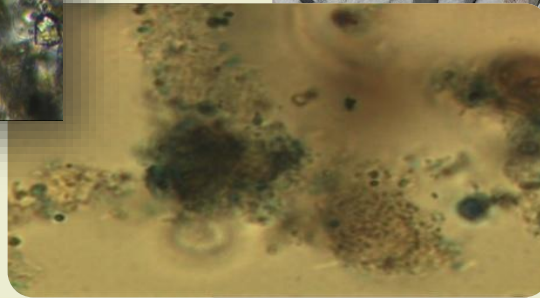
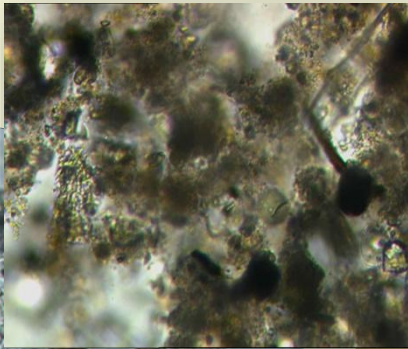
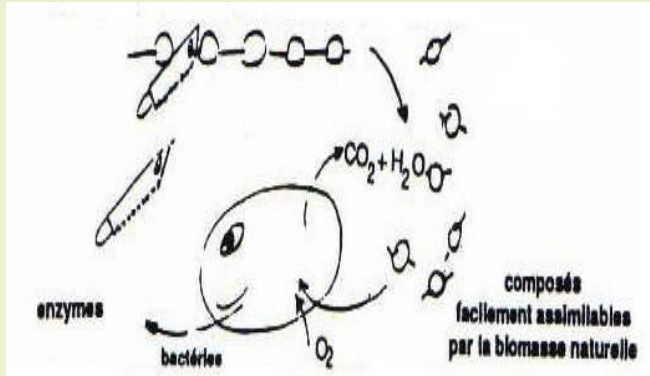
Various: Lac de Messéin (54), ONF Rambouillet (78), Sciez Lac Léman, Publier (74) - France ...

Port : Cavalaire (83), Camille Rayon, Gallice, Crouton, Cannes Marina (06), Carnon (34), Gravelines (59) – France – CAMG 77 –

Industrial Sites : Fluid System Technology (Portugal), Rompetrol Ploiesti et Constenta (Roumanie), St Gobain (54), HAROPA Port (Rouen 76) - Département 59 - France - ONF Rambouillet France



Samples of finished products



Class 1 microorganisms that are not dangerous for humans or environment (European Federation of Biotechnologies - CR 12894:1997) - Free to use without referring to the competent authority (European Directive 2000/54/EC1 of September 18, 2000)



Examples of applications and results



Spreading examples



Spraying by powder



Spraying by bags

Spraying by hovercraft





Examples of spreading

**Directional
spreader**



Floating barge



Roadside ditch dusting



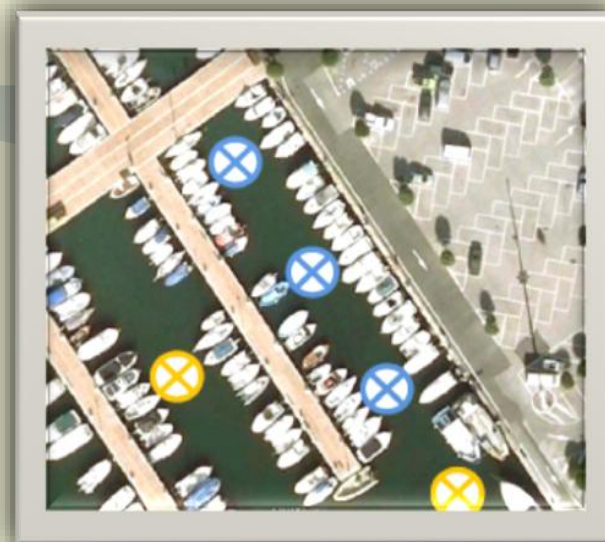
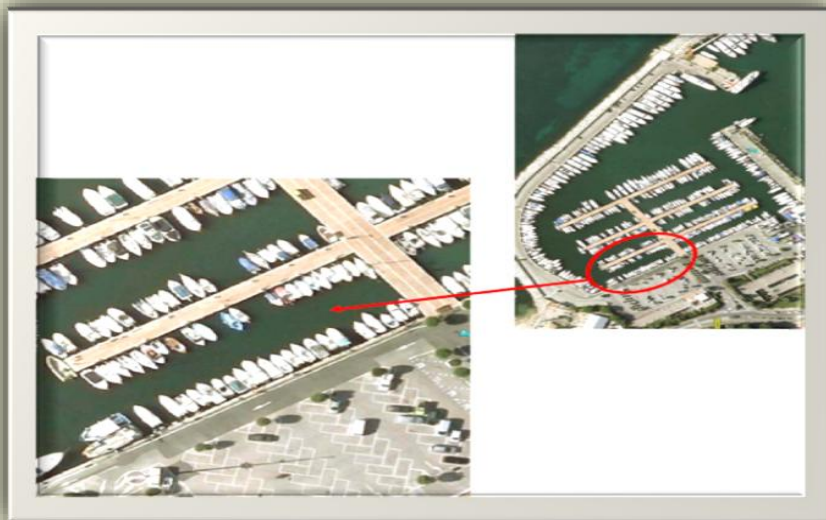
Examples of Applications & Results for seaports and bodies of water



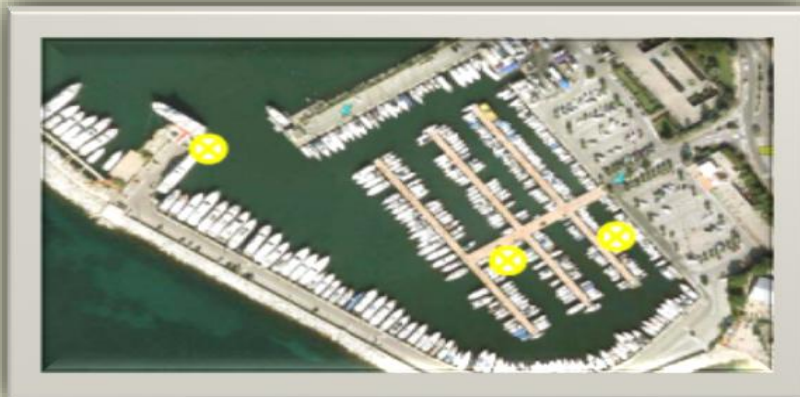
PORT GALLICE - Antibes-Juan Les Pins (06) - France

Reduction in sediment heights and volumes

Surface biotreatment 1,239 m²



Positions
of mussel
cages



Positions of sediment
monitoring stations





Biological treatment PORT GALLICE Antibes-Juan Les Pins (06) - France

Reduction in sediment heights, volumes, and weights

49 measurement points

BEFORE and 9 months **AFTER** TREATMENT



**Bottom view through transparency - Before
treatment concrete sill covered by sediments**



**Bottom view through transparency - After treatment
Exposed concrete sill and cables visible on the
bottom**



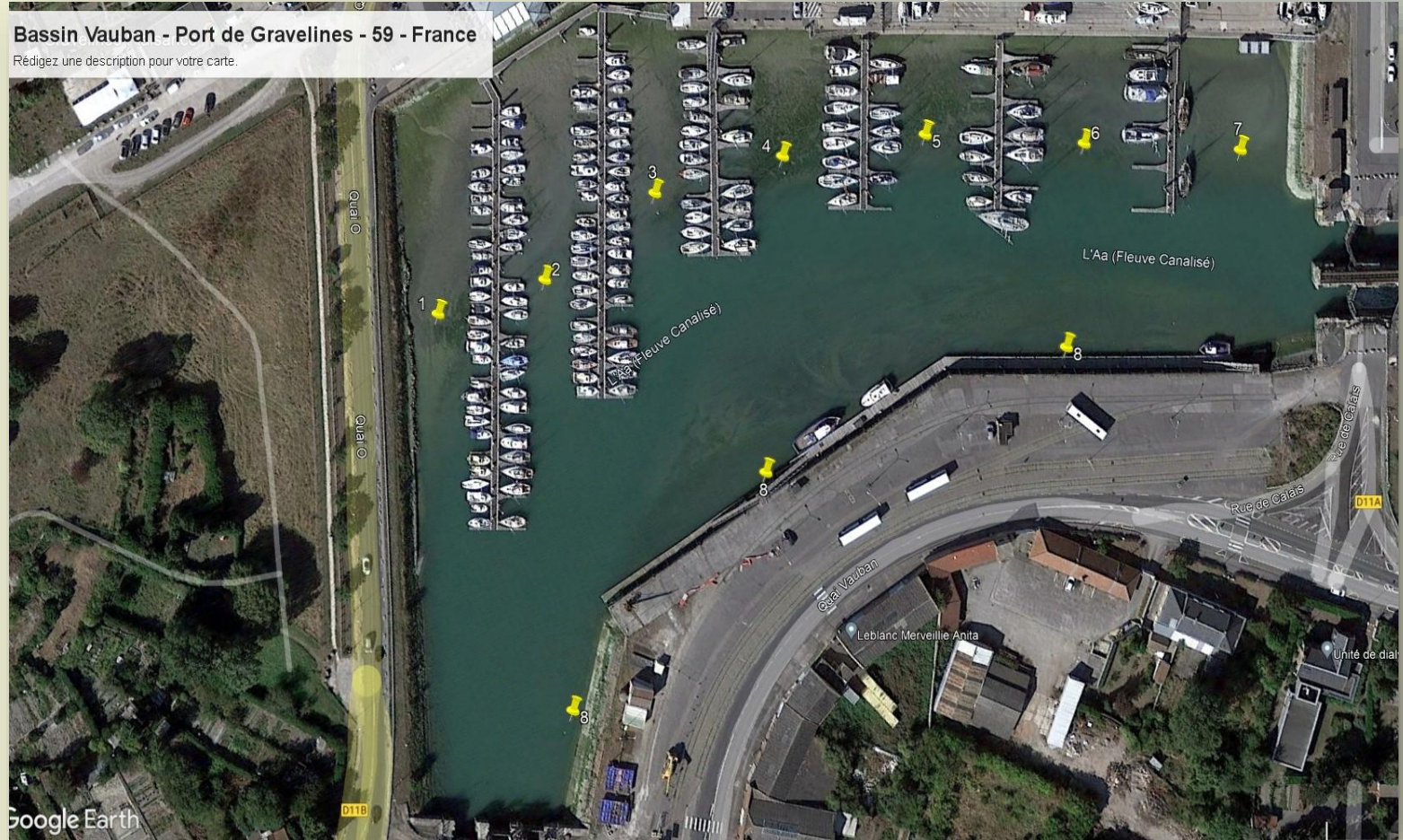
Port of Gravelines (59) France Biological treatment



Maritime port in the North Sea, with 2 ebb tides / 24 hours
Crossed by a river (the Aa), regulated by a lock (entrance/exit of the port)
Surface area of 3 hectares



Port of Gravelines (59) France - Biological treatment of the Vauban basin



Custom design and manufacturing of 19 tons of finished products

Spreading (according to precise specifications) → 12 tons on July 18, 2022 and 7 tons on May 22, 2023

Particle size distribution → 0,5-1 / 0,7-2 / 2-5 //



Port of Gravelines - Vauban Basin (59)- France
Biological treatment → Amounts degraded
(Surface / Height of sediment impacted / Average MS (32%)
TCH → 1481 kg (1,48*10⁹ mg) PAHs → 2,07 kg (2,07*10⁶ mg)

**Samples and analyses
conducted by the Ecole des
Mines de Douai (59), France**

	05/2022	11/2023	Diminution	Rendement
Point 1				
HCT (mg/Kg MS)	976	266	710	73%
HAP (mg/Kg MS)	2,047	1,07	0,97	48%
Point 2				
HCT (mg/Kg MS)	894	220	674	75%
HAP (mg/Kg MS)	2,291	1,06	1,231	54%
Point 3				
HCT (mg/Kg MS)	894	198	69	78%
HAP (mg/Kg MS)	1,547	0,865	0,682	44%

Fluoranthène - 4 rings

	Before	After	Diminution	Rendement
Site 1	0,271	0,157	0,114	42%
Site 2	0,386	0,136	0,250	65%
Site 3	0,193	0,113	0,080	41%

Benzo b Fluoranthène - 5 rings

	Before	After	Diminution	Rendement
Site 1	0,275	0,133	0,142	52%
Site 2	0,307	0,112	0,195	64%
Site 3	0,194	0,050	0,144	74%

Benzo a Pyrène - 5 rings

	Before	After	Diminution	Rendement
Site 1	0,156	0,050	0,106	68%
Site 2	0,170	0,050	0,120	71%
Site 3	0,113	0,050	0,063	56%

Benzo (ghi) Pérylène - 6 rings

	Before	After	Diminution	Rendement
Site 1	0,149	0,050	0,099	66%
Site 2	0,159	0,050	0,109	69%
Site 3	0,105	0,050	0,055	52%



Port of Gravelines (59) - France

Biological treatment of the Vauban Basin

Conclusion: reduction in sediment heights and volumes

Tables:

The following tables show that the results obtained by considering individually the periods between the two bathymetries conducted by BATHY DRONE SOLUTIONS/INGEO or by aggregating them differ slightly.

ETAT	DEBLAI (m3)	REMBLAI (m3)	VARIATION DE VOLUME (m3)	INTERPRETATION EN BAISSE DE HAUTEUR DE SEDIMENT	
				SURFACE DE REFERENCE (m2)*	VARIATION MOYENNE DE HAUTEUR DE SEDIMENT (m)
BDS - Etat 0 (Juillet 2022) / Etat 1 (Nov.2022)	-1809	1151	-658	29800	-0,0221
BDS - Etat 1 (Nov.2022) / Etat 2 (Mai 2023)	-4284	575	-3709	29800	-0,1245
INGEO (Mai 2023) / INGEO (Nov.2023)	-1197	1006	-191	33400	-0,0057
VARIATION TOTALE DE VOLUME (m3)			-4558		-0,1523

ETAT	DEBLAI (m3)	REMBLAI (m3)	VARIATION DE VOLUME (m3)	INTERPRETATION EN BAISSE DE HAUTEUR DE SEDIMENT	
				SURFACE DE REFERENCE (m2)*	VARIATION MOYENNE DE HAUTEUR DE SEDIMENT (m)
BDS - Etat 0 (Juillet 2022) / Etat 2 (Mai 2023)	-4593	452	-4141	29800	-0,1390
INGEO (Mai 2023) / INGEO (Nov.2023)	-1197	1006	-191	33400	-0,0057
VARIATION TOTALE DE VOLUME (m3)			-4332		-0,1447

The different reports used specific surface areas tailored to their studies to convert the results expressed in sediment volume into sediment height.

Bathymetric surveys conducted by INGEO Engineering and Surveyor Expert BLENDECQUES 62502 SAINT-OMER Equipment: professional bathymetric boat using a R2SONIC2024 multi-beam echosounder compliant with IHO S44 Special Order



Port of Gravelines (59) - France

Biological treatment of the Vauban basin

Conclusion: reduction in sediment heights and volumes

Analyzing the effects of biotreatment necessarily involves understanding the recurrent natural sedimentation of the Vauban Basin. Indeed, the observed decrease in sediment height after biotreatment is inseparable from the sediment height that would have accumulated over a period of 16 months between the last and first bathymetry surveys and which was mitigated by the biotreatment.

The siltation of the Vauban Basin is a major concern for maintaining its activities, and various studies have been conducted to address this issue. The most recent study, conducted in 2023 by the consulting firm IDRA, estimated the annual sedimentation to be 900 m³ based on a basin surface area of 22,128 m².

The avoided siltation can therefore be estimated at 5.42 cm ($900/22128/12 \times 16$) based on the study conducted by the consulting firm IDRA.

The effect of bio-treatment on sediment height, referring to the previous table, ranges between :

- 15.23 cm + (5.42 cm) resulting in 20.65 cm.
- 14,47 cm + (5,42 cm) resulting in 19,89 cm

It prevented sedimentation and reduced the height of the sediments initially in place during the first spreading, with an average height of 20.27 cm (+/- 5645 m³).

Nord Department (59) - France

Biological treatment of road ditches 2 x 30 meters

Comparative states: 06/2016 - 09/2016 - 09/2017



Site of RD 644- PR9 (Cambrésis) - 2 spreadings: 06/2016 and 02/2017

The effectiveness of BIOSYNERGIE bio-treatment is characterized across all parameters (TOC, TCH, PAHs, PCBs, and BTEX), but the initial values are very low. **Effectiveness is demonstrated despite possible exogenous inputs during treatment.**

Site of RD 204- PR01 (Dunkirk area) - 2 spreadings: 06/2016 and 02/2017

The effectiveness of BIOSYNERGIE bio-treatment is primarily characterized by the reduction of TOC and TCH, and to a lesser extent by the reduction of PAHs, PCBs, and BTEX, as the initial values are very low. Effectiveness is demonstrated despite possible exogenous inputs during treatment. **The unconsolidated sediments, initially measured by graduated rod in late June 2016 (ranging from 0 to 36 cm with an average of 11 cm over 32 points), had disappeared by September 2016 and October 2017. There is also an observation of the disappearance of unpleasant odors.**



Nord Department (59) -France

Biological treatment of road ditches 15 km

Yields from 2019 to 2021(TOC – TCH – PAHs)



Taux abattement moyen	T0 à T1 (3,5 mois Printemps/Été, 1 ensemencement, pluviométrie faible)			T1 à T2 (9 mois, Automne/Hiver, 1 ensemencement, pluviométrie forte)			T0 à T2 (12,5 mois)			T2 à T3 (10 mois, Automne/Hiver, pas d'ensemencement, pluviométrie moyenne)			T3 à T4 (6 mois, Printemps/Été, 1 ensemencement, pluviométrie moyenne)			T2 à T4 (16 mois)			T0 à T4 (28,5 mois)		
	COT	HCT	HAP	COT	HCT	HAP	COT	HCT	HAP	COT	HCT	HAP	COT	HCT	HAP	COT	HCT	HAP	COT	HCT	HAP
RD 300-G	40%	69%					38%	54%				68%						56%			
RD 300-D				11%	49%	22%	1%	21%				41%	18%	27%							
RD 318-G		10%		27%	27%	2%		46%				80%	14%	34%							
RD 318-D	29%				18%		20%				17%	60%	40%	23%	32%		36%	72%	1%		
RD 52-G	14%	37%	35%	6%	9%		19%	53%					16%	41%	91%	37%				23%	27%
RD 52-D	4%			9%		7%	13%				18%		21%	9%	84%		25%				
RD 18-G		79%	11%	9%									49%	72%	95%				42%	61%	35%
RD 18-D	25%	55%				38%							58%	70%	21%				27%		
RD 79-G				70%	84%	56%	42%	58%	34%										42%		
RD 79-D	55%	76%	61%	37%	39%		72%	85%				73%	23%						27%	32%	
RD 168-G	66%	38%									7%	60%		9%		43%	15%		33%		
RD 168-D	66%	90%	79%				56%	71%	77%			13%	42%	49%			15%	5%	55%	75%	78%
RD 928-G		1%	30%						7%	3%	2%	54%						6%			12%
RD 928-D		15%			22%	36%		34%	14%		12%	6%									
RD 138-G	76%	92%	81%				50%	91%	64%			91%	83%	65%		55%			78%	85%	63%
RD 138-D	34%	39%	51%	20%	52%		47%	78%	33%			77%				24%		48%	35%		65%
	10/16	12/16	7/16	8/16	8/16	6/16	10/16	10/16	6/16	1/16	5/16	11/16	10/16	10/16'	5/16	4/16	4/16	5/16	9/16	5/16	6/16
	63%	75%	44%	50%	50%	38%	63%	63%	38%	6%	31%	69%	63%	63%	31%	25%	25%	31%	56%	31%	38%
	29	60%		22	46%		26	54%		17	35%		25	52%		13	27%		20	42%	

Nord Department (59) – France

Biological treatment of road ditches 15 km

Yields from 2019 to 2021 (PAHs - 4 et 5 rings)



Taux abattement moyen	T0 à T1 (3,5 mois Printemps/Été, 1 ensemencement, pluviométrie faible)			T1 à T2 (9 mois, Automne/Hiver, 1 ensemencement, pluviométrie forte)			T0 à T2 (12,5 mois)			T2 à T3 (10 mois, Automne/Hiver, pas d'ensemencement, pluviométrie moyenne)			T3 à T4 (6 mois, Printemps/Été, 1 ensemencement, pluviométrie moyenne)			T2 à T4 (16 mois)			T0 à T4 (28,5 mois)		
	Benzo(a)	Benzo(b)	Fluoranthène	Benzo(a)	Benzo(b)	Fluoranthène	Benzo(a)	Benzo(b)	Fluoranthène	Benzo(a)	Benzo(b)	Fluoranthène	Benzo(a)	Benzo(b)	Fluoranthène	Benzo(a)	Benzo(b)	Fluoranthène	Benzo(a)	Benzo(b)	Fluoranthène
RD 300-G				53%	42%	50%	29%	14%	38%												
RD 300-D					11%	30%			30%	52%	45%	25%				36%	33%	14%			40%
RD 318-G						20%			7%	84%	84%	79%				13%	15%				
RD 318-D										62%	67%	59%		28%	40%	75%	77%	75%			
RD 52-G	32%	36%	23%				69%						91%	92%	90%		33%	45%	24%	26%	27%
RD 52-D					55%	9%							87%	88%	84%						
RD 18-G	18%	10%	29%										95%	95%	95%	89%	88%	89%	44%	29%	35%
RD 18-D				18%	25%	40%								24%	25%						
RD 79-G	53%				58%	51%	25%	39%	37%												
RD 79-D	63%	72%	69%				32%	51%	46%	31%	21%										
RD 168-G										54%	48%	65%									
RD 168-D	80%	80%	78%				75%	74%	78%	28%	34%	3%				23%	23%		81%	80%	77%
RD 928-G	43%	35%	22%				2%		10%	58%	66%	53%				20%	31%	13%	22%	11%	22%
RD 928-D			7%	43%	23%	18%			23%	9%	19%	9%									14%
RD 138-G	83%	82%	82%				57%	54%	70%	93%	94%	91%				8%	22%		60%	64%	69%
RD 138-D	48%	46%	48%				12%	13%	28%	80%	78%	80%				48%	48%	58%	55%	55%	70%
	8/16	7/16	8/16	3/16	6/16	7/16	8/16	6/16	10/16	10/16	10/16	9/16	3/16	5/16	5/16	8/16	9/16	6/16	6/16	6/16	8/16
	50%	44%	50%	19%	38%	44%	50%	38%	63%	63%	63%	56%	19%	31%	31%	50%	56%	38%	38%	38%	50%
	23	48%		16	33%		24	50%		29	60%		13	27%		23	48%		20	42%	



Conclusions

The primary objective, in this open and heavily impacted environment by uncontrolled multifactorial events, was to verify the degradation capacity of selected consortia, cultivated and applied tailor-made according to the database collected upstream and the characterizations carried out by the IMT. The efficiency correlated with temporality was intended to calibrate a rational application recommendation. Even though throughout the experimentation, variations in concentrations are observed due to the aforementioned specificities, in terms of yields and reductions, the processes implemented have yielded results. Thus, very significant yields are observed for almost all the averages calculated for both sides (left or right) of the ditches.

For example:

- TOC up to 76%, which is 49g less (RD138 G T0/T1)
- PAHs up to 54%, which is 48.5mg less (RD928 G T2/T3)
- TCH up to 92%, which is 1.76g less (RD138 G T0/T1)
- Benzo(a)pyrene (5) up to 43%, which is 4.4mg less (RD928 G T0/T1)
- Benzo(b)fluoranthene (5) up to 66%, which is 11.78mg less (RD928 G T2/T3)
- Fluoranthene (4) up to 80%, which is 6.37mg less (RD138 D T2/T3)



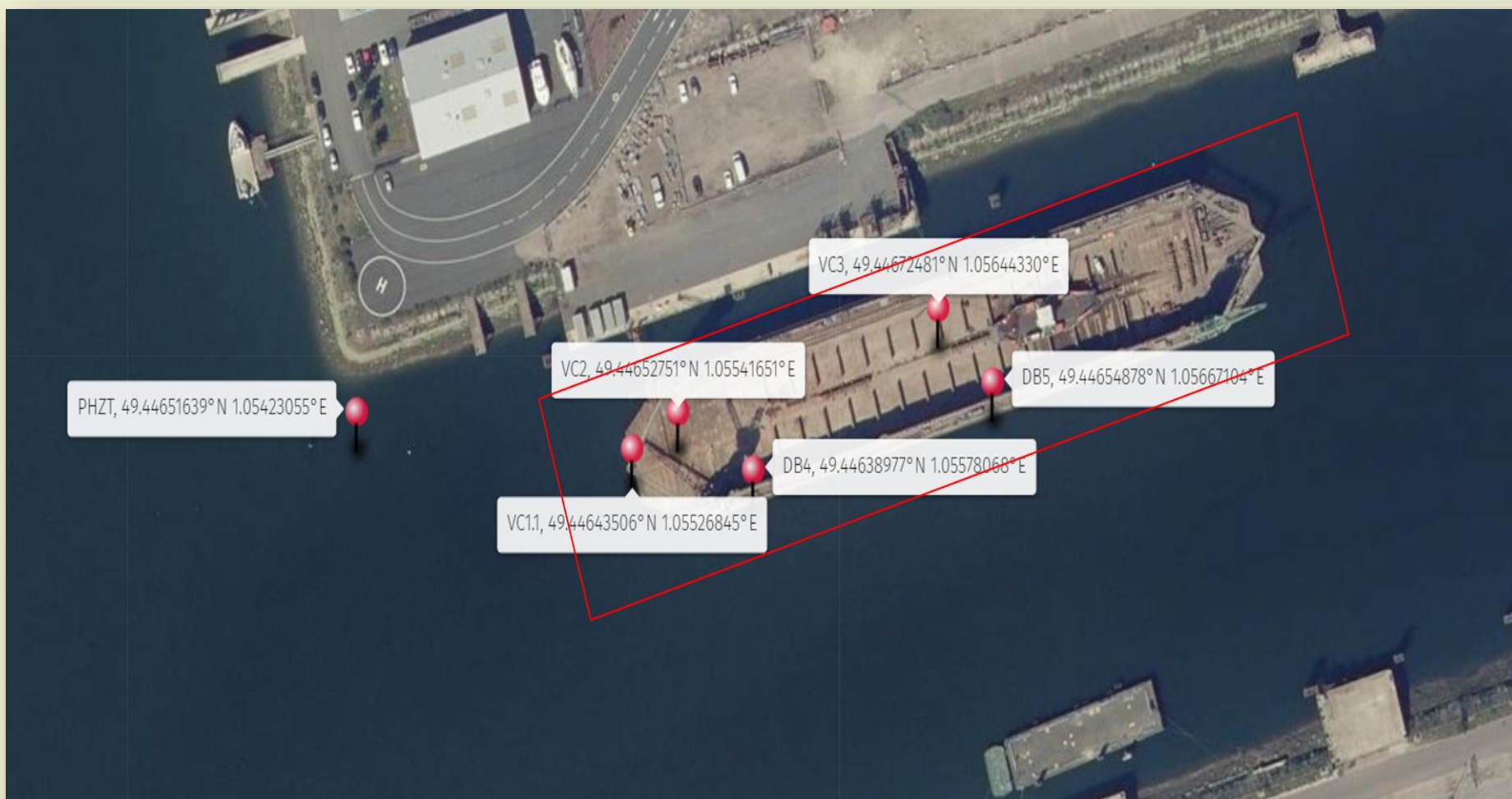
The causes of these decreases can be discussed (elution, dispersion, transport, degradation...). However, for poorly soluble products accumulating on-site, the hypothesis of degradation is likely to be favored in the first place. Especially for PAHs with 4 rings or more, which are persistent pollutants in the environment due to their stable chemical structure (due to the presence of aromatic rings), half-life duration → up to 110 months. We were able to draw scientific conclusions on the effectiveness of bio-treatment in terms of degradation of refractory undesirable compounds and shape 3 broad-spectrum consortia to consider large-scale background treatment.

And alongside this, formulate hypotheses that are as many ways of work regarding:

- Some inconsistencies regarding the evolution of parameters
- The useful and practical application of bio-treatment for road services



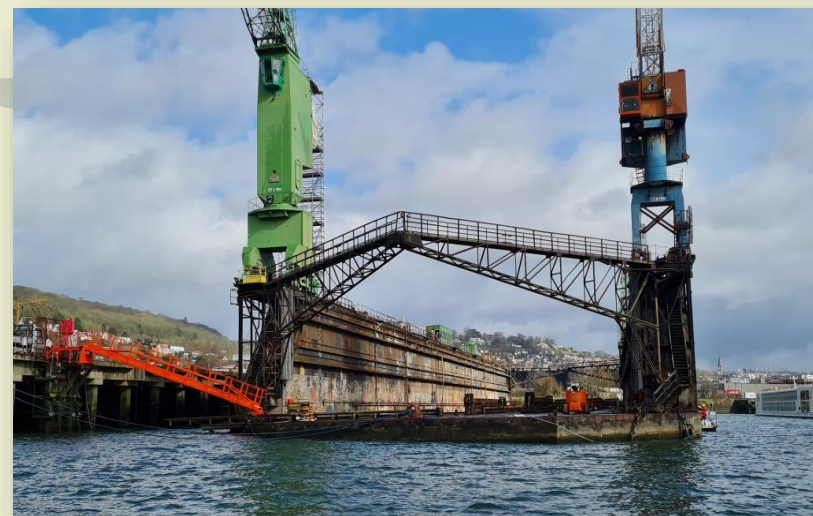
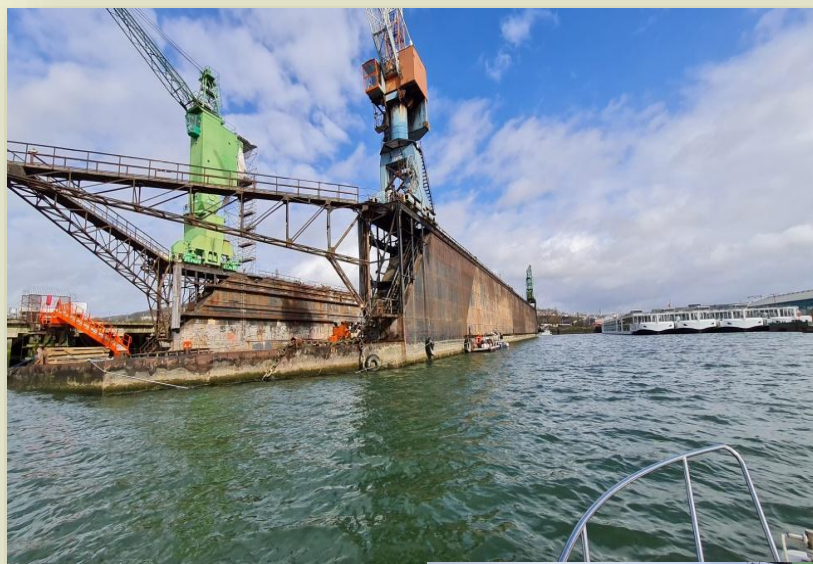
Bio-treatment of sediments from the Floating Dock Fluvio-Maritime Port of the Seine - Rouen Axis - 76 - France



Sedimentation zone around and under the floating dock



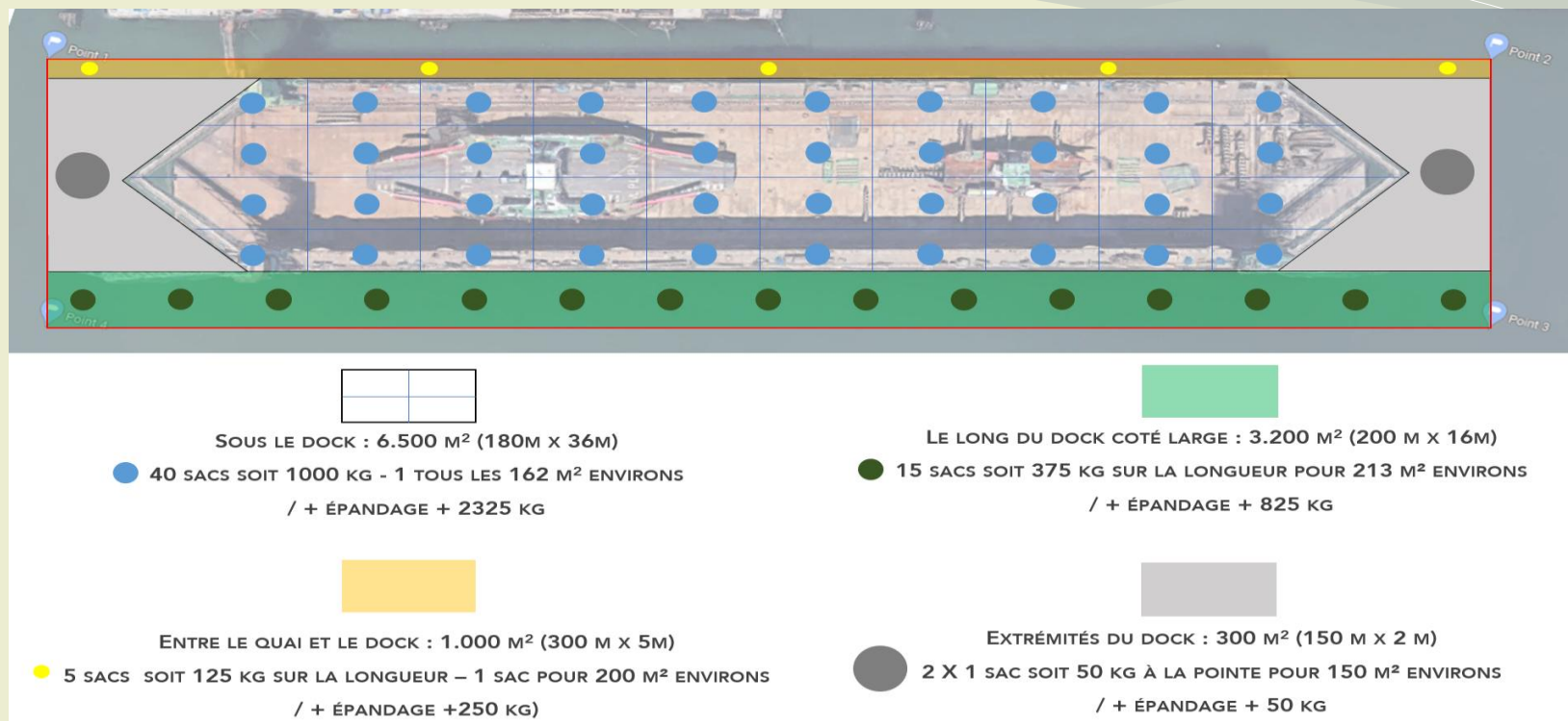
Bio-treatment of sediments from the Floating Dock Fluvio-Maritime Port of the Seine - Rouen - 76 - France





Bio-treatment of sediments from the Floating Dock Fluvio-Maritime Port of the Seine - Rouen - 76 - France

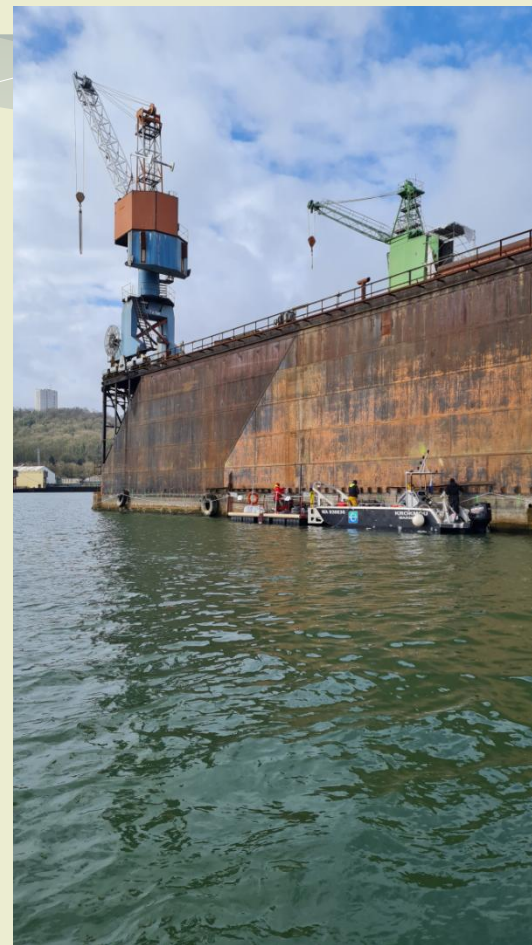
Spreading diagram





Bio-treatment of sediments from the Floating Dock Fluvio-Maritime Port of the Seine - Rouen - 76 - France

Photos of implementation





Bio-treatment of sediments from the Floating Dock Fluvio-Maritime Port of the Seine - Rouen - 76 – France - Results

	SEPTEMBRE 2020					DECEMBRE 2021					FIN MAI 2022					NORMES
	DB4	DB5	VC1	VC2	VC3	DB4	DB5	VC1	VC2	VC3	DB4	DB5	VC1	VC2	VC3	
MS %	36,9	35,4	42,9	40,5	38,1	36,8	30,6	42,4	34,5	30,6	34,1	33,0	36,3	37,7	29,4	
H C10-C40 mg/kg/MS	1300	2500	850	1900	1300	2000	1300	1500	860	880	600	380	27	560	430	1000
COT BRUT g/kg/MS	60,2	63,8	22,9	36,5	31,7	54,2	54,2	48,1	53,9	54,4	50,3	53,5	52,9	50,9	52,1	60
HAP 16 mg/kg/MS	7,34	12,4	22,46	11,2	19,93	12,98	10,6	29,11	13,77	7,39	14,80	12,60	16,70	12,00	8,10	50
HAP 6 mg/kg/MS	3,95	7	12,9	5,89	10,38	6,76	5,75	14,2	7,38	4,05	7,55	6,66	8,54	6,04	4,40	10
PCB 7 µg/kg/MS	132	189	55,7	110	323	169	76	338	176	125,3	120,00	110,00	120,00	90,00	70,00	200

NON CONFORMES

CONFORMES

EVOLUTION MOYENNES DES POINTS DE PRELEVEMENTS			
	Sept.2020	Déc. 2021	Mai 2022
H C10-C40 mg/kg/MS	1570	1308	399,4
TOC BRUT g/kg/MS	43,02	52,96	51,9
PAHs 16 mg/kg/MS	14,67	14,77	12,84
PAHs 6 mg/kg/MS	8,02	7,63	6,63
PCBs 7 µg/kg/MS	161,9	176,9	102,00

Evolution zone non traitée Déc. 2021 - Mai 2022				Evolution zone traitée Déc. 2021 - Mai 2022			
HAP 16 mg/kg/MS	11,89	11,42	-3,95%	HAP 16 mg/kg/MS	14,77	12,84	-13,06%
HAP 6 mg/kg/MS	6,37	5,90	-7,38%	HAP 6 mg/kg/MS	7,63	6,63	-13,00%
PCB 7 µg/kg/MS	119,5	110,00	-16,31%	PCB 7 µg/kg/MS	176,9	102,00	-42,34%

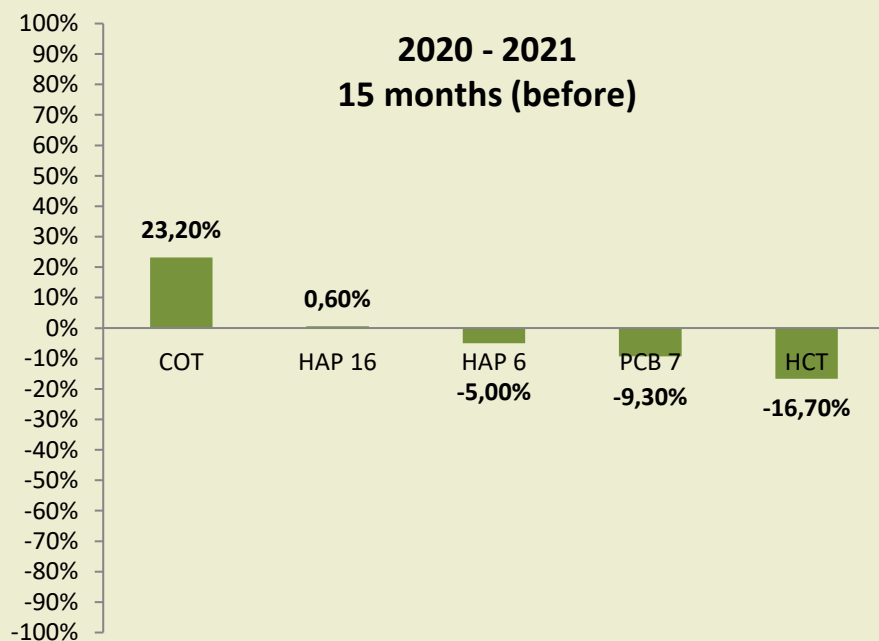
POINT DE PRELEVEMENT	ECHANTILLON A PRELEVER
DB4	0-1m
DB5	1-1.5m
VC1.1	0-0.8m



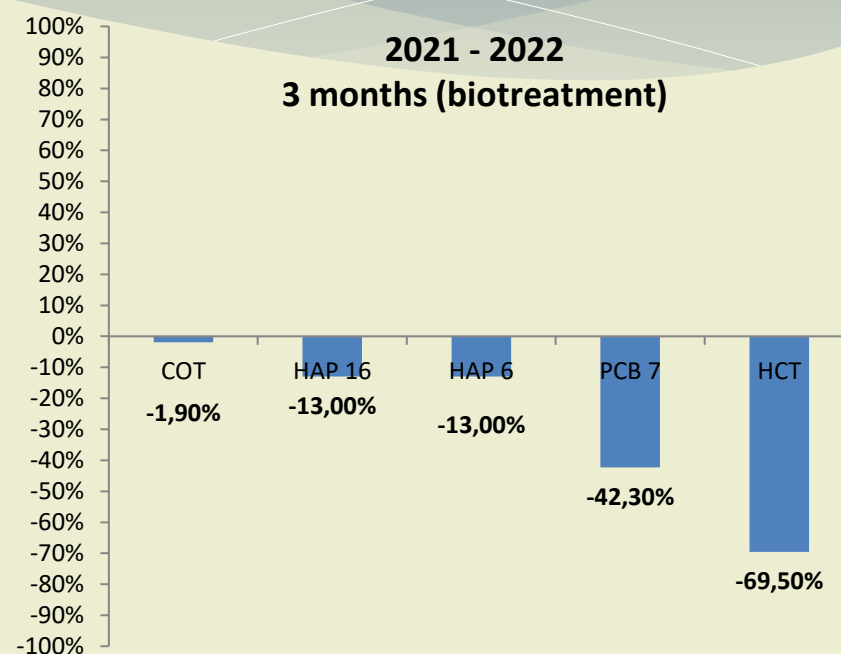
Biological treatment of sediments from the Floating Dock Fluvio-Maritime Port of the Seine - Rouen - 76 - France

Evolution of yields over the average of sampling points

2020 - 2021
15 months (before)



2021 - 2022
3 months (biotreatment)





Biological treatment of sediments from the Floating Dock Fluvio-Maritime Port of the Seine - Rouen - 76 - France

Conclusions

The quality of the results should be assessed in the context of the problem:

Biological degradation over a given area (1.1 hectares), within a larger open natural environment:

- of compounds (PAHs₆ and PAHs₁₆ / PCBs₇ / TCH C20 - C40) ranging from slightly to very difficult to biodegrade
 - over a short period (3 months)
 - under a floating dock and its surroundings (11,000 m²)
 - during cold temperatures (February)
 - with sampling depths of sediments up to 1.5 meters
 - at over 6 meters of water depth
 - despite continuous but unspecified exogenous inputs, related to industrial site operations during the application of the biotreatment.
-
- Total quantities biodegraded (surface/depth of sediments/MS)
 - TCH 5667 kg - PAHs₁₆ 8.85kg (8.85106 mg) - PAHs₆ 1.88 kg – PCBs₇ 0.29 kg

Sampling and physico-chemical analyses were conducted by the usual providers HAROPA PORT. The DDTM 76 France approved the operation.

À Rouen, Haropa Port utilise des bactéries pour laver le fond de la Seine

Frédéric Durand

Au fond du port de Rouen, la darse Charles Babin héberge depuis 1924 un dock flottant pour la maintenance et la réparation des navires. Il sera bientôt remplacé par Archimède acheté aux Émirats arabes unis. Pour placer ses 180 m de long et ses 37 m de large, Haropa Port a dû prévoir le dragage de la souille sur 11 000 m² : « Cela représente 30 000 m³ de sédiments à retirer. Mais, avant toute intervention, nous devons faire des analyses de pollution car ces sédiments fins non valorisables doivent être déposés à la ballastière d'Yville pour le remblaiement d'une carrière afin de recréer une prairie humide », explique Claire Bertolone, cheffe du service environnement chez Haropa Port. Mais, au retour du laboratoire indépendant, les échantillons ont montré des dépassements de niveau de pollution par certains contaminants notamment des hydrocarbures, de la cellulose, de l'azote et des PCB (Polychlorobiphényle) qui ne permet donc pas, selon la grille d'acceptabilité mise en place il y a une vingtaine d'années, de les stocker dans la nature en état. Alors, le choix s'est orienté vers un biotraitement unique en France à cette échelle : le lavage des sédiments par des micro-organismes sur place pour faire baisser la concentration des polluants.

Un procédé novateur

Haropa Port a fait pour cela appel à Neo-Eco fondée en 2008 pour une remédiation : « Nous sommes un bureau d'études en économie circulaire spécialiste autour de solutions de revalorisation de déchets. Fin 2019, nous avons commencé à travailler avec Haropa Port sur la revalorisation d'une partie de leurs sédiments marins afin d'alimenter le territoire en nouvelles matières premières alternatives et créer des boucles économiques », décrit Maude Soubeiran, cheffe de projet économie circulaire chez Neo-Eco. Face aux problématiques de surface, volume et profondeur pour la darse, la start-up lilloise a fait appel à Biosynergie, expert en dépollution « qui a développé un brevet à base de bactéries. C'était une première in situ. Ils ont cultivé les micro-organismes vivants de catégorie 1, les mêmes qu'utilisés dans l'agroalimentaire comme pour mettre dans les yaourts et compatible avec l'environnement. Ils ont quantifié le volume à mettre en place. Ensuite, ils les ont intégrés dans des substrats minéraux (sables, gravier, etc.). Huit tonnes ont été épanchées en février 2022 ».

Le résultat a été probant. « Au bout de trois mois, nous avons atteint les seuils nécessaires alors que nous pensions faire un second épanchage. Pour le moment, le dragage n'a toujours pas été fait, car il reste des travaux à effectuer sur le nouveau dock flottant et l'autre est toujours en service. Il faudra trouver une fenêtre de tir pour ne pas pénaliser les réparations navales. Nous devons donc refaire des analyses sous le contrôle de la DDTM (Direction départementale des territoires et de la mer) de Seine-Maritime. Cela permettra de voir s'il est nécessaire de biotraitement de nouveau », indique Claire Bertolone.

Ouverture vers d'autres applications

Neo-Eco se félicite de ce premier partenariat à cette échelle avec Biosynergie : « C'est un procédé qui a d'autres opportunités comme sur les plantes invasives, les algues, etc. On va pouvoir aller plus loin pour valoriser des Gisements, des terres, des friches. On vise aussi des bouts de chenal ou des berges », spécifie Maude Soubeiran. ■



Etang de la Brosse (77) France -

Rainwater basin biotreatment - 27651 m²

Marne et Gondoire urban community (77 - France)





Etang de la Brosse (77) France -

Rainwater basin biotreatment - 27651 m²

Marne et Gondoire urban community (77 - France)

TIMELINE OF INTERVENTIONS

Bathymetry and volume measurements

	Service providers	Dates
Data call offer	EGIS (CONFLUENCES Ingénierie)	12/2018
Point 0	COVADIS	10/01/2024
et	INGEO	22/02/2024
Point 1	INGEO	27/05/2024
Point 2	INGEO	27/09/2024

Sediment samples

	Service providers	Dates
Data call offer	EGIS (CONFLUENCES Ingénierie)	12/0218
Point 0	IDRA	17/01/2024
Point 1	IDRA	28/05/2024
Point 2	IDRA	30/09/2024

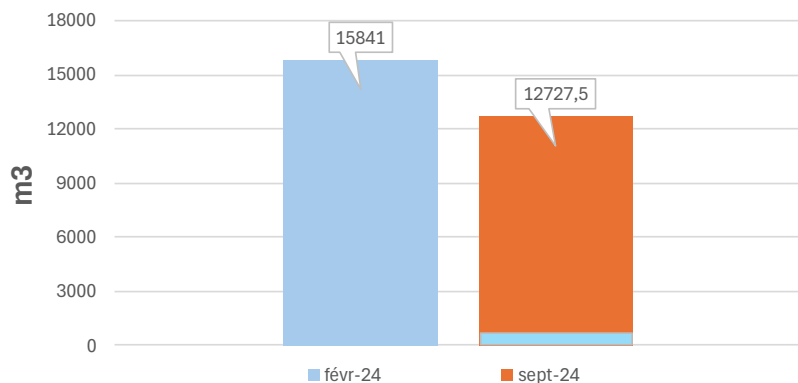
Spreading

Opération 1	25 au 29/03/2024	9 tonnes
Opération 2	10 au 14/06/2024	11 tonnes



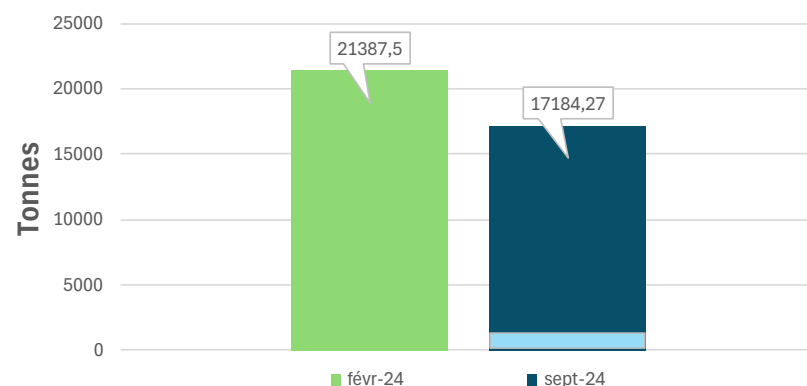
Etang de la Brosse (77) France - Rainwater basin biotreatment - 27651 m² Marne et Gondoire urban community (77 - France)

Decrease in sediment volume (-3113,5 m³)
Before and after treatment
according to INGENO measurements



dont 912 m³ d'envasement naturel évité sur la période

Reduction in sediment weight (-4,203 tons)
Before - After treatment
according to INGENO measurements and average density



dont 1231 tonnes d'envasement naturel évité sur la période

Decrease in pollutant concentrations:

- HCT by up to 42%, or 980 mg less (between May and September 2024 - EM3)
- PAHs by up to 45%, or 2.40 mg less (between May and September 2024 - EM1)
- Benzo(a)pyrene by up to 56%, or 0.13mg less (between 01 and 09/2024 - EM2)
- Benzo(b)fluoranthene by up to 48%, or 0.17mg less between 01 and 09/2024 - EM2
- Fluoranthene by up to 49%, or 0.54mg less (between 01 and 09/024 – EM1)



Biological treatment of three rainwater basins

TATINGHEM – BAINCTHUN - TILQUES

(62 - France)





Biological treatment of three rainwater basins

TATINGHEM – BAINCTHUN - TILQUES

(62 - France)

TIMELINE OF INTERVENTIONS

Bathymetry and volume measurements

	Service providers	Dates
Point 0	BPH	22/06/2022
Point 1	INGEO	05/06/2024
Point 2	INGEO	08/10/2024

Sediment samples

	Service providers	Dates
Point 0	EUROFINS	23/06/2022
Point 1	EUROFINS	05/04/2024
Point 2 (sauf TILQUES)	EUROFINS	26/09/2024

Spreading

Opération 1	April 2023
Opération 2	Septembre 2023
Opération 3	Juin 2024

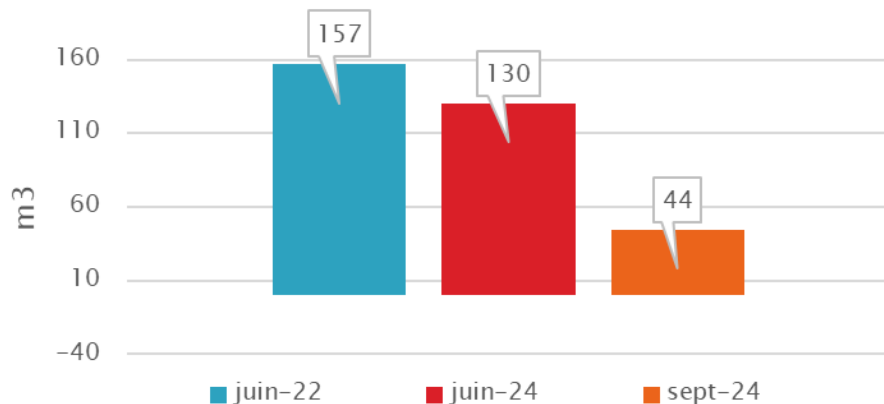


Biological treatment of three rainwater basins

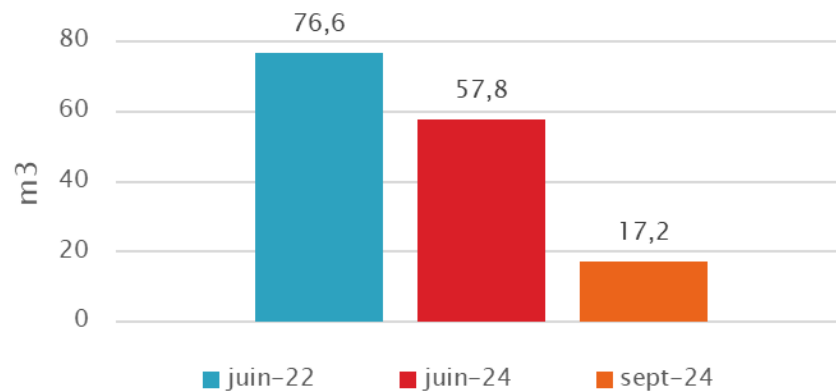
TATINGHEM – BAINCTHUN - TILQUES

(62 - France)

Sediment volume
Before - After treatment
TATINGHEM



MS volume
Before and after treatment
TATINGHEM





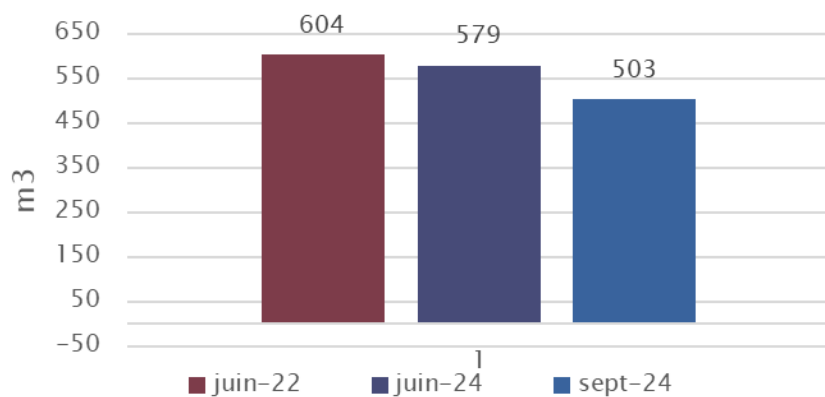
Biological treatment of three rainwater basins

TATINGHEM – BAINCTHUN - TILQUES

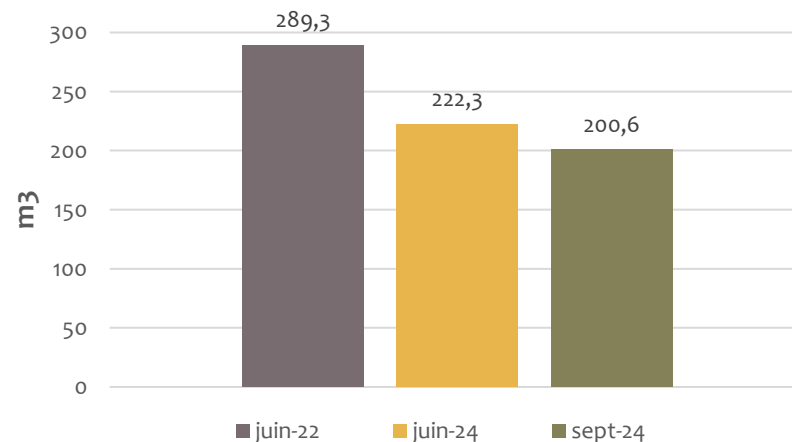
(62 - France)

Sediment volume
Before - After treatment

BAINCTHUN



MS volume
Before - After treatment
BAINCTHUN



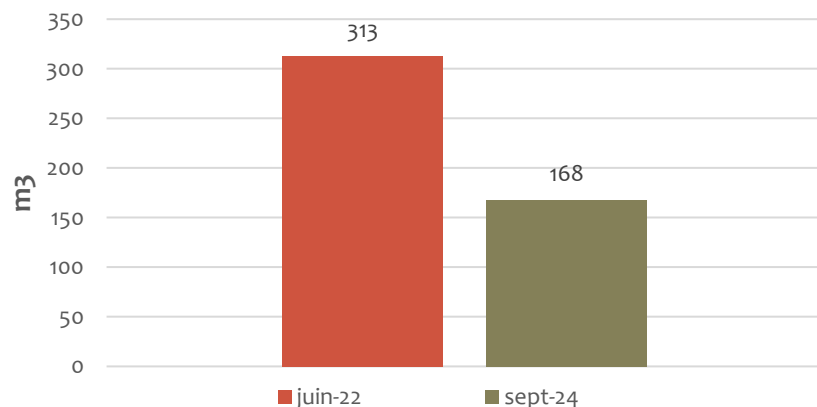


Biological treatment of three rainwater basins

TATINGHEM – BAINCTHUN - TILQUES

(62 - France)

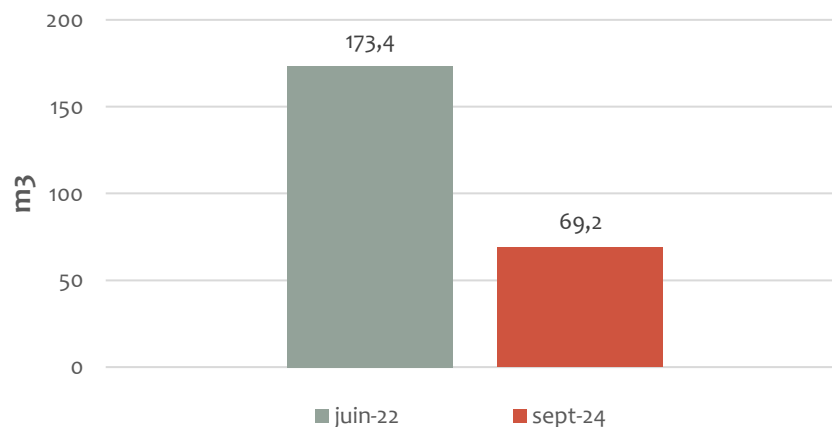
Sediment volume
Before - After Treatment
TILQUES



Decrease in pollutant concentrations:

- Total HCT (light and heavy) down by up to 36%, or 564 mg (04-09/2024 - BAINCTHUN)
- PAHs₁₆ down by up to 53%, or 3.8 mg (04-09/2024 BAINCTHUN) and 33.3%, or 0.5 mg (04-09/2024 TATINGHEM)
- Benzo(a)pyrene up to -58.5%, or -0.31mg (01-04/2024 - TILQUES)
- Indeno(1.2.3.cd)pyrene up to -54%, or -0.54mg (04-09/2024 - BAINCTHUN)
- Benzo(b)fluoranthene up to -43.4%, or -0.36mg (01-04/2024 - TILQUES)

MS volume
Before - After Treatment
TILQUES

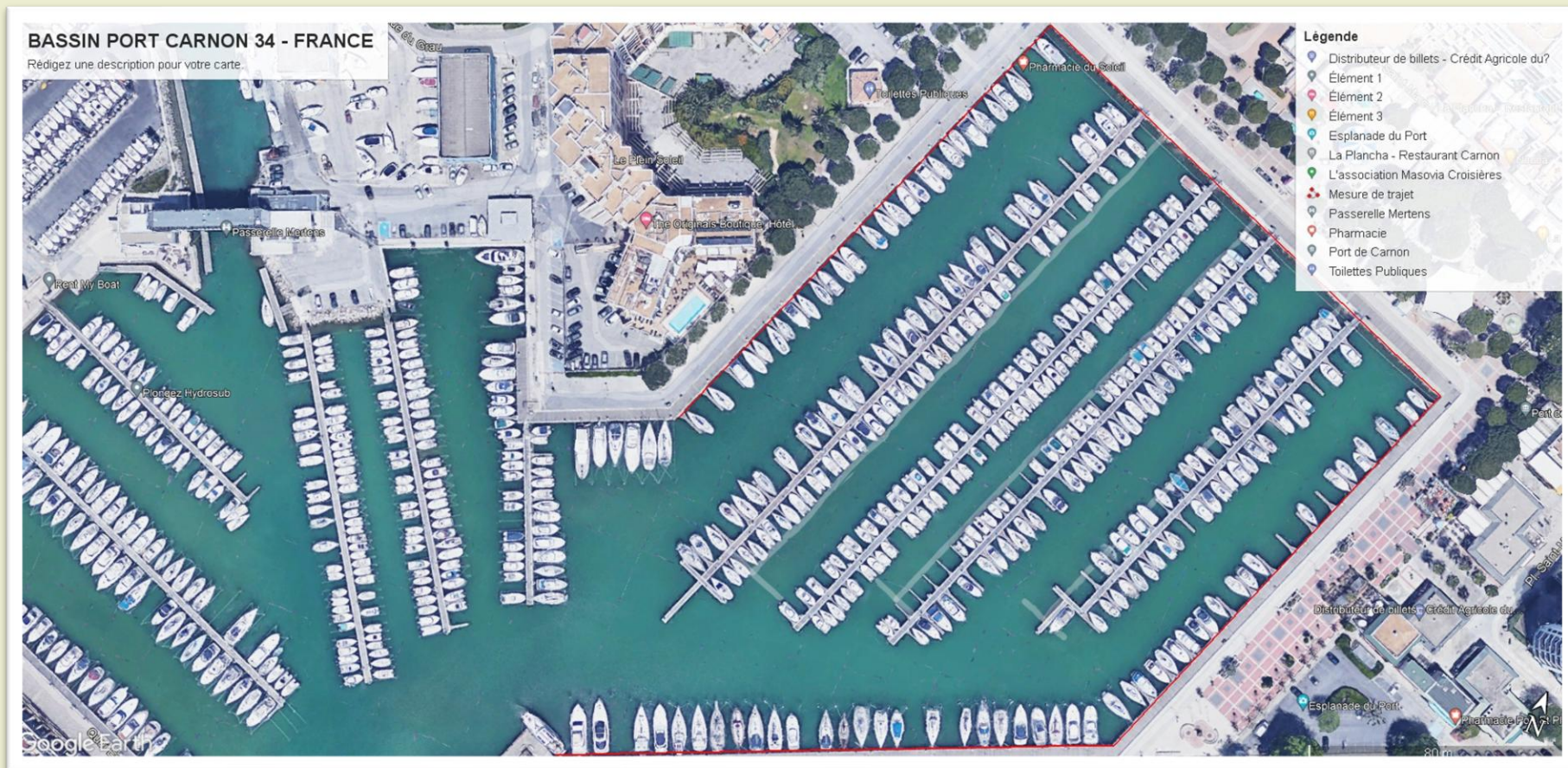




Biological treatment of marine sediments

Port Carnon (06) - France

Increase in water depth - Decrease in sediment volumes





Biological treatment of marine sediments

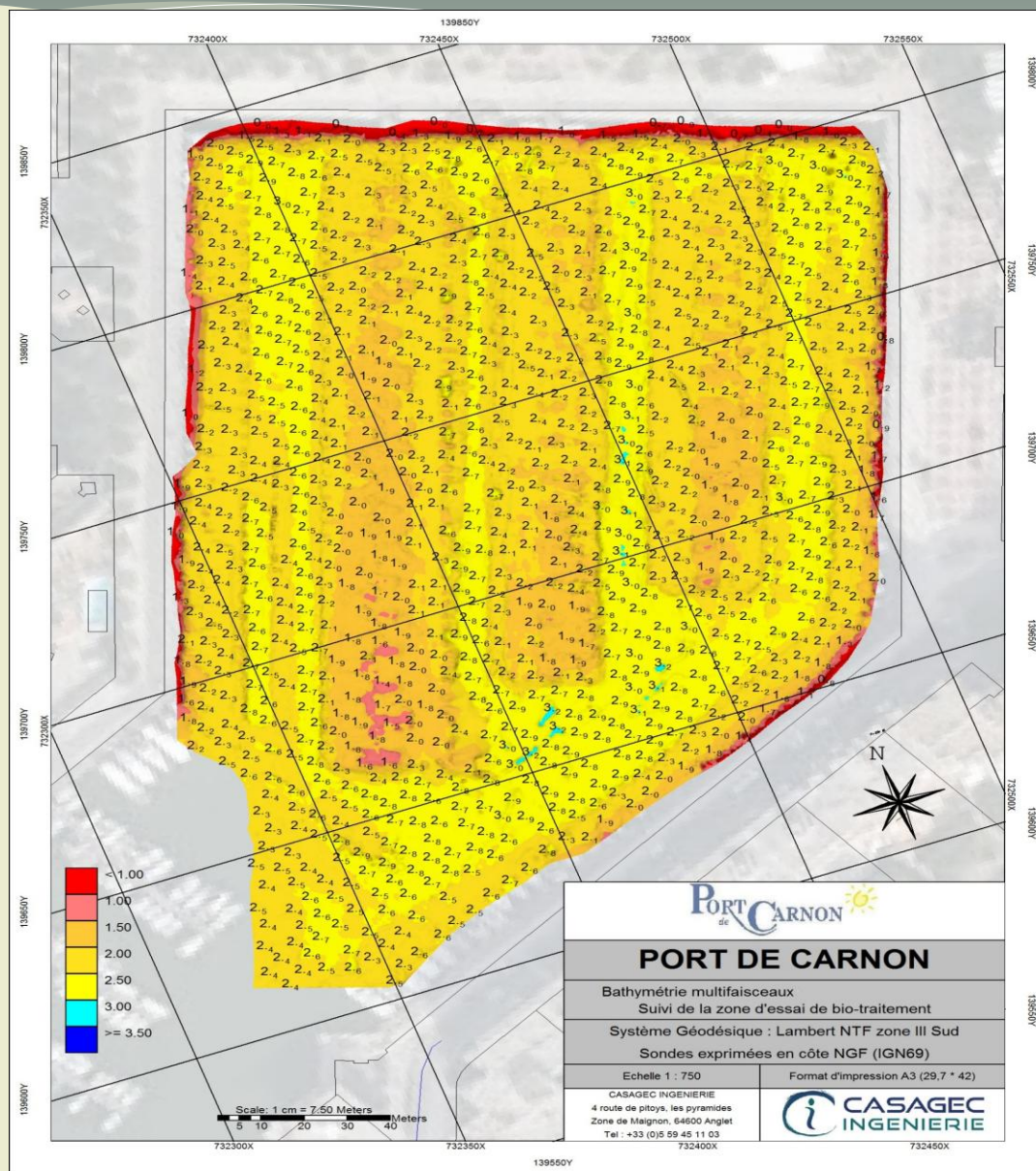
Port Carnon (06) - France

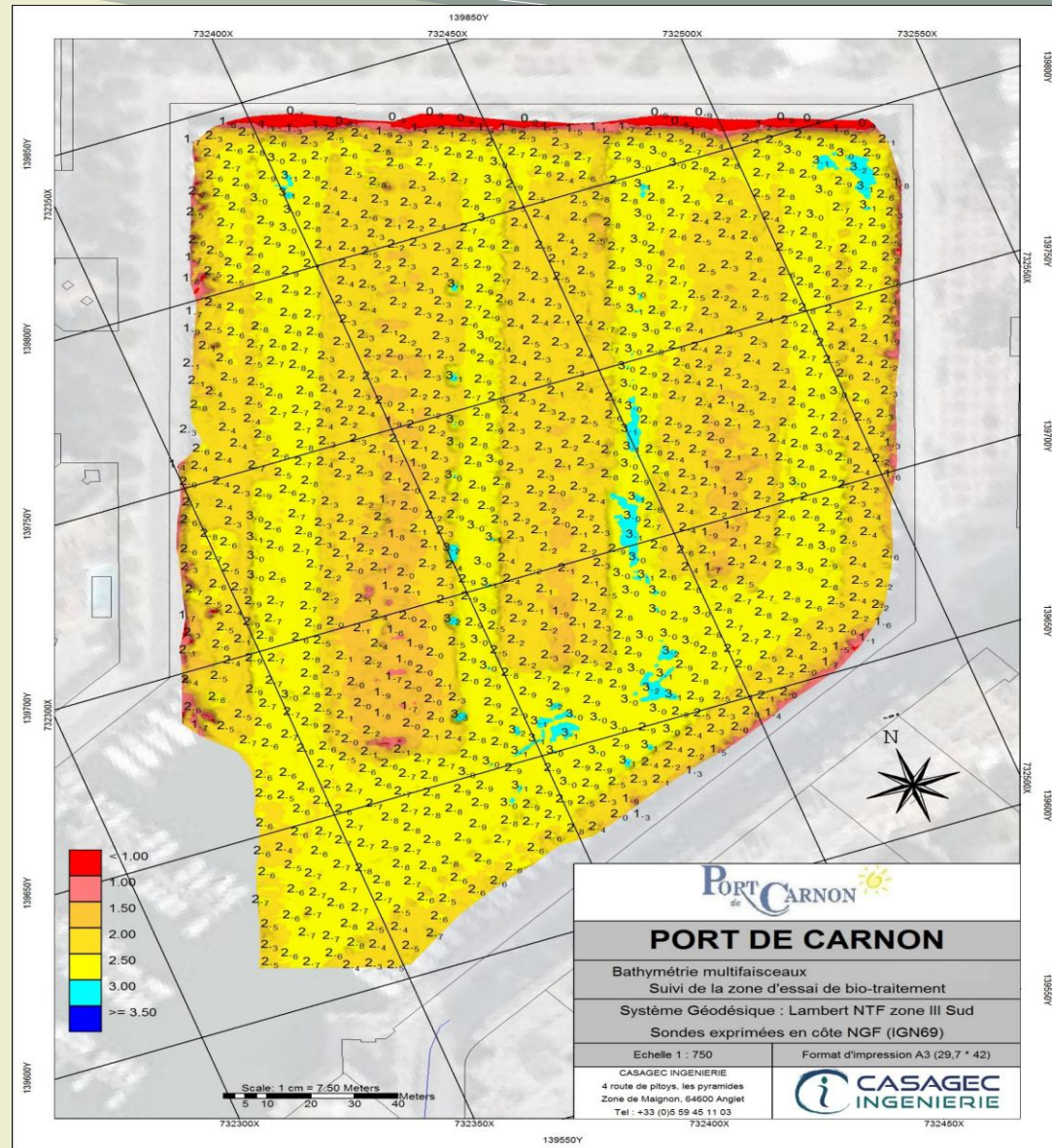
Increase in water depth - Decrease in sediment volumes





Bathymétries avant le bio-traitement des sédiments marins d'une partie du Port de Carnon (06 - France)







Bathymetric changes after 10 months of biotreatment of marine sediments in a part of the Port of Carnon (06 - France)

Conclusion

The treatment yields good, even very good results. Based on bathymetric surveys before March and after treatment January, the average gain in water depth can be estimated at +/- 39 cm, with very few minima at 0 and maxima at 0.60 meters.

Given the strong rotating hydrology in the basin (inlet → bottom → outlet return), both generally and effectively during spreading, a preferential seeding zone was decided upon (Pontons 2 and 3). This area benefits fully from these gains in water depth (multiple "blue" zones → 3 m / 3.50 m).

The volume of sediment removed can be estimated at 11,300 m³ throughout the basin. In addition to the degradation of sediments in place, there is also, albeit unquantifiable, degradation of additional inputs inherent to port activity (and its configuration) over 10 months, including 2.5 months of the summer period. There is also the disappearance of bad odors that have been bothering residents for several years.



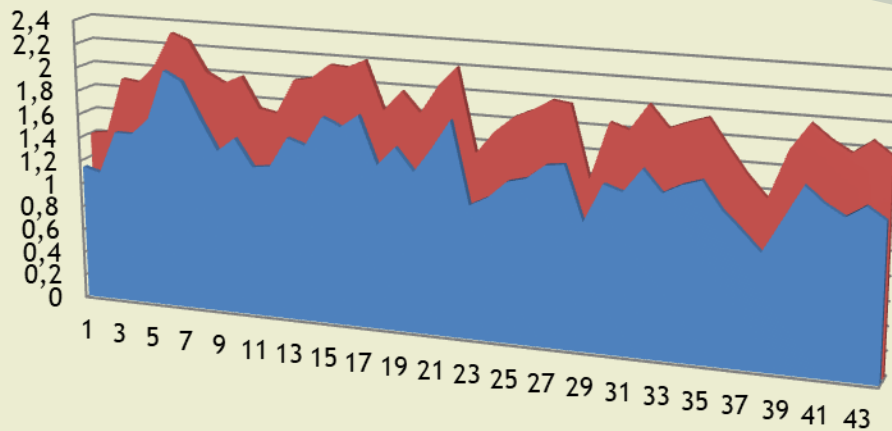
Biological treatment of marine sediments Port du Crouton, Juan Les Pins (06), France Increase in water depth - Decrease in sediment volumes





Biological Treatment at Port du Crouton Antibes - Juan-Les-Pins (06) - France

Increase in water depth - 44 measurement points
Before and **After** 6 months of treatment



Volume of degraded sediments
 $6000 \text{ m}^2 \times 0.43 \text{ (Ht.)} \rightarrow$
 2.580 m^3

TOC $\rightarrow$ 2,9 % - 11,6 % 11,4 % - 3,9 %

Dry matter content: 30%
Sediments rich in posidonia residues

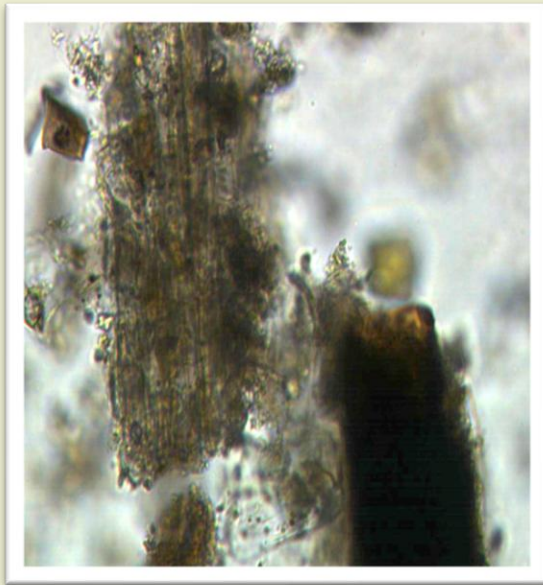


**Disappearance of the foul odors reported by boaters,
as observed by port employees**

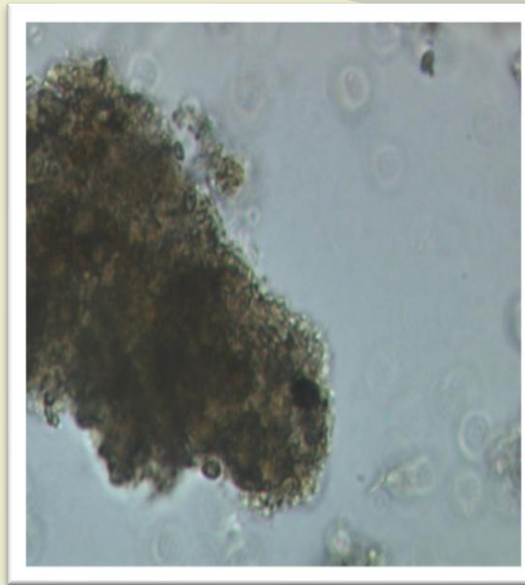


Microscopic examination of sediments after spreading (January 31, 2017)

*Christian DRAKIDÈS - Research Engineer CNRS
University of Montpellier II - UMR - Hydro-sciences*



Vegetal debris with Bacteria
(20x magnification)



Dense bacterial floc
(40x magnification)



Mineral substrate seeded
Diameter 50mm / (40x magnification)
With colonies on the periphery



Biological treatment of sediments

Combating eutrophication

(Swimming ban ARS → Cyanobacteria)

LAKE of MESSEIN (54) - France

INITIAL STATE

- Total lake area: 19 hectares/ Numerous sources of pollution: infiltrations, rainwater, domestic wastewater
- Algal bloom in summer – chlorophytes, diatoms, cyanobacteria... at the level of the nautical base leading to its closure during the summer period.
- Physico-chemical analysis of sediments:
 - April 30 DCO – g O₂/kg MS : 43
 - COT – g C/kg MS : 460

PARTIAL LAKE TREATMENT:

- Spread 5 tons of microbiological complex (1 to 8 mm) on a delimited area of 1 hectare; (see spreading plan) – early May

RESULTS :

See annexed graphs

From the first year, reopening of the nautical base throughout the summer period except on July 2nd and 3rd

- Treatment continued with maintenance doses during 5 years
1800 kg/year - Permanent opening of the nautical base
- Water transparency:
- Before treatment: less than 0.30 m
- + 4 years: over 2.50 m → possibility of underwater diving

Updating and removal of metallic waste present on the bottom due to the decrease in sediment heights.



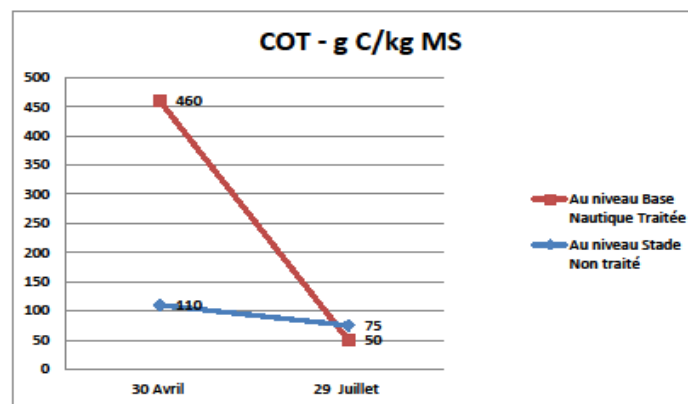
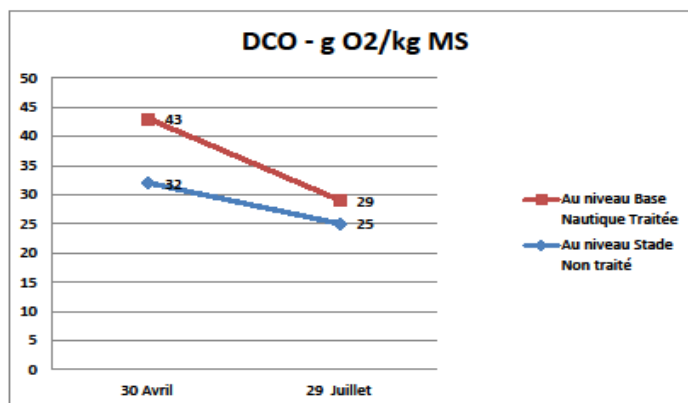
MESSEIN : Rendements entre rapport d'analyses du 30 avril et rapport du 29 juillet

Sédiments - Prélèvements au niveau de la base nautique (traitée)

Paramètres	30 Avril	29 Juillet	Rendements	Abattements
DCO - g O ₂ /kg MS	43	29	32,56%	14
COT - g C/kg MS	460	50	89,13%	410

Sédiments - Prélèvements au niveau stade (non traité)

Paramètres	30 Avril	29 Juillet	Rendements	Abattements
DCO - g O ₂ /kg MS	32	25	21,88%	7
COT - g C/kg MS	110	75	31,82%	35





Biological treatment of sediments and water Combating eutrophication LAKE of MESSEIN (54) - France





Biological Treatment of Sediments Combatting Eutrophication Lake of Messein (54) – France

DATABASE – Lake of MESSEIN					
EAUX					
STADIUM (untreated)					
	30/04		29/07	31/08	30/10
COT mg/l	7,9		8	8,4	9,5
COTd mg/l	7,1		7,6	4,9	9,2
DCO mg/l	49		24	8	5
DBO ₅ mg/l	23		8	5	5,8
MES mg/l	28		17	15	6,3
NH ₄ ⁺ mg NH ₄ /l	<0,05		<0,05	<0,05	0,93
NTK mg/l	1,6		4	2,4	2,6
NO ₃ mg NO ₃ /l	<0,5		<0,5	<0,5	0,9
NO ₂ mg NO ₂ /l	<0,01		<0,01	<0,01	0,11
ORTHO mg PO ₄ /l	<0,02		0,04	0,06	0,13
PT mg P ₂ O ₅ /l	0,25		0,53	0,48	0,47
MO (2DBO ₅ + DCO/3)	31.66		13.33	6	5,53

BASE (treated)	30/04		29/07	31/08	30/10	Standards
COT mg/l	8	E	9,8	9	10	7
COTd mg/l	8	P	9,9	9	9,9	7
DCO mg/l	30	A	14	8	7	20
DBO ₅ mg/l	19	N	5	5	4	25
MES mg/l	21	D	5	9	8,8	
NH ₄ ⁺ mg NH ₄ /l	<0,05	A	<0,05	<0,05	0,88	
NTK mg/l	1,3	G	3,1	2,8	2,6	1
NO ₃ mg NO ₃ /l	<0,5	E	<0,5	<0,5	0,8	
NO ₂ mg NO ₂ /l	<0,01		<0,01	<0,01	0,11	
ORTHO mg PO ₄ /l	0,03		0,03	0,02	0,07	0,035
PT mg P ₂ O ₅ /l	0,17		0,4	0,47	0,5	
MO (2DBO ₅ + DCO/3)	22.6		8	6	5	



Biological Treatment of Sediments Combating Eutrophication Lake of Messein (54) – France

DATEBASE – Lake of MESSEIN					
SEDIMENTS					
STADIUM (untreated)					
	30/04		29/07	31/08	30/07
MS (%)	26,2			17,3	36,4
DCO (g O ₂ /kg)	32		27	38	44
DBO ₅ (g O ₂ /kg)	0,6		2	1	1
NTK (g N/ kg)	4,29			8,86	5,05
NH ₄ (g N/ kg)	0,0092			<0,12	0,017
NO ₂ (g N/ kg)	< 0,0007			<0,0005	<0,0002
NO ₃ (g N/ kg)	< 0,0036			<0,0025	0,0038
PT (g P /kg)	0,971			1,32	1,08
ORTHO (g P /kg)	0,0018			0,0016	0,00081
COT (C/kg)	110		75	66	34

BASE (treated)					
	30/04	E	29/07	31/08	30/10
MS (%)	13,1	P		18	23,1
DCO (g O ₂ /kg)	43	A	29	30	34
DBO ₅ (g O ₂ /kg)	0,8	N	1	5	2
NTK (g N/ kg)	4,18	D		3,2	2,58
NH ₄ (g N/ kg)	0,23	A		<0,0022	0,05
NO ₂ (g N/ kg)	<0,0015	G		<0,0004	<0,0002
NO ₃ (g N/ kg)	<0,0072	E		<0,0087	<0,0010
PT (g P /kg)	0,0738			1,05	1,56
ORTHO (g P /kg)	0,088			0,0011	0,0014
COT (C/kg)	460		50	43	30



Biological Treatment of Sediments and Water Combatting Eutrophication Port of Sciez (74) - France Swimming and Launching Areas

Sciez - Lac Léman - France. Mise à l'eau 2800 m² et Baignade 7700 m²

Rédigez une description pour votre carte.





Biological Treatment of Sediments Combatting Eutrophication Port of Sciez (74) - France Swimming and Launching Areas

Summary of Spreading and Dredging Dates	
Swimming Area	Dates
Spreading 1	Sept. 9
Spreading 2	Late April/early May
Boat launching area	Dates
Spreading 1	Sept. 12
Spreading 2	Late April/early May
Dredging 1	Late April/early May
Spreading 3	Early June/mid-June
Dredging 2	Early June/mid-June



Biological Treatment of Marine Sediments Port of CAMILLE RAYON (06) - France

Increase in water depth - Reduction in sediment volumes





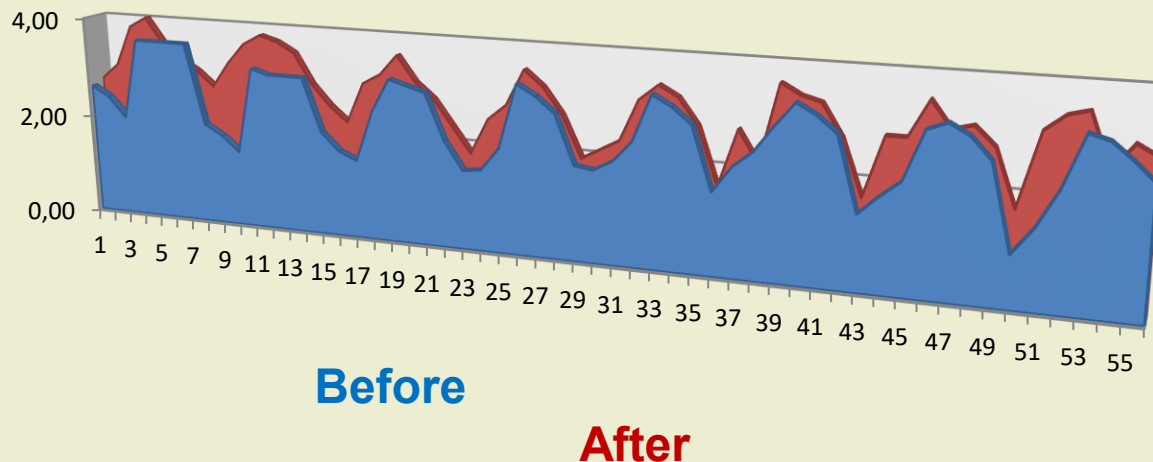
Biological Treatment of Marine Sediments Port of CAMILLE RAYON (06) - France

Increase in water depth - Reduction in sediment volumes

AVANT		25	21	17	14	11	7	4	0
	0	-2,60	-2,00	-2,05	-2,10	-1,85	-1,60	-1,45	-1,00
	7	-2,40	-1,80	-1,70	-1,55	-1,80	-2,10	-1,80	-1,50
	14	-2,00	-1,50	-1,55	-1,60	-2,00	-2,40	-2,10	-2,20
	21	-3,60	-3,20	-2,55	-2,05	-2,40	-2,90	-3,05	-3,20
	28	-3,60	-3,10	-3,20	-3,30	-3,30	-3,35	-3,20	-3,10
	35	-3,60	-3,10	-3,10	-3,10	-3,10	-3,15	-3,00	-2,80
APRES	42	-3,60	-3,10	-3,00	-2,80	-2,80	-2,85	-2,60	-2,45
		25	21	17	14	11	7	4	0
	0	-2,70	-2,70	-2,50	-2,30	-1,90	-1,60	-1,65	-1,70
	7	-3,00	-3,20	-2,20	-1,80	-2,10	-2,70	-2,80	-3,10
	14	-3,80	-3,60	-3,00	-2,50	-2,30	-2,10	-2,80	-3,40
	21	-4,00	-3,80	-3,20	-2,80	-3,10	-3,60	-3,50	-3,50
	28	-3,50	-3,70	-3,60	-3,50	-3,40	-3,40	-3,00	-2,50
	35	-3,20	-3,50	-3,10	-3,20	-3,20	-3,30	-3,10	-3,00
	42	-3,00	-2,90	-2,80	-2,70	-2,70	-2,70	-2,75	-2,80

AFTER TREATMENT: M5
BEFORE TREATMENT

Gain in bathymetry reported to the
volume of degraded sediment /
Surface 1000 m² X 0.39 m (Height)
= 390 m³

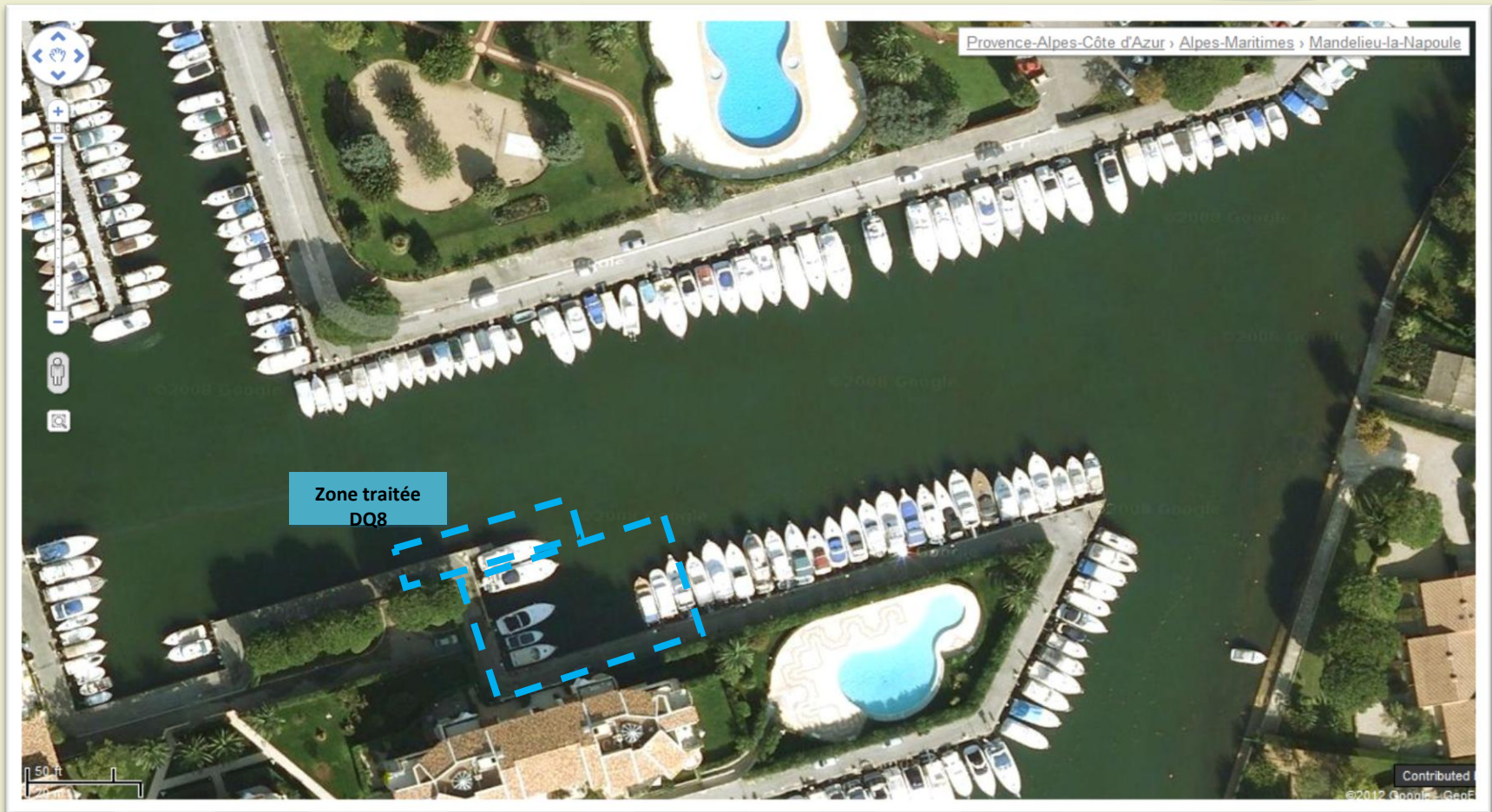


TOC -> 3 to 4%
at 3 sampling
points

Dry matter ->
37 to 45%
at 3 sampling
points



Marine Sediment Bioremediation Port CANNES MARINA (06) - France Increase in water depth - Reduction in sediment volumes

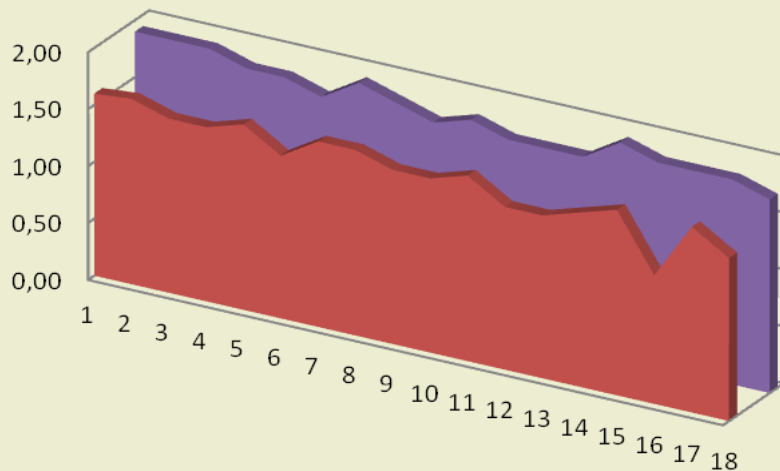




Objectives set with the client: Increase water depth by 10 to 20%
Bathymetric surveys conducted by the client
Treatment conducted in 2 spreading sessions: September and November

	Treated area = 250 m ²																		
DQ8- Bathy	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	Moyenne
Sept. 9	1,60	1,63	1,53	1,53	1,63	1,43	1,63	1,63	1,53	1,53	1,63	1,43	1,43	1,53	1,63	1,13	1,63	1,43	1,53
Jan. 9	1,90	1,90	1,90	1,80	1,80	1,7	1,9	1,8	1,7	1,8	1,7	1,7	1,7	1,9	1,8	1,8	1,8	1,7	1,79
Gain bathy en cm	0,30	0,27	0,37	0,27	0,17	0,27	0,27	0,17	0,17	0,27	0,07	0,27	0,27	0,37	0,17	0,67	0,17	0,27	0,26
Rendement bathy	18,75%	16,56%	24,18%	17,65%	10,43%	18,88%	16,56%	10,43%	11,11%	17,65%	4,29%	18,88%	18,88%	24,18%	10,43%	59,29%	10,43%	18,88%	16,99%

WATER HEIGHT GAIN



DQ8

Before
After

SUCCESSFUL TREATMENT
OBJECTIVES ACHIEVED
IN 3 MONTHS
BEFORE TREATMENT 07/09
BEFORE TREATMENT 09/01

Reduction of approximately 130 m³ of sediments

Initial sedimentology:
IDAC (Nantes)

- Relatively high dry matter content → 53%
- Relatively low organic fraction → 11%
- Average Total Organic Carbon (TOC) → 3%



Bio-treatment of sediments (bio-dredging)

Elements required for the design of a project

- **Surface(s) to be treated located** on a site plan (Google map or dimensioned diagram) with possible hydrology data
- **Activities** (port, swimming, fishing...) and local environment
- **Sampling** by coring (number to be defined) +/- x cm
- **Physico-chemical analysis** of sediments and/or water column (to be defined according to the cases)
 - DS/OM/MM/TOC/pH/TKN/TP/granulometry/density/raw and leachable heavy metals/TCH/PAHs₁₆/PCBs₇TBT...
 - **Bacteriology:** Fecal streptococci-enterococci, total coliforms, Escherichia coli...
 - **Phytoplankton:** (cyanobacteria, chlorophyceae...)
- **Height** of sediments and/or bathymetry



Economic / Practical / Ecological Aspects Bio-treatment of Sediments (Bio-dredging)

ECONOMIC

- Much less expensive than dredging, cutting, and removal, along with their preliminary studies and follow-ups
- No reduction in site activity during treatment
- No disturbance to peripheral activities (businesses, traffic, etc.)
- Optimization of potential future sediment valorization opportunities

PRACTICAL

- Spreading and stirring are easy to carry out, involving local labor
- No displacement of pontoons, boats, chains, etc.
- No reduction in site activity during treatment
- No dredges, trucks on site and on roads, no noise, visual, or olfactory nuisances

ECOLOGICAL

- No deterioration of the environment due to significant physical and chemical variations during mechanical dredging phases – increased turbidity, suspended solids, COD, nutrient dispersion, metal reintroduction into the ring, burial of benthic fauna, decreased dissolved oxygen, reduced photosynthesis, migration of buried pollutants
- Beneficial for fauna and flora
- Mineralizes and reduces sludge, clarifies water
- Suppresses and prevents excessive algae growth
- Reduces fecal and/or pathogenic germs
- Eliminates pollutants (hydrocarbons, pesticides, fertilizers, etc.)
- Stops and prevents bad odors
- Uses natural products and processes
- Eliminates risks of spills in public spaces during sediment transport to storage sites



Other References and Results



Improvement of Treatment Plant and Lagoon Yields

Effluents from refinery, petrochemical, steel, metallurgy, and urban sources



WABAG – Petrobrazi - Ploiesti – Roumanie – 2000 m³/h



Arcelor Mittal Galati – Roumanie -



Improvement of Treatment Plant Yields

ROMPETROL Constenza - Romania

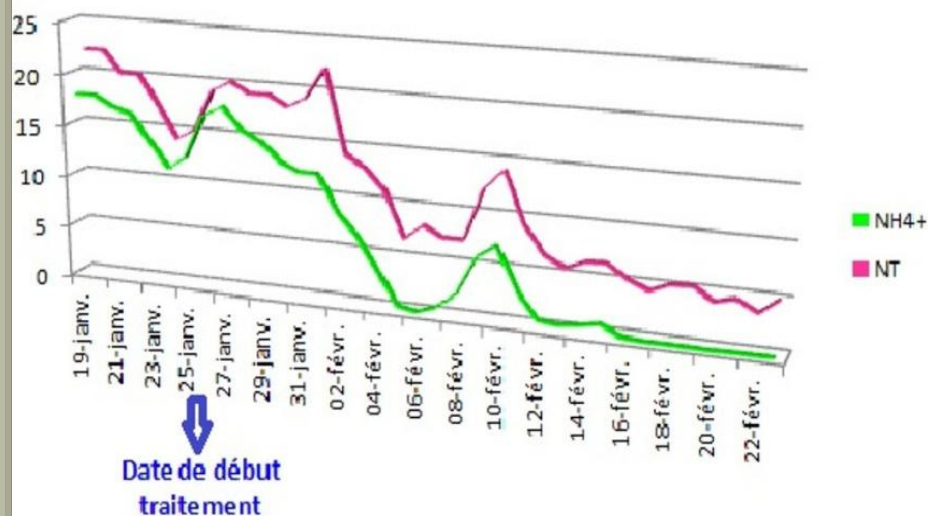
Effluents from refinery, petrochemical, and urban sources - 2000 m³/h

Rendements NH₄⁺ et NT



Ammonium (NH₄⁺) and Total Nitrogen (NT) Yields (%)

Valeurs en sortie NH₄⁺ et NT



Evolution in NH₄⁺ and NT output (in mg/l)



Improvement of the efficiency of a wastewater treatment plant
DOLJCHIM Craiova - Romania
Effluents from the chemical industry and urban sources - 550 m³/h



After treatment





Laboratory Work

Tests on the Biodegradation of Polycyclic Aromatic Hydrocarbons (PAHs) SEDIAPHALTE Convention - France





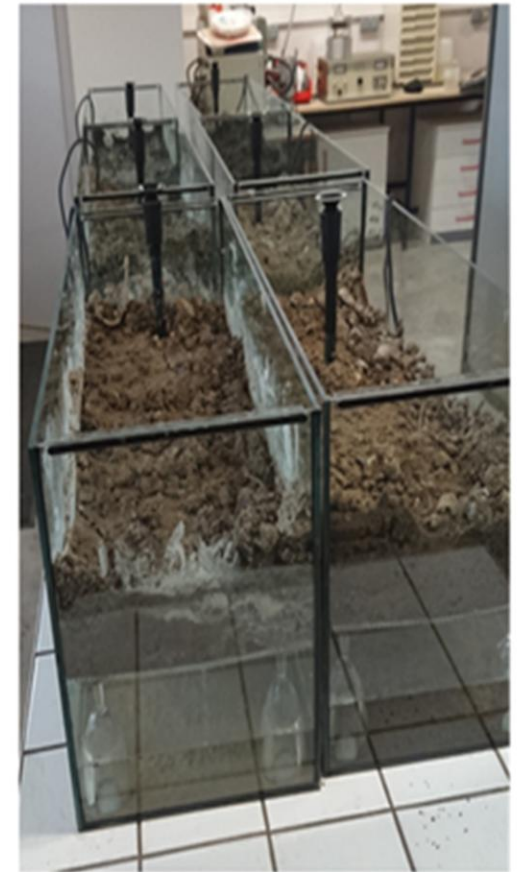
Water Conduit

Sediments + bacterial strains



Water compartment

Pumps



Side View

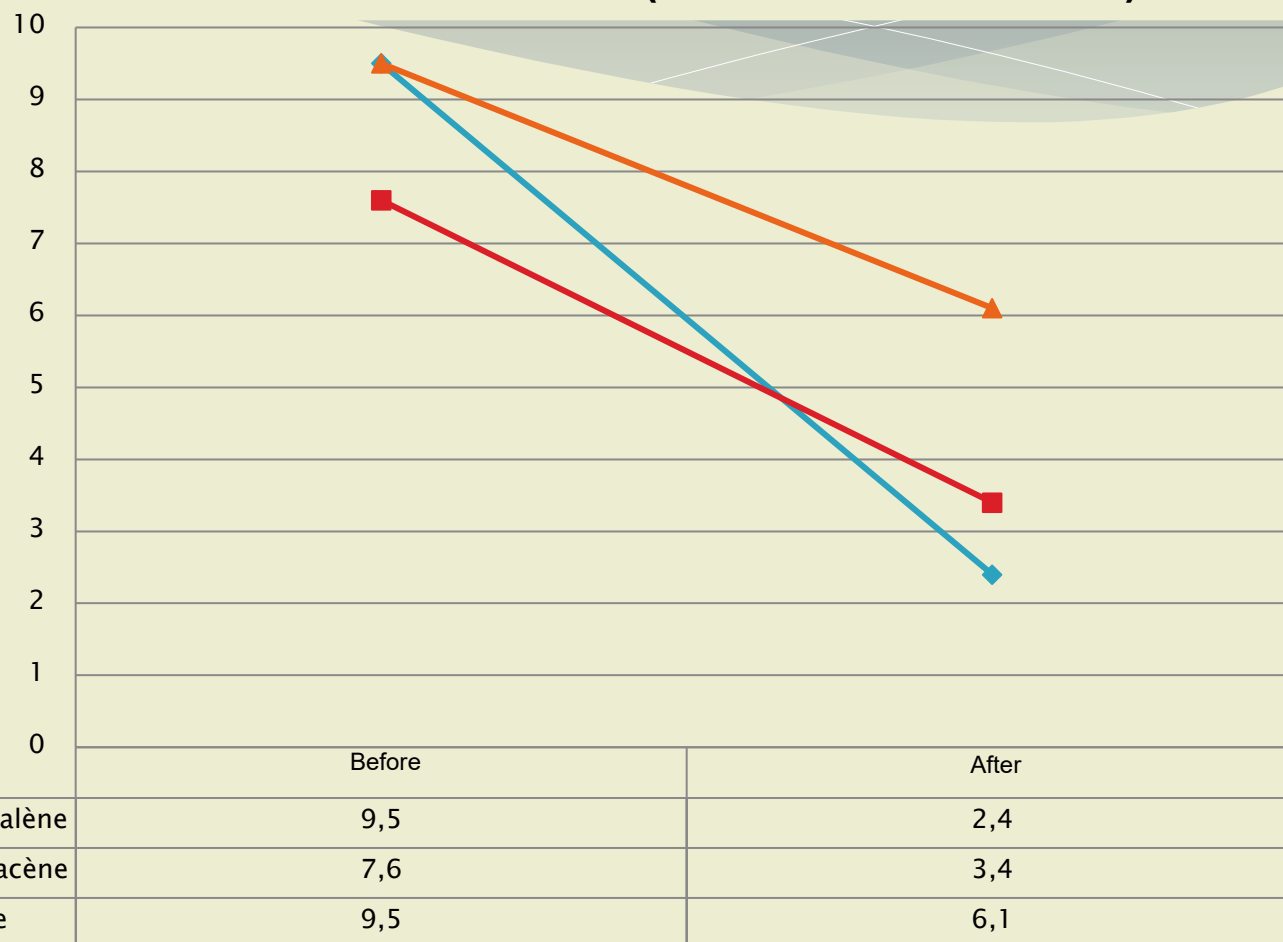




Tests conducted between July and November year 2020



Naphtalene - Anthracene - Pyrene - (mg/kg DM) Before - After (at low concentration)





Tests conducted between July and November – year 2020



**Naphtalene - Anthracene - Pyrene - (mg/kg DM) Before - After
(at high concentration)**

