BIOSYNERGIE

Reconciling economy and ecology

Biotreatment case studies

Water, soil and sediments — industrial, urban and natural environments

Biological processes* · Prevention · Pollution treatment

biosynergiecontact@gmail.com · www.biosynergie.net

* *Patented processes*



REFERENCES & PARTNERS

Scientific partnerships and research

Tripartite departmental partnership agreement (P.R.I.D.) – 12 years
COP21 contribution (Solutions Climat platform)

BIOSED project – Université du Littoral Côte d'Opale (ULCO)
Partner of the ECOSED Digital 4.0 (sediment valorisation) and CIRVAL (IMT Nord Europe) chairs

Honorary professor – IMT Nord Europe, Douai
Master's in circular economy engineering applied to sustainable materials

Research collaboration contract – University of Montpellier 2
Nitrification-denitrification test model and sludge evolution in treatment systems (2008)

Scientific publications
World Journal of Modelling and Simulation (Dec. 2009) · Water Research – Elsevier (Feb. 2008)

Hydrocarbon degradation in fresh water – stormwater at Paris-Orly airport (94)
Prof. Paule Vasseur, European Laboratory of Environmental Sciences (Metz) – pharmacy thesis, Besançon, 1993

Mare Nostrum scientific meetings – 11 May 2012 – Polytech Nice Sophia Antipolis

REFERENCES & PARTNERS

Outreach and selected references



Speaker at M.I.T. (Massachusetts Institute of Technology) in 2010, Oceanographic Institute of Monaco



Patented processes presented to French Environment ministers – Nautic Paris 2011 and 2012

Water bodies and natural environments

Lake Messein (54), ONF Rambouillet (78), Sciez – Lake Geneva, Publier (74), Pas-de-Calais stormwater basins (62), CAMG (77)

Ports

Cavalaire (83), Camille Rayon, Gallice, Crouton, Cannes Marina (06), Carnon (34), Gravelines (59)

Industrial sites

Fluid System Technology (Portugal), Rompetrol Constanța (Romania), Saint-Gobain (54), HAROPA Port (Rouen, 76)

WHAT WE DO

Reconciling economy and ecology

After studying the situation, the product is applied directly on site using a patented application technology ®.

1. Select
custom, for each problem, harmless micro-organisms that are free to use

2. Grow and concentrate
combine the strains and concentrate them: 100 million colonies per gram of product

3. Fix on minerals
adsorption on specific minerals that protect the colonies and help them grow, and also boost enzyme kinetics. A given metabolic activity can be favoured.

4. Apply and degrade
degrade excess and refractory organic matter in situ, in natural, industrial or urban environments

Every organic waste (hydrocarbons, cyanides, silt, sludge…) has its counterpart in the environment: micro-organisms (bacteria, algae, fungi…) able to degrade it. But we produce xenobiotic molecules, far more than nature can assimilate: hence accidental or chronic pollution and costly treatment systems. **All our projects are carried out in close association with scientists from many fields.**

Micro-organisms compliant with European Directive 2000/54/EC of 18/09/2000 and the E.F.B. (CR 12894:1997).

WHAT WE DO

Fields of action

Natural marine and freshwater environments

Lakes, ports, rivers…

- Reduce silt heights and volumes, decontaminate in situ for the long term
- Fight harmful germs in bathing water
- Remove algae (eutrophication) and invasive plants
- Treat accidental and chronic pollution
- Reduce the bioavailability of heavy metals

Urban and industrial environments

Plants, networks, sites…

- Improve the efficiency of treatment plants, separate sewers and lagoons, without modification
- Degrade refractory pollutants (hydrocarbons, PCBs, PAHs…); treat contaminated soil
- Clean up livestock effluent; improve fish farming and aquaculture
- Improve landfill operation; reduce grease in the food industry
- Clean up sewers, stormwater and septic tanks; reduce odours

WHAT WE DO

Industrial products biodegradable with our processes*

Non-exhaustive list

- Aliphatic (alkanes, alkenes, alkynes…), cyclic and aromatic hydrocarbons
- Mineral oils, lubricants, petroleum products
- PAHs (naphthalenes, phenanthrenes…), phenolic polymers, phenols
- Non-ionic, anionic and cationic detergents
- Cellulose- and lignin-rich residues
- Organochlorine compounds (pentachlorophenol…), pesticides
- Polychlorinated biphenyls (PCBs)
- Cyanides and derivatives
- Organosulphur compounds (H_2S); control of sulphate-reducing bacteria
- Nitrification (ammonia uptake) and denitrification
- Polar solvents: ethanol, methanol, butanol, isopropanol, ketones, glycol…
- Proteins, fats and sugars (dairy and food-industry effluent)

Dosage: depends on the problem to treat. A high starting dose lets the micro-organisms acclimatise and grow, then it is gradually reduced to a low maintenance dose.

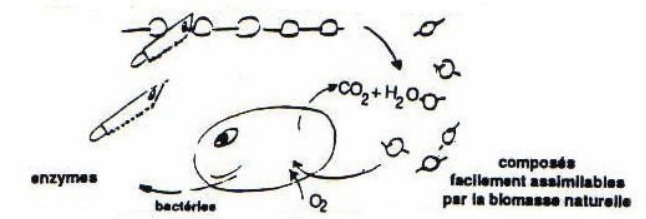
** Products and applications made exclusively to order, to a specification and within a scientific framework. Harmless micro-organisms, free to use (Directive 2000/54/EC and E.F.B. CR 12894:1997).*

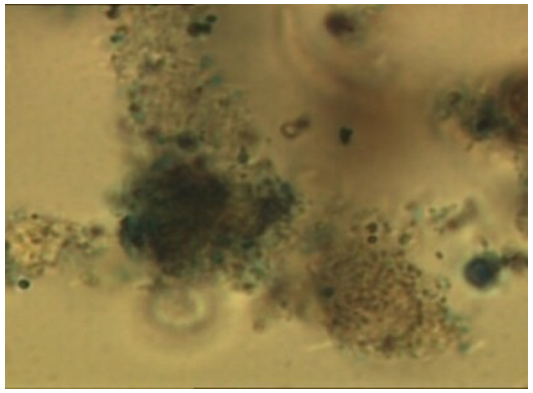
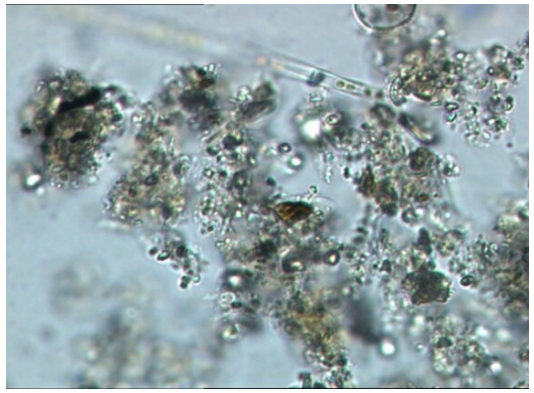
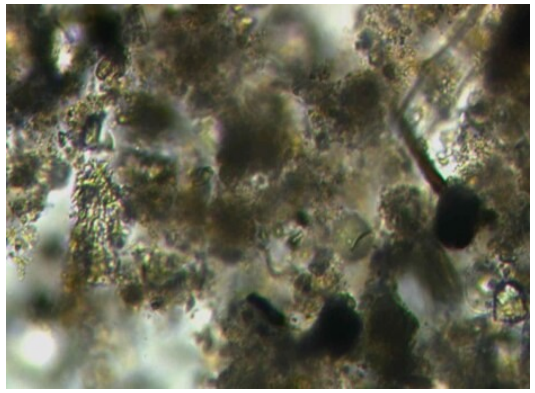
WHAT WE DO

Examples of finished products





Seeded mineral supports and microscopic views of bacterial colonies.

Class 1

Micro-organisms harmless to humans and the environment (European Federation of Biotechnology – CR 12894:1997).

Free to use without referring to the competent authority (European Directive 2000/54/EC of 18/09/2000).

WHAT WE DO

Examples of application



Application in bags



Application by airboat



Application by dusting



Directional spreader



Floating barge



Floating barge

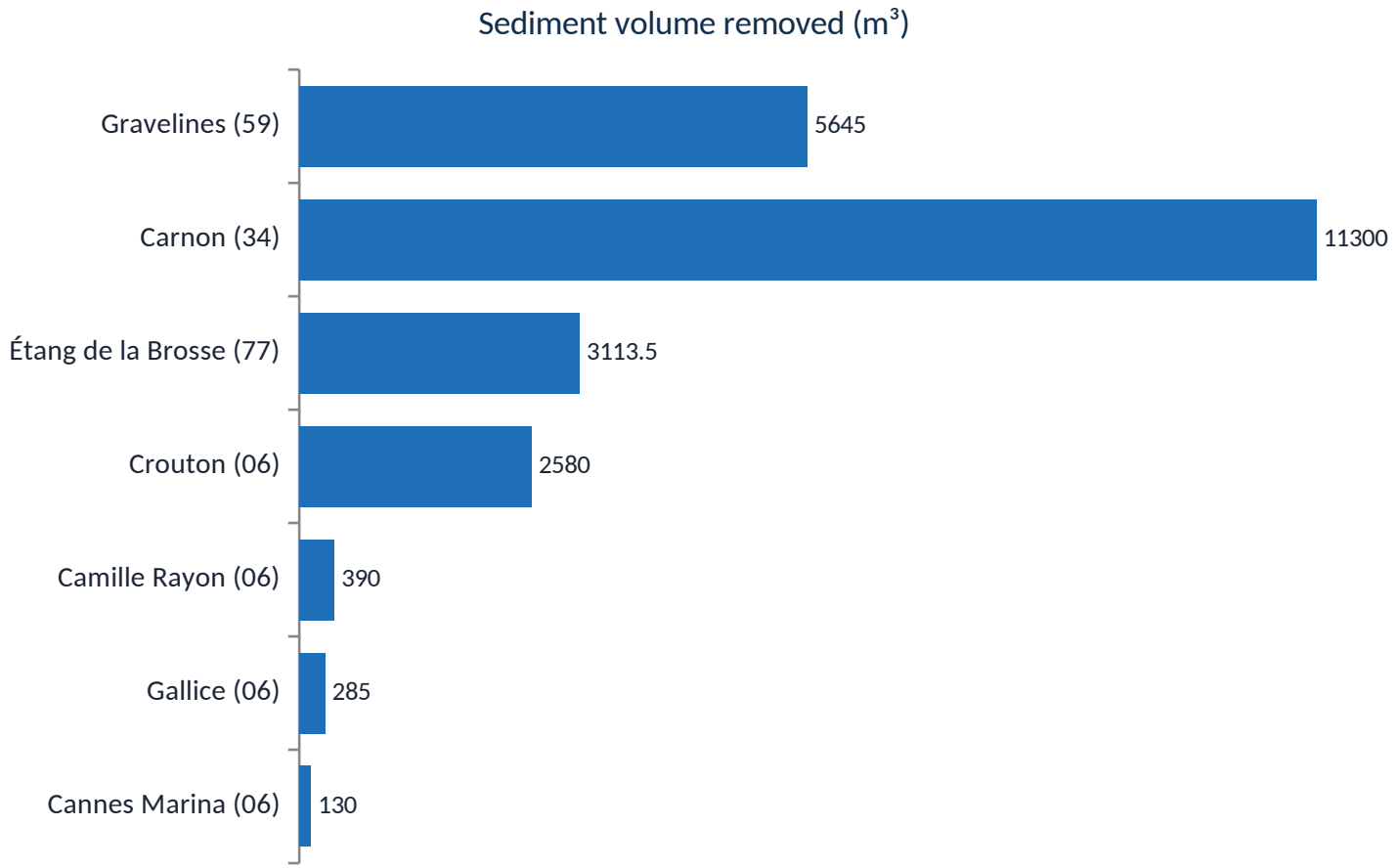


Dusting of roadside ditches

SUMMARY

Summary of results: sediment removed

Sediment volume removed by biotreatment, as measured or estimated on each site shown



Total calculated from the volumes given for each site. Carnon: estimate for the whole basin.

≈ 23,400 m³
of sediment removed in total on these 7 sites

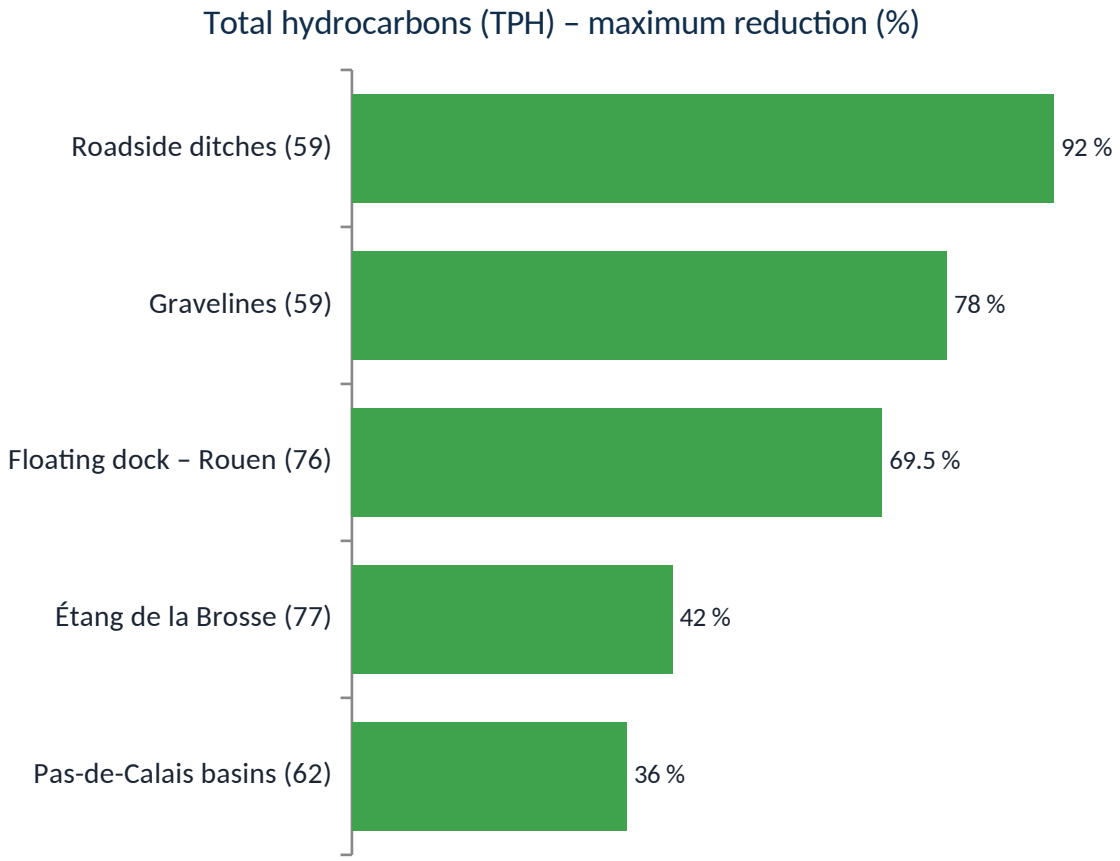
+ 39 cm
of water depth gained on average at Carnon port in 10 months

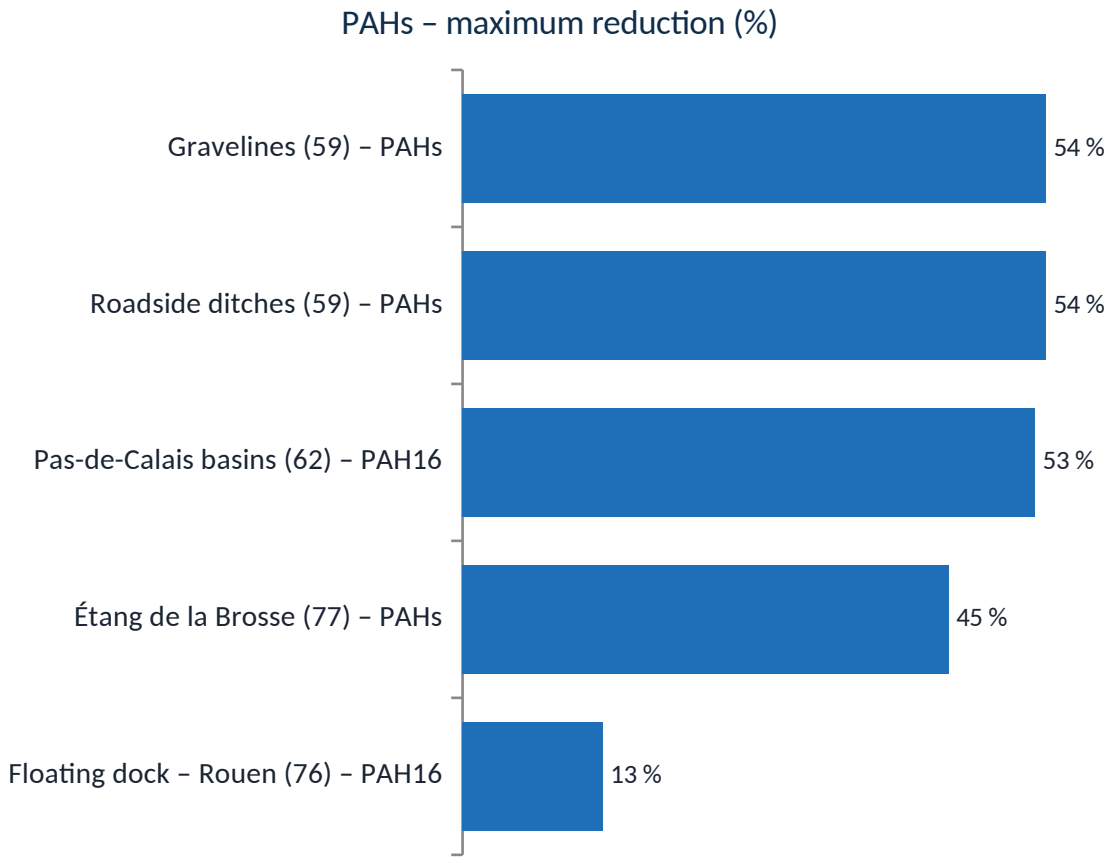
– 49 %
of sediment height at Port Gallice in 9 months

SUMMARY

Summary of results: pollutant reductions

Best reductions recorded on each site (total hydrocarbons and PAHs)





"Up to" values taken from each site's results; durations, matrices and measurement methods differ between sites. Rouen: 3 months of treatment.

Ports and water bodies

Application examples and results



BIOSYNERGIE · biosynergiecontact@gmail.com · www.biosynergie.net

PORT · ANTIBES-JUAN-LES-PINS (06)

Port Gallice: lower sediment heights and volumes

Biotreatment over 1,239 m² – 49 measuring points, before and 9 months after treatment



Sediment monitoring stations and mussel cages

– 49,93 %
sediment volume (– 285 m³)

– 49 %
sediment height (– 23 cm)

– 49 %
total weight (– 371 tonnes)

– 16,2 %
dry matter (– 23 m³)

– 8.73 m³
organic matter

Monitoring by the Copramex consultancy
Operation carried out with the approval of DDTM 06

PORT · ANTIBES-JUAN-LES-PINS (06)

Port Gallice: the seabed before and after treatment

Views of the bottom through the water – 9 months of biotreatment



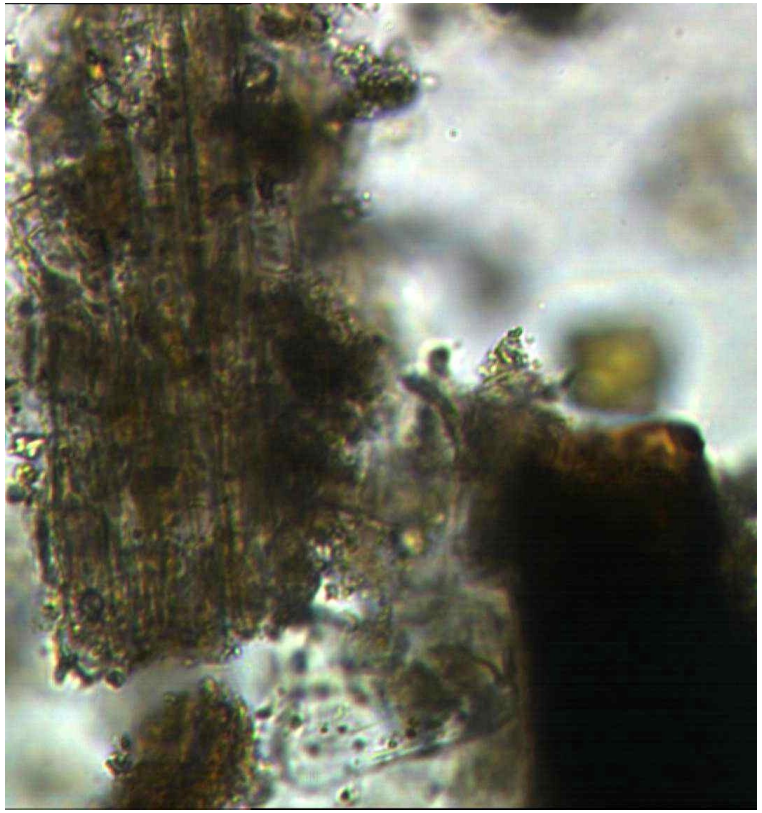
Concrete footing covered by sediment



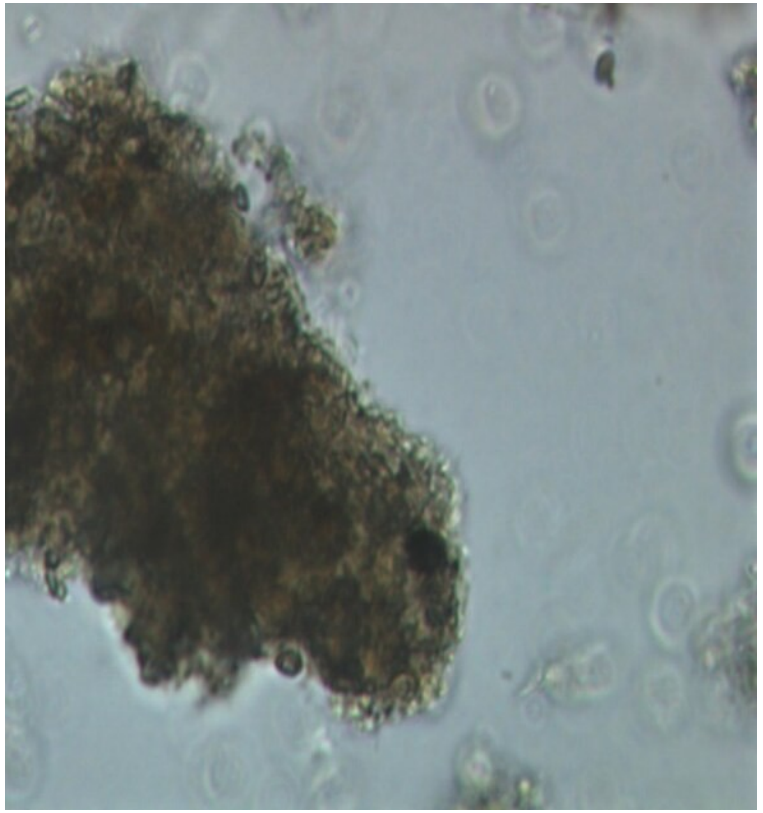
Concrete footing uncovered, cables visible on the bottom

Microscopic examination of sediment after application (31/01/2017)

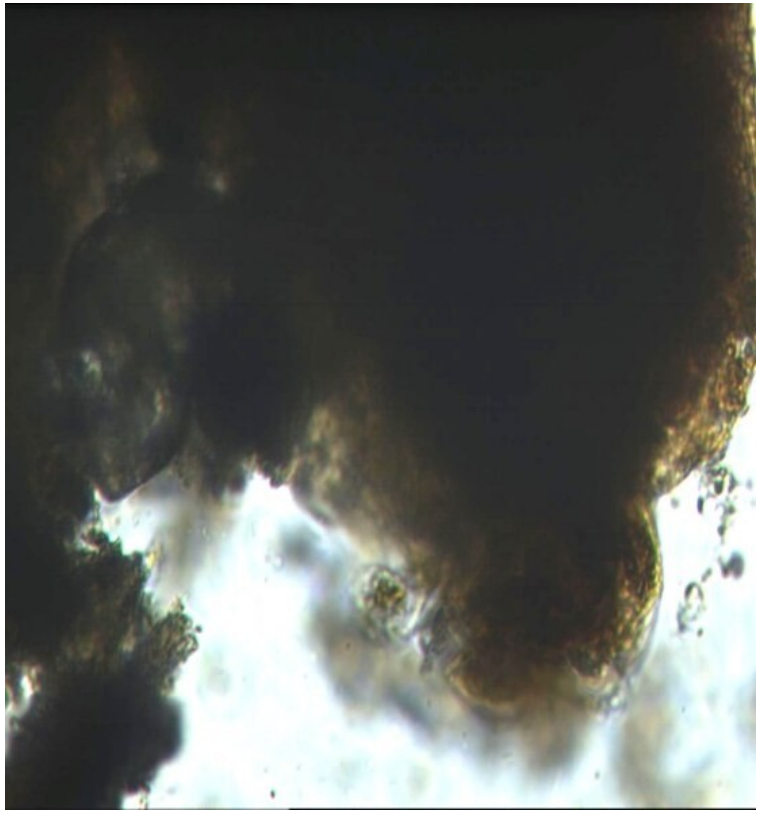
Christian Drakidès – CNRS research engineer, University of Montpellier II, UMR HydroSciences



Plant debris with bacteria (× 20 objective)



Dense bacterial floc (× 40 objective)



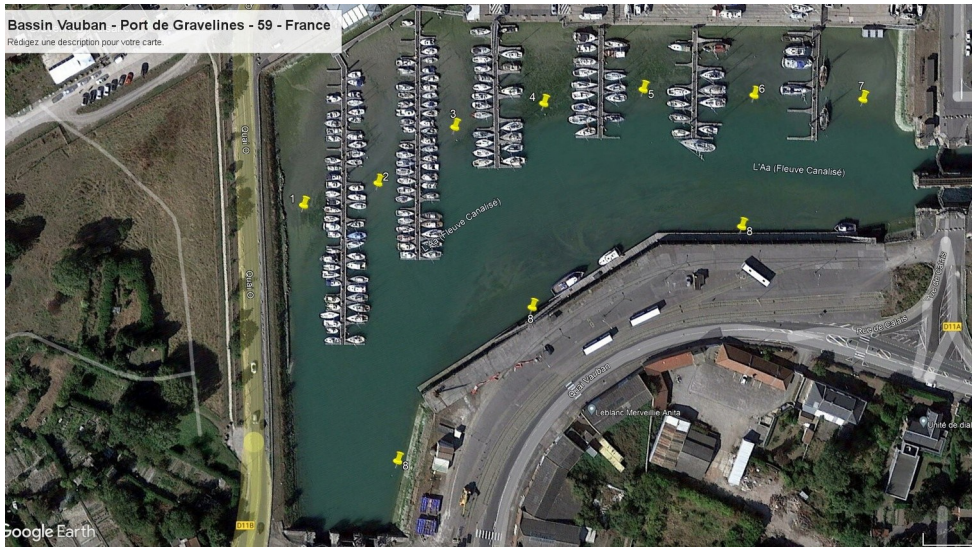
Seeded mineral support, colonies around the edge (× 40)

PORT · NORTH SEA (59)

Port of Gravelines: biotreatment of the Vauban basin



Seaport crossed by the river Aa, regulated by a lock



- North Sea port, 2 drying tides every 24 hours
- Crossed by a river (the Aa), regulated by a lock
- Area of about 3 hectares

19 tonnes
of finished products designed and made to order

12 + 7 tonnes
applied on 18/07/2022 and 22/05/2023 (precise layout)

0.5 to 5 mm
grain sizes 0.5-1 / 0.7-2 / 2-5

Operation carried out with the approval of DDTM 59

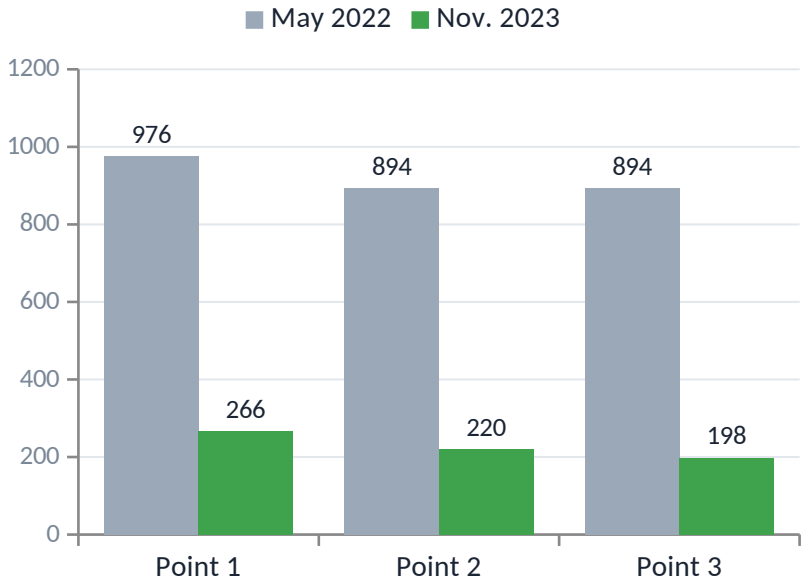
BIOSYNERGIE · biosynergiecontact@gmail.com · www.biosynergie.net

PORT · NORTH SEA (59)

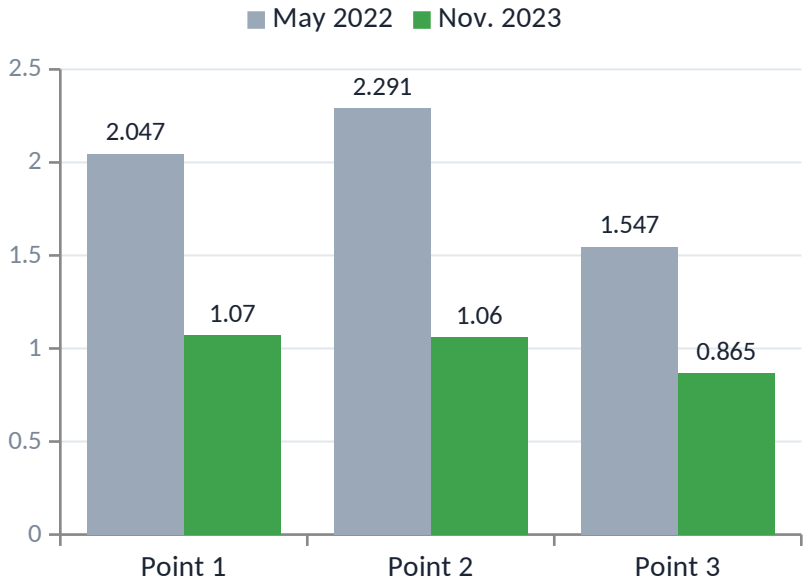
Gravelines: 16 months of biotreatment, the reductions

Sediment volume 5,645 m³ (14,508 tonnes) – area × affected height, mean DM 32.81 %, density 2.57

TPH (mg/kg DM) – May 2022 / Nov. 2023



PAHs (mg/kg DM) – May 2022 / Nov. 2023



1,852 m³
of DM degraded, i.e. 4,760 tonnes

3.3 tonnes
less hydrocarbons (TPH)

4.57 kg
less PAHs

– 73 %
TPH point 1

– 75 %
TPH point 2

– 78 %
TPH point 3

– 48 / – 54 / – 44 %
PAH points 1 / 2 / 3

Sampling and analysis: École des Mines de Douai – IMT (59). Weights based on mean DM volume and density.

PORT · NORTH SEA (59)

Gravelines: lower PAH concentrations (4, 5 and 6 rings)

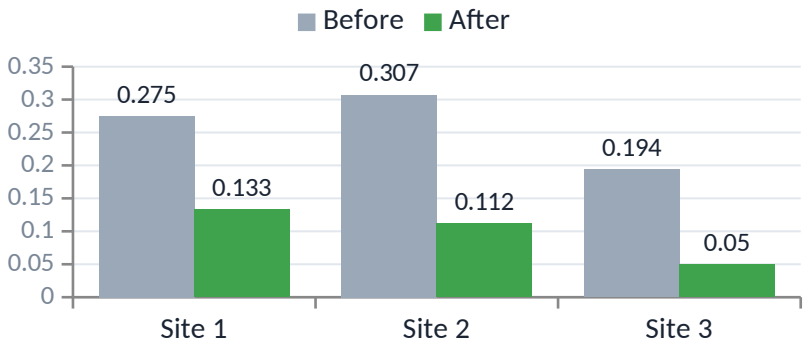
Concentrations in mg/kg DM at 3 sites, before and after 16 months of biotreatment

Fluoranthene – 4 rings



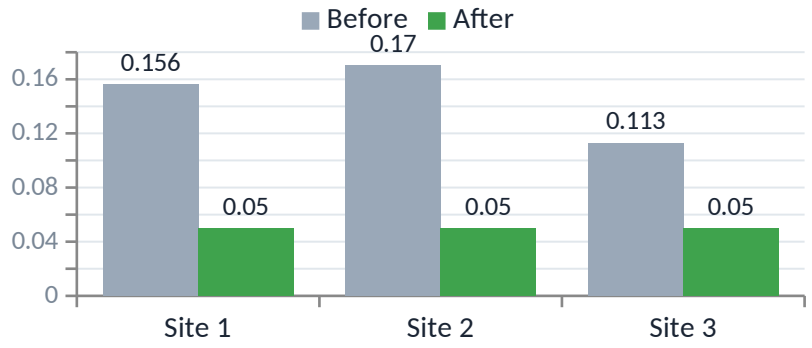
65 %
max. reduction
(sites 1/2/3:
42 / 65 / 41 %)

Benzo(b)fluoranthene – 5 rings



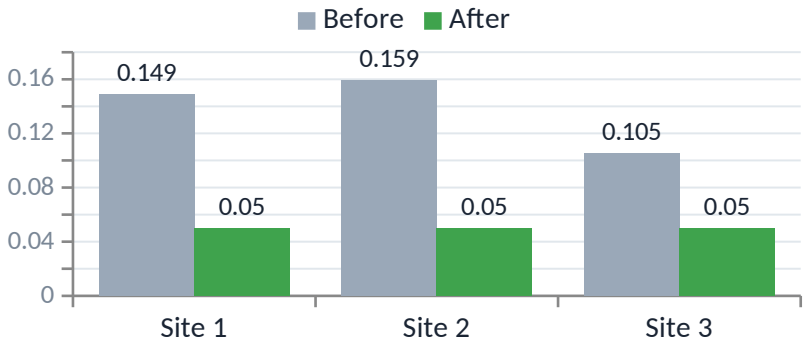
74 %
max. reduction
(sites 1/2/3:
52 / 64 / 74 %)

Benzo(a)pyrene – 5 rings



71 %
max. reduction
(sites 1/2/3:
68 / 71 / 56 %)

Benzo(ghi)perylene – 6 rings



69 %
max. reduction
(sites 1/2/3:
66 / 69 / 52 %)

Sampling and analysis: École des Mines de Douai – IMT (59).

Gravelines: lower sediment heights and volumes

INGEO bathymetric surveys (Saint-Omer) – R2SONIC 2024 multibeam echosounder, IHO S-44 special order

Tableaux :

Les tableaux ci-après montrent que les résultats obtenus en considérant individuellement les périodes entre les deux bathymétries de BATHY DRONE SOLUTIONS/INGEO ou en les globalisant diffèrent peu.

				INTERPRETATION EN BAISSE DE HAUTEUR DE SEDIMENT	
ETAT	DEBLAI (m3)	REMBLAI (m3)	VARIATION DE VOLUME (m3)	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

				INTERPRETATION EN BAISSE DE HAUTEUR DE SEDIMENT	
ETAT	DEBLAI (m3)	REMBLAI (m3)	VARIATION DE VOLUME (m3)	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

**les différents rapports utilisés mentionnant des surfaces spécifiques propres à leurs études afin de traduire les résultats exprimés en volumes en hauteurs de sédiments.*

Analyser les effets du bio traitement impose nécessairement d'appréhender l'envasement naturel récurrent du Bassin Vauban. En effet, la baisse de hauteur de sédiments constatée après bio traitement est indissociable de la hauteur de sédiment qui se serait déposée sur une période de 16 mois entre la dernière et la première bathymétrie et qui a été gommée par le bio traitement.

L'ensablement du Bassin Vauban constituant une préoccupation majeure pour le maintien de ses activités, différentes études ont été réalisées. La dernière en date, en 2023, établie par le bureau d'études IDRA, a estimé cette sédimentation annuelle à 900 m³ et sur la base d'une surface du Bassin estimée à 22 128 m².

L'envasement évité peut donc être estimé à 5,42 cm (900/22128/12*16) sur la base de l'étude du bureau d'étude IDRA.

L'effet du bio traitement sur la hauteur des sédiments, en référence au tableau précédent, se situe entre : - 15,23 cm + (- 5,42 cm) soit 20,65 cm
- 14,47 cm + (- 5,42 cm) soit 19,89 cm.

Il a évité l'envasement et réduit la hauteur des sédiments initialement en place lors du premier épandage, d'une hauteur moyenne de 20,27 cm (+/- 5645 m3)

– 5,645 m³
of sediment between May 2022 and November 2023

20.27 cm
less average sediment height

1,199 m³
of natural silting avoided over the period, i.e. 5.42 cm

Annual silting of the basin is estimated at about 900 m³ (IDRA study) over an area of 22,128 m².

NORD DEPARTMENT (59)

Roadside ditches: biotreatment of 2 × 30 lm (2016-2017)

Comparison 06/2016 – 09/2016 – 09/2017 – 2 applications (06/2016 and 02/2017)







2 × 30 lm
of ditches treated (RD 644 and RD 204)

2 applications
in June 2016 and February 2017

RD 644 – PR9 (Cambrésis)

Effective on all parameters (TOC, TPH, PAHs, PCBs, BTEX), despite very low starting values and possible outside inputs.

RD 204 – PR01 (Dunkerquois)

Effective mainly on TOC and TPH. Unconsolidated sediment (0 to 36 cm, 11 cm on average over 32 points, June 2016) had gone by September 2016 and October 2017. Bad odours disappeared.

15 km of roadside ditches: reductions 2019-2021 (TOC, TPH, PAHs)

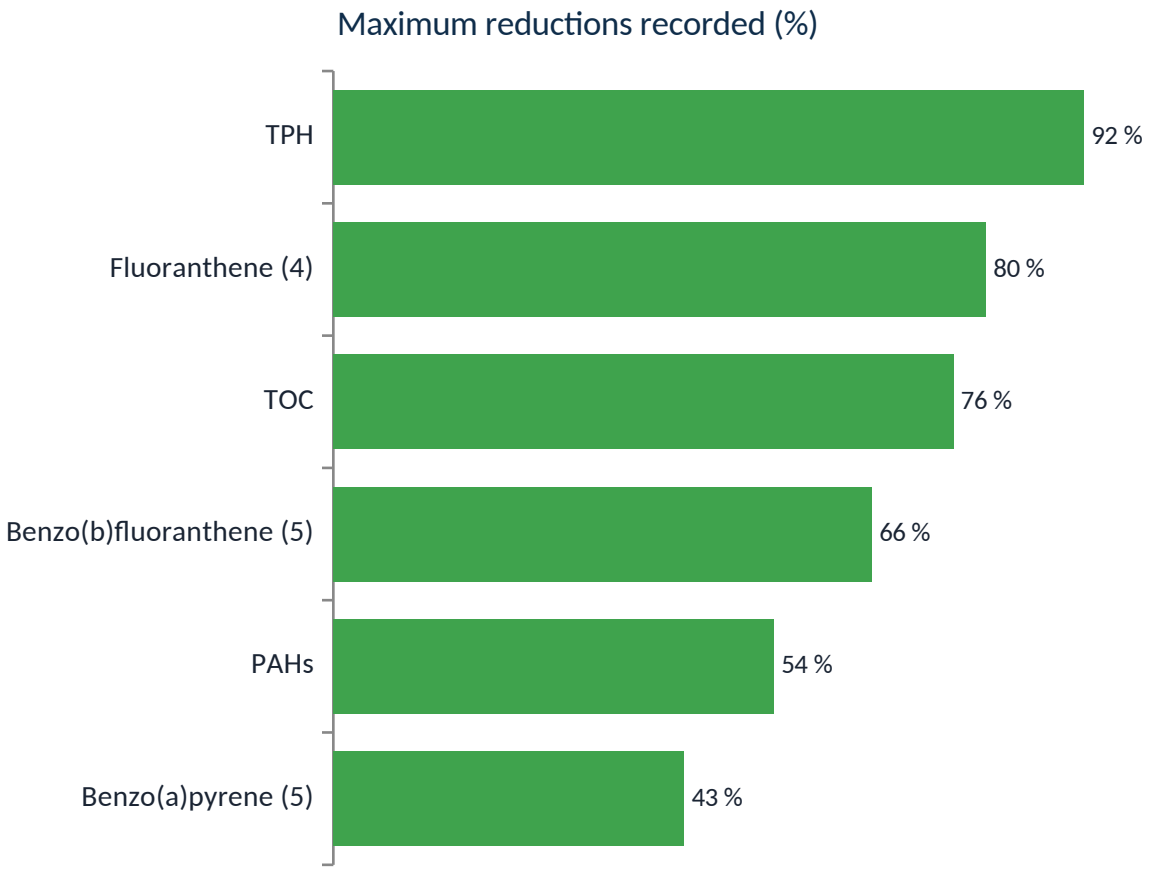
Taux abattement moyen	T0 à T1 (3,5 mois Printemps/Eté, 1 ensemencement, pluviométrie faible)			T1 à T2 (9 mois, Automne/Hiver, 1 ensemencement, pluviométrie forte)			T0 à T2 (12,5 mois)			T2 à T3 (10 mois, Automne/Hiver, pas d'ensemencement, pluviométrie moyenne)			T3 à T4 (6 mois, Printemps/Eté, 1 ensemencement, 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%	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%**	

15 km of roadside ditches: reductions 2019-2021 (4- and 5-ring PAHs)

Taux abattement moyen	T0 à T1 (3,5 mois Printemps/Eté, 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/Eté, 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%	

15 km of roadside ditches: conclusions

Open environment, heavily affected by uncontrolled multi-factor events



- TPH up to 92 % (– 1.76 g, RD138 G T0/T1); TOC up to 76 % (– 49 g, RD138 G T0/T1)
- Fluoranthene up to 80 % (– 6.37 mg); benzo(b)fluoranthene 66 % (– 11.78 mg); PAHs 54 % (– 48.5 mg); benzo(a)pyrene 43 % (– 4.4 mg)
- For these poorly soluble products that build up on site, degradation is the most likely explanation, especially for PAHs with 4 or more rings (half-life up to 110 months).
- **Result: 3 broad-spectrum consortia developed, paving the way for large-scale treatment.**



Next steps: consistency of some parameters over time and practical use by road services.

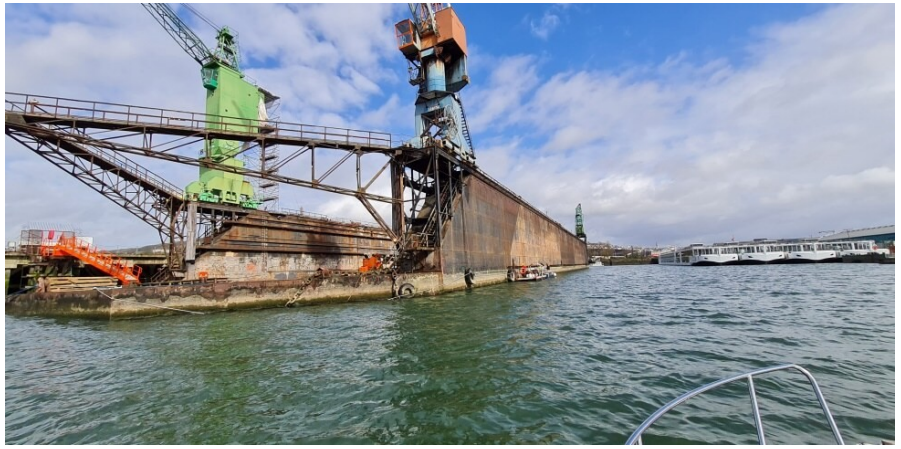
RIVER AND SEA PORT · ROUEN (76)

Floating dock – HAROPA Port: sediment biotreatment

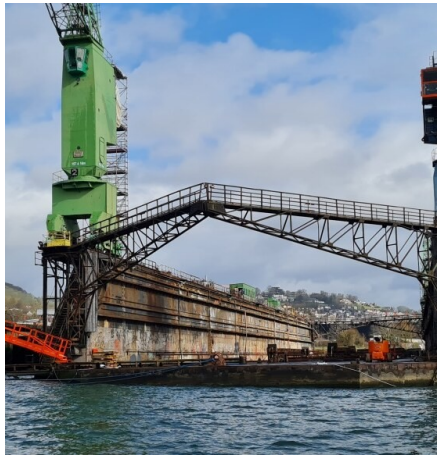
Sedimentation area around and under the floating dock – Seine Axis river and sea port



Sampling points around the floating dock

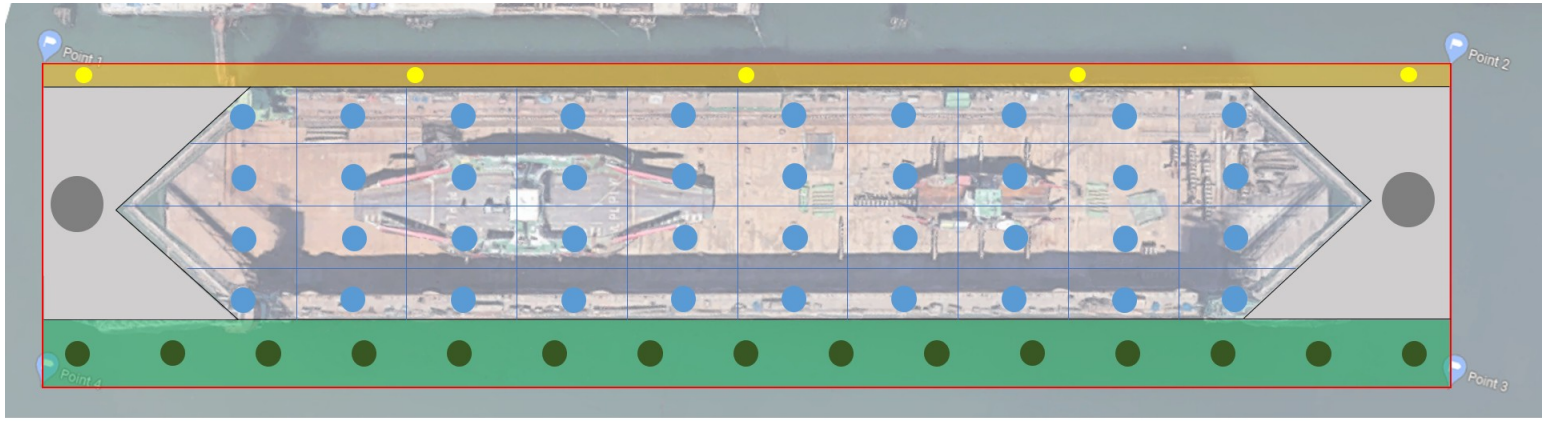






Operation carried out with the approval of DDTM 76

Floating dock: application plan and implementation



SOUS LE DOCK : 6.500 M² (180M X 36M)

40 SACS SOIT 1000 KG - 1 TOUS LES 162 M² ENVIRONS

/ + ÉPANDAGE + 2325 KG

LE LONG DU DOCK COTÉ LARGE : 3.200 M² (200 M X 16M)

15 SACS SOIT 375 KG SUR LA LONGUEUR POUR 213 M² ENVIRONS

/ + ÉPANDAGE + 825 KG

ENTRE LE QUAI ET LE DOCK : 1.000 M² (300 M X 5M)

5 SACS SOIT 125 KG SUR LA LONGUEUR – 1 SAC POUR 200 M² ENVIRONS

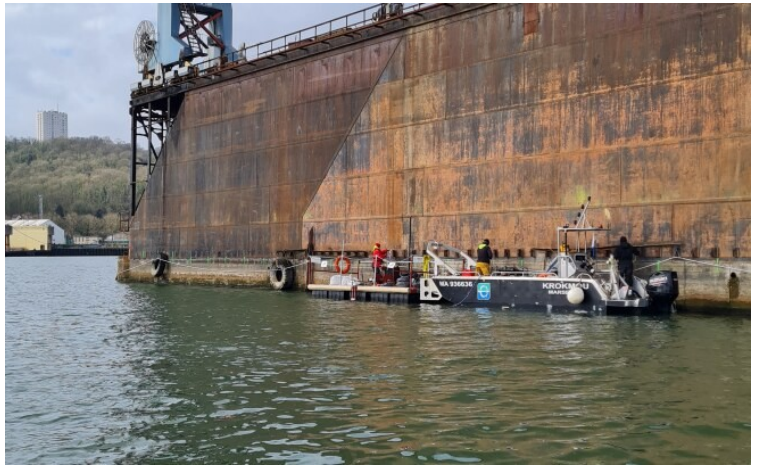
/ + ÉPANDAGE +250 KG)

EXTRÉMITÉS DU DOCK : 300 M² (150 M X 2 M)

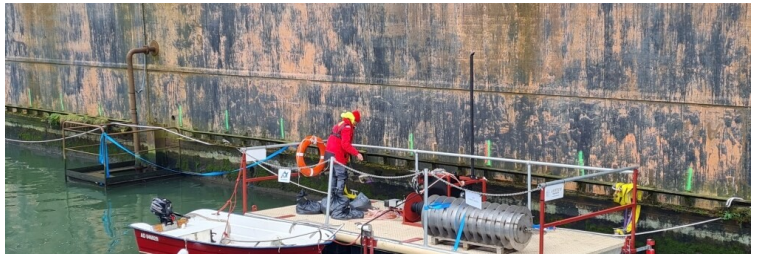
2 X 1 SAC SOIT 50 KG À LA POINTE POUR 150 M² ENVIRONS

/ + ÉPANDAGE + 50 KG

Application plan

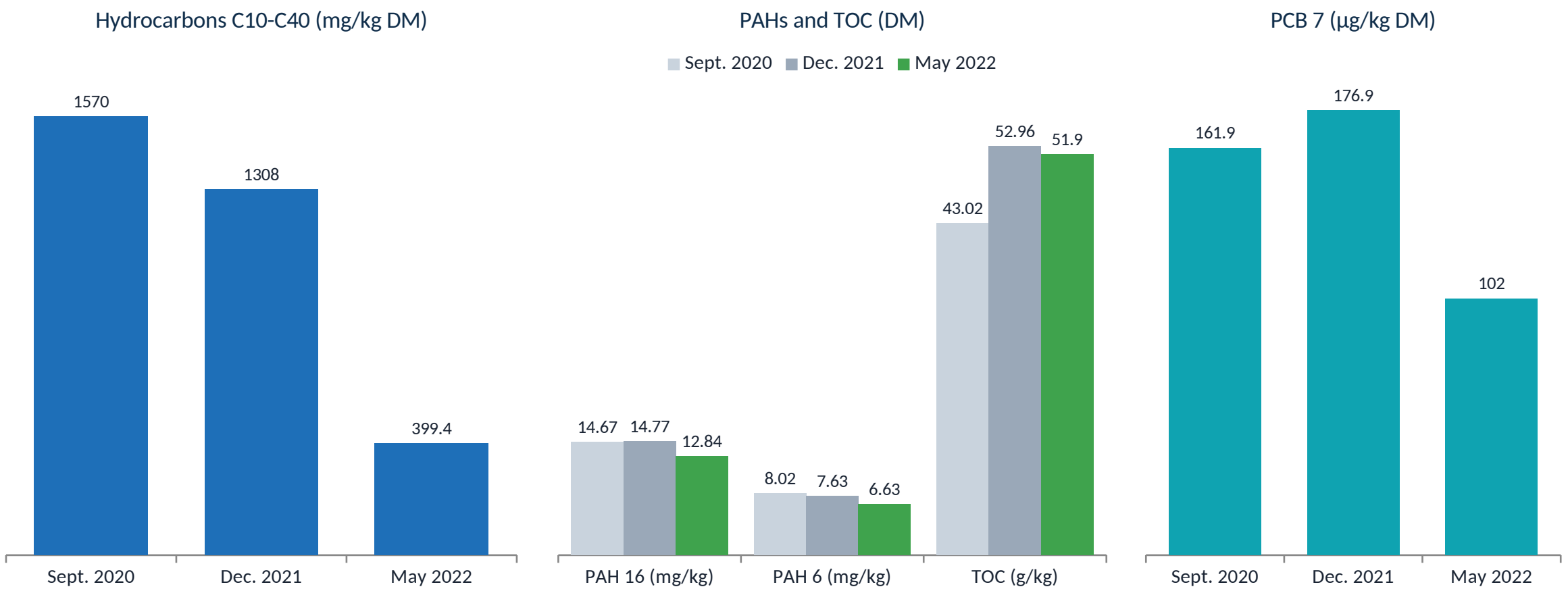






Floating dock: change in pollutants

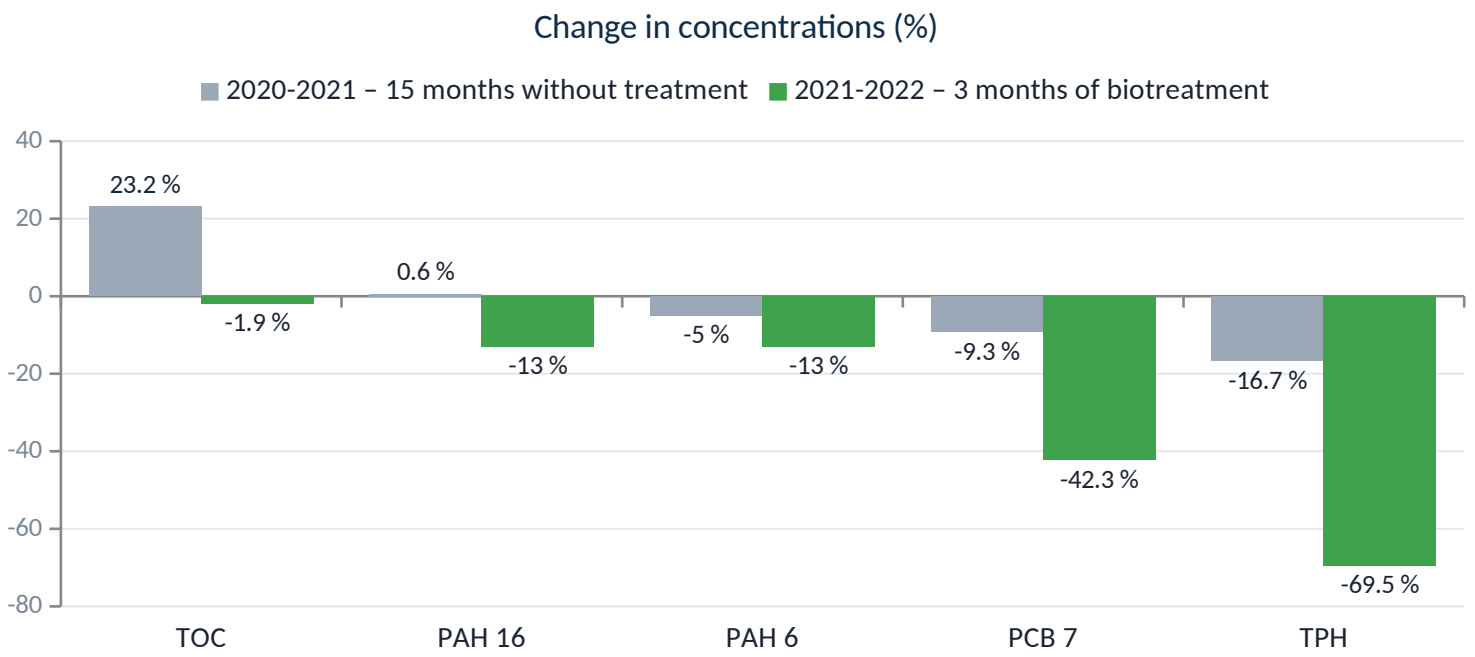
Averages of sampling points DB4 (0-1 m), DB5 (1-1.5 m) and VC1.1 (0-0.8 m)



3-month biotreatment (February to May 2022): TPH – 69.5 % and PCB 7 – 42.3 % between December 2021 and May 2022.

Floating dock: change before and during biotreatment

Change in the average of sampling points – a negative value means a lower concentration



	SEPTEMBRE 2020					DECEMBRE 2021					EPANDAGE fin FEVRIER 2022	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

– 69,5 %
hydrocarbons in 3 months

– 42,3 %
PCB 7 in 3 months

Untreated and treated areas, Dec. 2021 – May 2022

Floating dock: conclusions

Biologically degrading, over 1.1 hectares within a larger open natural environment:

- compounds that are hard to very hard to biodegrade (PAH 6 and 16, PCB 7, TPH C20-C40)
- over a short period (3 months), in cold temperatures (February)
- under and around the floating dock (11,000 m²)
- on sediment up to 1.50 m thick, in more than 6 m of water
- despite constant outside inputs from the site's industrial operation

Sampling and analysis by HAROPA Port's usual contractors. Operation approved by DDTM 76.

Total quantities biodegraded

5,667 kg
of hydrocarbons (TPH)

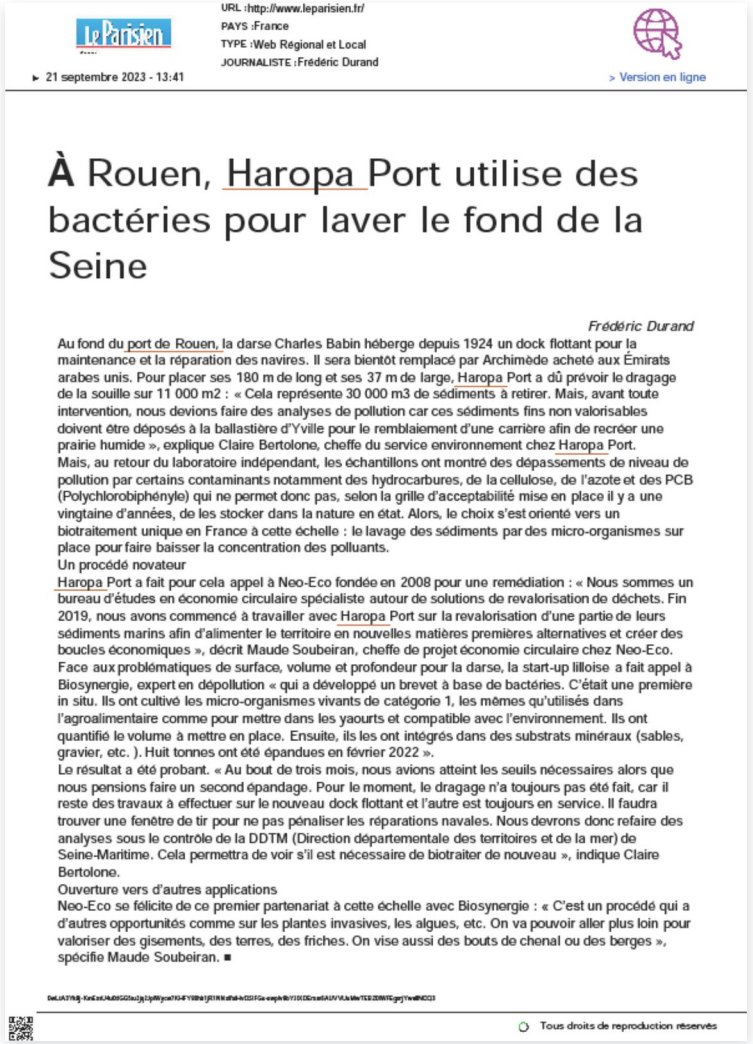
8.85 kg
of PAH 16

1.88 kg
of PAH 6

0.29 kg
of PCB 7

Quantities calculated from area × sediment height × DM.

Floating dock: the operation in the press



Le Parisien

URL :http://www.leparisien.fr/
PAYS :France
TYPE :Web Régional et Local
JOURNALISTE :Frédéric Durand

► 21 septembre 2023 - 13:41

» Version en ligne

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 devions 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 épandues en février 2022 ».

Le résultat a été probant. « Au bout de trois mois, nous avions atteint les seuils nécessaires alors que nous pensions faire un second épandage. 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 devrons 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 biotraiter 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. ■

Tous droits de reproduction réservés

STORMWATER BASIN · MARNE ET GONDOIRE (77)

Étang de la Brosse: biotreatment of a 2.7-hectare basin

Marne et Gondoire urban community



Timeline of operations

Stages	Bathymetry	Sampling
Call for tenders (EGIS)	12/2018	12/2018
Point 0	10/01/2024 (COVADIS) · 22/02/2024 (INGEO)	17/01/2024 (IDRA)
Point 1	27/05/2024 (INGEO)	28/05/2024 (IDRA)
Point 2	27/09/2024 (INGEO)	30/09/2024 (IDRA)

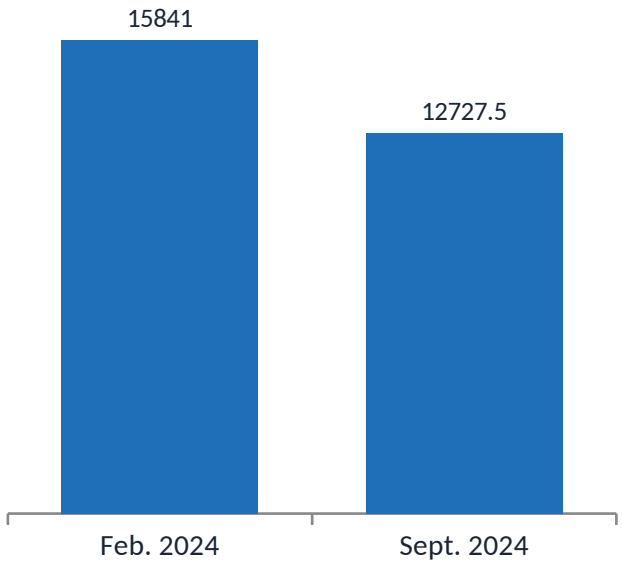
9 tonnes
applied from 25 to 29/03/2024

11 tonnes
applied from 10 to 14/06/2024

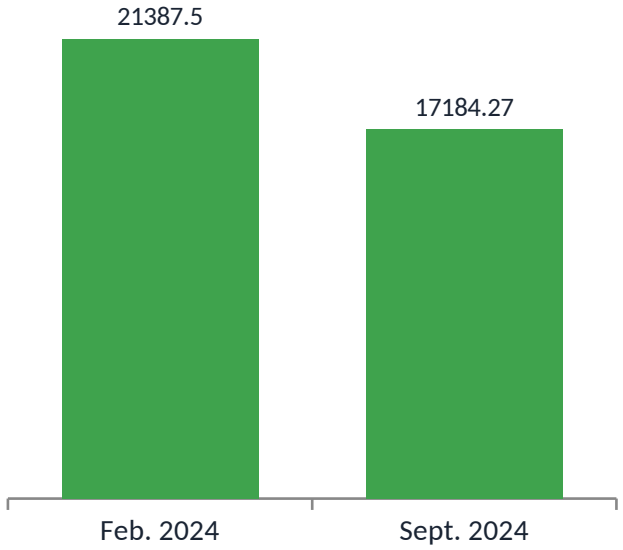
Étang de la Brosse: results

INGEO volume surveys – February to September 2024

Sediment volume (m^3)



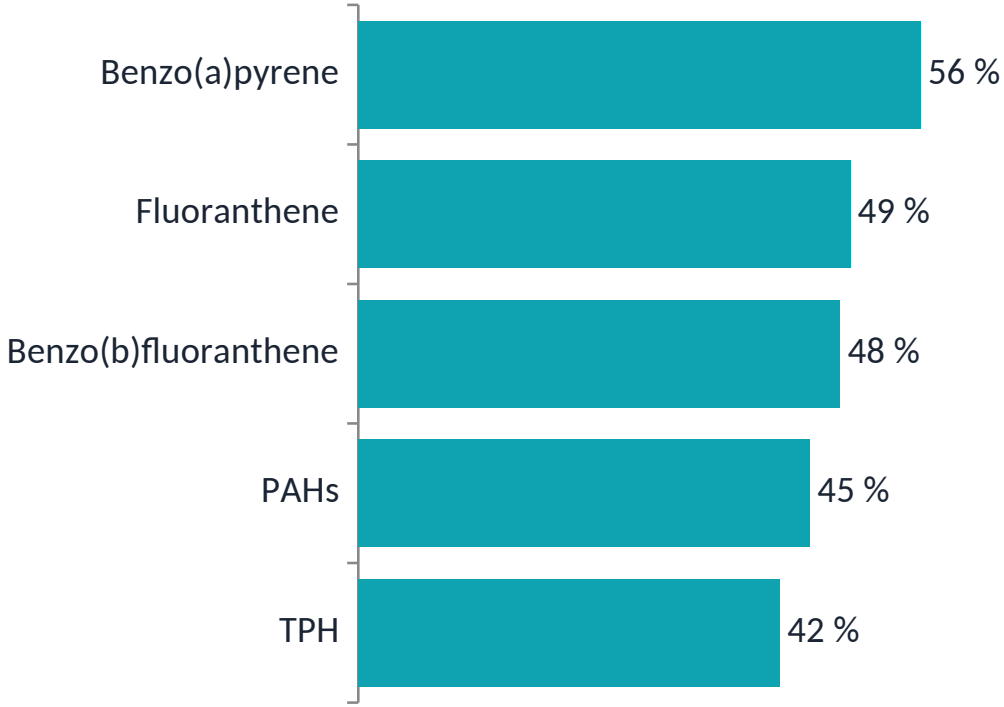
Sediment weight (tonnes)



– 3,113.5 m^3
including 912 m^3 of natural silting avoided

– 4,203 tonnes
including 1,231 tonnes of silting avoided

Drop in concentrations – maximum (%)



TPH – 980 mg (EM3, 05→09/2024) · PAHs – 2.40 mg (EM1) · BaP – 0.13 mg, BbF – 0.17 mg (EM2, 01→09/2024) · fluoranthene – 0.54 mg (EM1)

Biotreatment of 3 basins: Tatinghem, Bainchtun, Tilques







Tilques: approximate sampling locations

Applications

Apr. 2023
Operation 1

Sept. 2023
Operation 2

June 2024
Operation 3

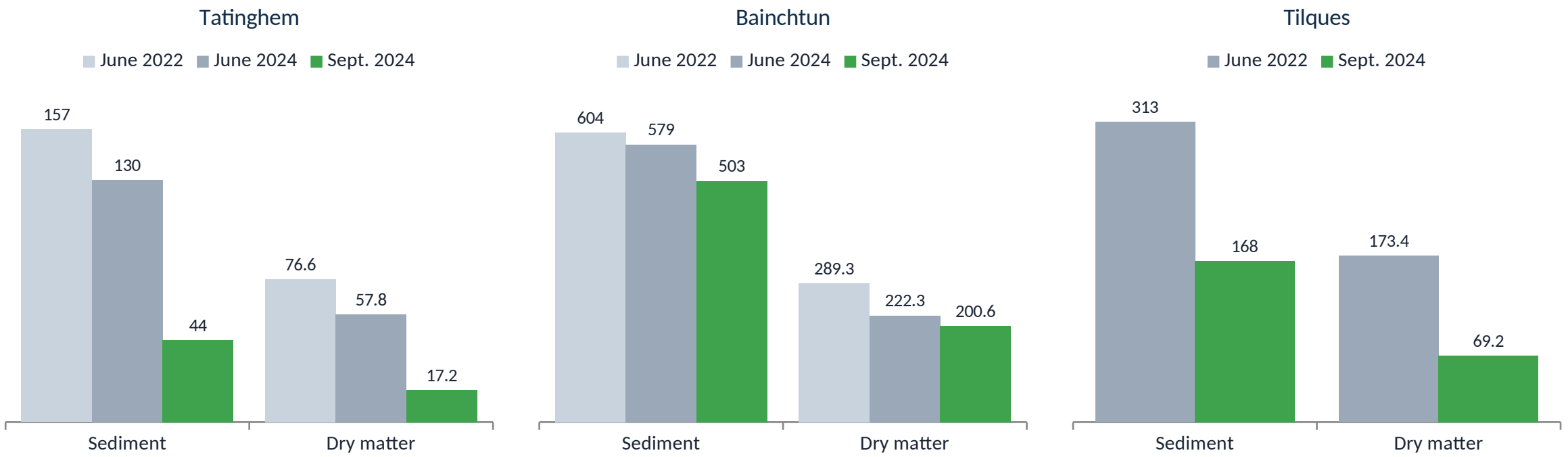
Timeline of operations

Stages	Bathymetry	Sampling
Point 0	22/06/2022 (BPH)	23/06/2022
Point 1	05/06/2024 (INGEO)	05/04/2024
Point 2	08/10/2024 (INGEO)	26/09/2024*

*Sampling: EUROFINS. * Except Tilques.*

Pas-de-Calais basins: lower volumes

Sediment and dry matter volumes (m³) before and after treatment

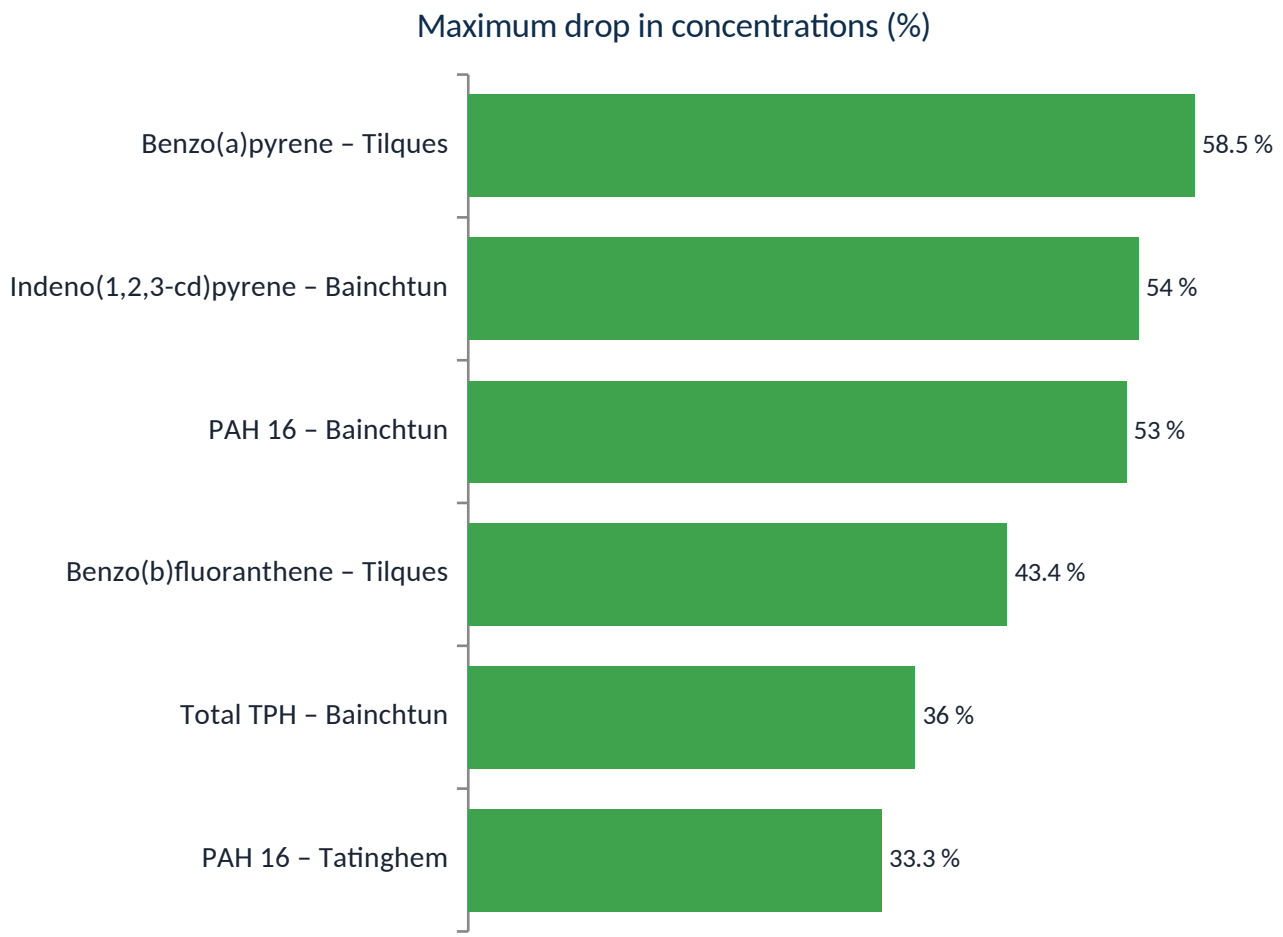


– 113 m³
of sediment at Tatinghem (157 → 44)

– 101 m³
of sediment at Bainchtun (604 → 503)

– 145 m³
of sediment at Tilques (313 → 168)

Pas-de-Calais basins: lower concentrations



– 564 mg
total TPH (light and heavy), Bainchtun, 04→09/2024

– 3.8 mg
PAH 16, Bainchtun, 04→09/2024 (– 0.5 mg at Tatinghem)

– 0.31 mg
benzo(a)pyrene, Tilques, 01→04/2024

– 0.54 mg
indeno(1,2,3-cd)pyrene, Bainchtun, 04→09/2024

PORT · CARNON (34)

Port of Carnon: deeper water, lower volumes

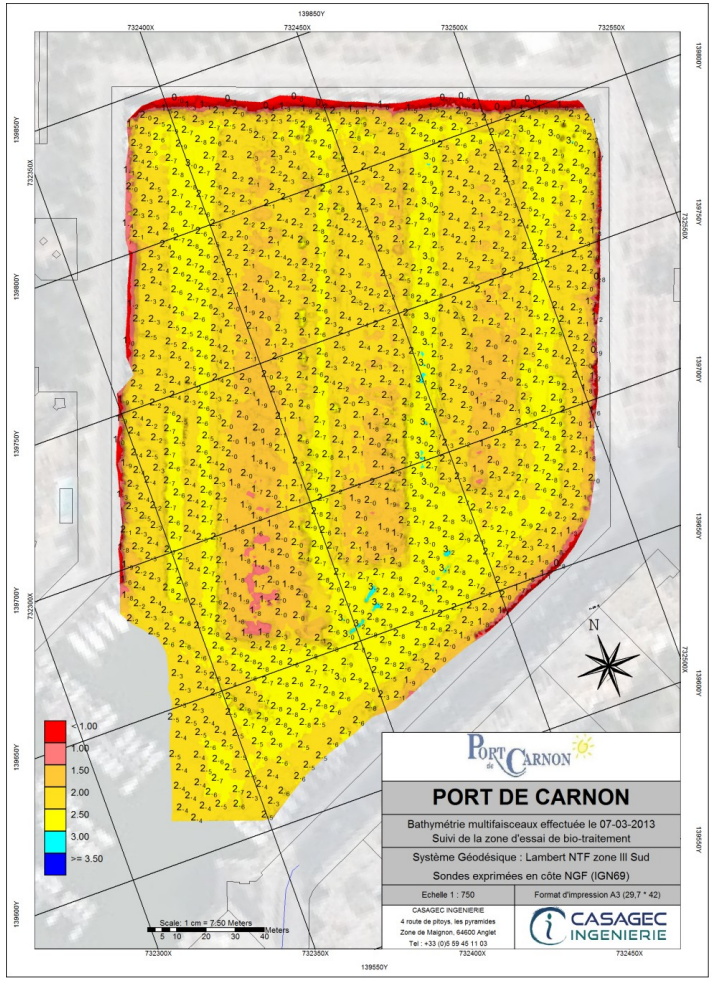
Biotreatment of marine sediment in part of the port



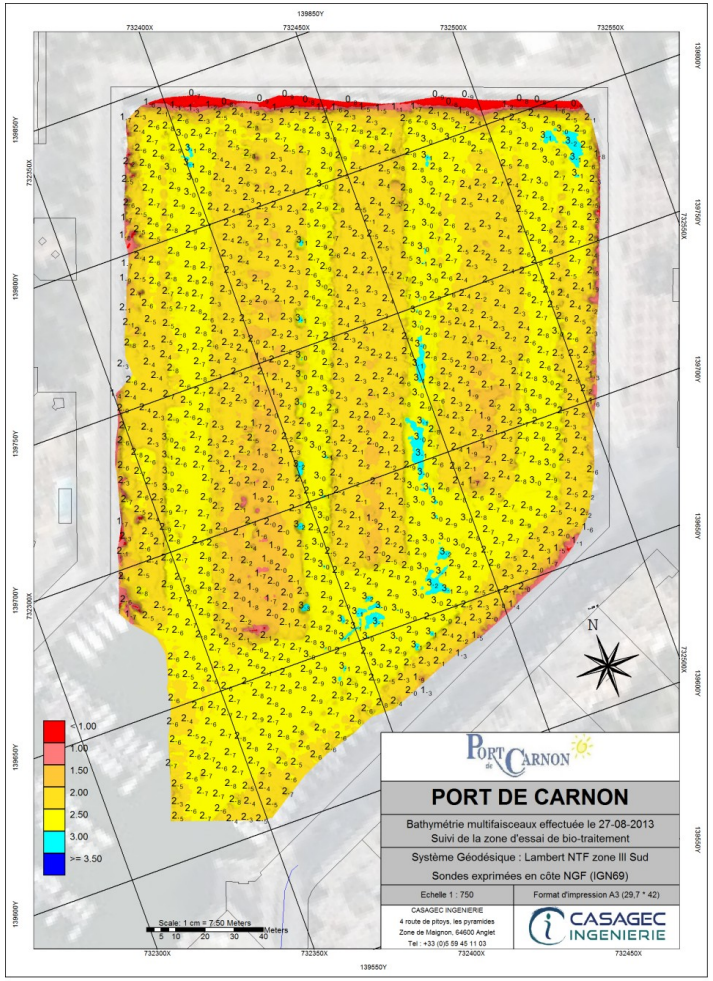


PORT · CARNON (34)

Port of Carnon: bathymetry before and after 10 months of biotreatment



Before treatment (March 2013)



After 10 months of biotreatment (January 2014)

PORT · CARNON (34)

Port of Carnon: conclusion

Good to very good results according to the March 2013 and January 2014 bathymetry

+ 39 cm
of water depth on average (rare minima at 0, maxima at 0.60 m)

11,300 m³
of sediment removed, estimated for the whole basin

3 to 3.50 m
of water depth in the priority area (pontoons 2 and 3)

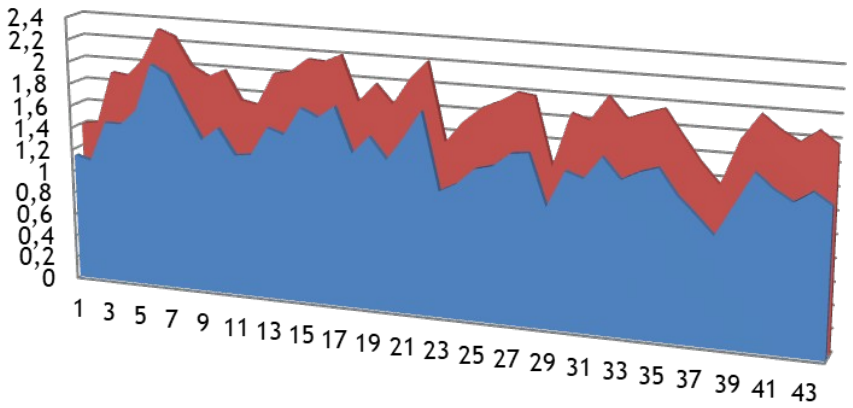
- Strong circulating flow in the basin (entrance → back → return → exit): a priority seeding area was chosen (pontoons 2 and 3).
- On top of this, inputs from port activity over 10 months, including two and a half months of summer season, were also degraded (not quantifiable).
- The bad odours that had bothered local residents for years disappeared.

PORT · ANTIBES-JUAN-LES-PINS (06)

Port du Crouton: deeper water checked at 44 points

Measurements by port staff – before (September 2016) and after 6 months of treatment (March 2017)





Water depth at 44 points: before (blue) and after treatment (red)

2,580 m³
of sediment degraded (6,000 m² × 0.43 m)

30 %
dry matter; sediment rich in Posidonia

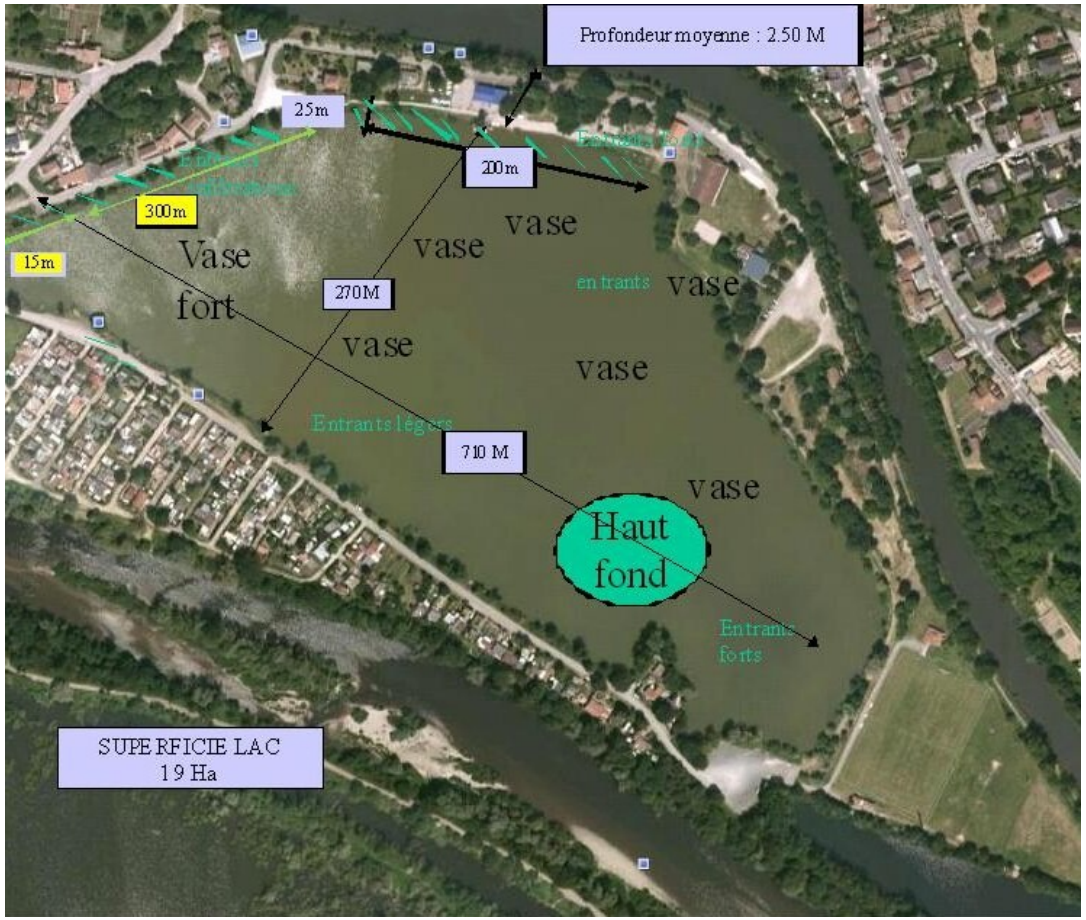
2.9 to 11.6 %
TOC depending on the point

0 odour
bad odours gone (boat owners)

LAKE · MESSEIN (54)

Lake Messein: fighting eutrophication

Biological treatment of sediment and water – swimming banned by the health authority (cyanobacteria)



Initial state

- 19-hectare lake, many pollution sources (seepage, stormwater, domestic wastewater)
- Algal bloom in summer (green algae, diatoms, cyanobacteria): water sports centre closed
- Sediment on 30 April 2009: COD 43 g O_2/kg DM, TOC 460 g C/kg DM

Partial treatment of the lake

5 tonnes of microbiological complex (1 to 8 mm) applied over a marked-out hectare – early May 2009

Summer 2009
water sports centre reopened in the first year

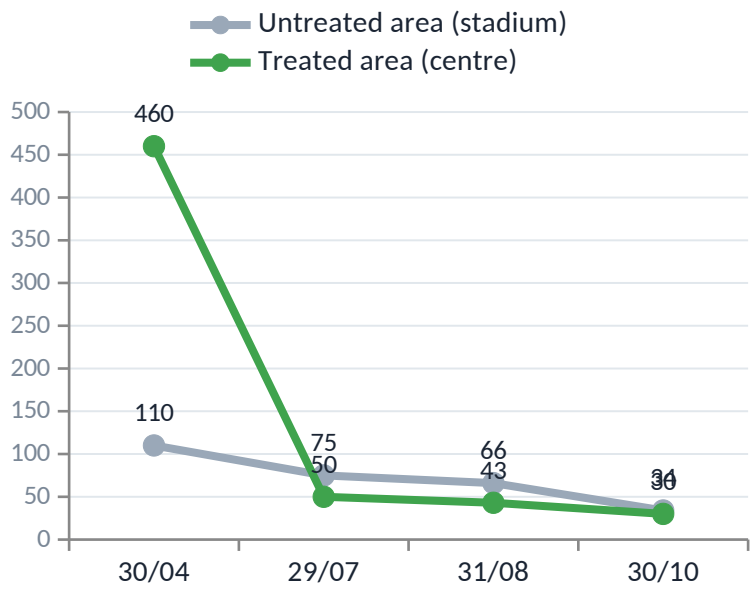
1,800 kg/year
maintenance treatment 2010-2014: open all the time

LAKE · MESSEIN (54)

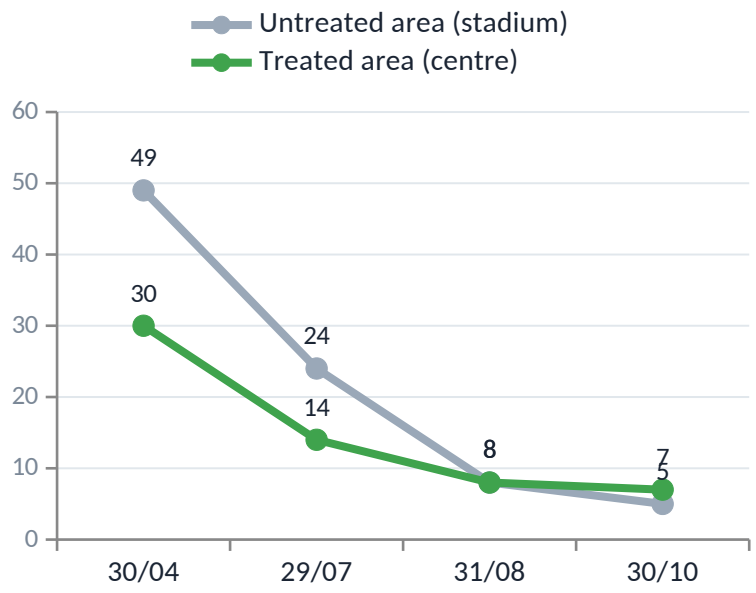
Lake Messein: change in water and sediment in 2009

Treated area (water sports centre) compared with an untreated area (stadium)

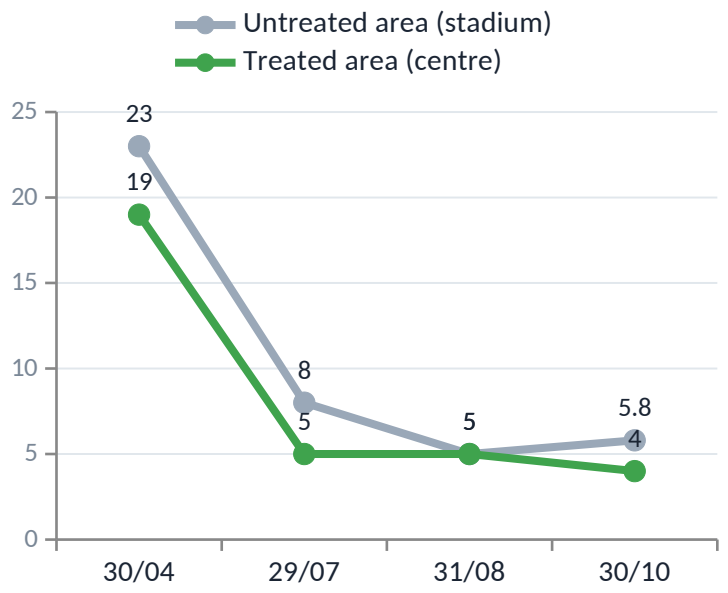
Sediment – TOC (g C/kg)



Water – COD (mg/l)



Water – BOD5 (mg/l)



460 → 30
Sediment TOC in the treated area (g C/kg), April → October 2009

< 0.30 m → > 1.50 m
water clarity: before treatment → 2013 (diving possible)

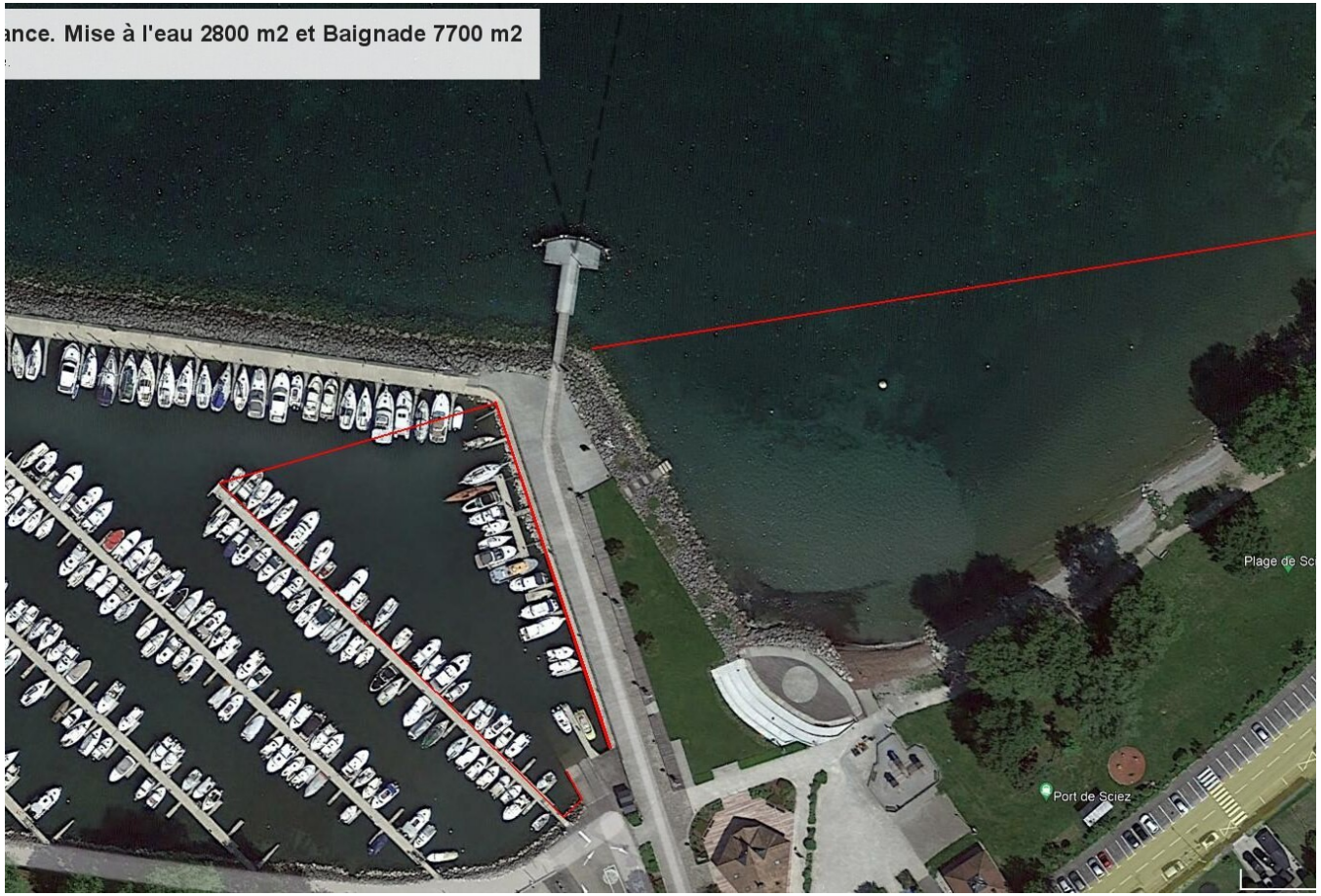
Clear lake bed
metal waste uncovered and removed thanks to lower sediment

Lake Messein analysis database, 2009. The untreated area is the reference.

PORT · SCIEZ, LAKE GENEVA (74)

Port of Sciez: swimming and launching areas

Biological treatment of sediment and water – fighting eutrophication



Area and operation	Date
Swimming – application 1	12/09/2013
Swimming – application 2	late April / early May
Launching – application 1	12/09/2013
Launching – application 2 and raking 1	late April / early May
Launching – application 3 and raking 2	early to mid-June

Port of Sciez: IDAC analysis reports

I D A C
BP 52703 - 44327 Nantes Cedex 3
Tél. 02 51 85 44 44 - Fax 02 51 85 44 50 www.idac.fr

Rapport d'analyse n° : D130700712
CAPITAINERIE DU PORT DE SCIEZ
650 Route du Port
74140 SCIEZ

Imprimé le : 30/07/2013 Date enregistrement 03/07/2013

Echantillon n° : SED004381 Référence client : Sédiments (SED_DIV)
Descriptif : ZONE DE BAIGNADE
(EDITION PARTIELLE)
Prélevé le : 26/06/2013

Analyses	Résultats / brut	/ sec (MS)	Unités	Spécifications	Types méthodes	Limite de Quantification
10 ETM (ar.9/08/2006 sédiment eau douce)				arrêté du 9 août 2006 (niveaux de référence S1)		
* Phosphore	< 0,37	< 0,50	g/kg P		ICP	
* Cuivre		< 3	mg/kg Cu	<= 100	ICP	3
* Zinc		20	mg/kg Zn	<= 300	ICP	10
* Cadmium		< 0,40	mg/kg Cd	<= 2.00	ICP	0.40
* Chrome		13	mg/kg Cr	<= 150	ICP	5
* Nickel		9	mg/kg Ni	<= 50	ICP	3
* Plomb		6	mg/kg Pb	<= 100	ICP	5
* Aluminium		< 1 000	mg/kg Al		ICP	1000
* Mercure		< 0,05	mg/kg Hg		spectro-fluoresatom.(minéral"eau régale	0.05
* Arsenic		2,10	mg/kg As	<= 30.00	ICP-MS	0.50
PCB et HPA (sédiments d'eau douce)				arrêté du 9 août 2006 (niveaux de référence S1)		
* Acénaphtène		< 25	µg/kg		GC/MS(/MS)	10
* Acénaphtylène		< 25	µg/kg		GC/MS(/MS)	10
* Anthracène		< 25	µg/kg		GC/MS(/MS)	10
* Benzo (a) anthracène		54	µg/kg		GC/MS(/MS)	10
* Benzo (3,4)(a) pyrène		47	µg/kg		GC/MS(/MS)	10
* Benzo (3,4)(b) fluoranthène		61	µg/kg		GC/MS(/MS)	10
* Benzo (1,12)(ghi) pérylène		< 63	µg/kg		GC/MS(/MS)	25
* Benzo (11,12)(k) fluoranthène		33	µg/kg		GC/MS(/MS)	10
* Chrysène		80	µg/kg		GC/MS(/MS)	10
* Dibenzo (ah) anthracène		< 63	µg/kg		GC/MS(/MS)	25
* Fluoranthène		111	µg/kg		GC/MS(/MS)	10
* Fluorène		< 25	µg/kg		GC/MS(/MS)	10
* Indéno (1,2,3-cd) pyrène		< 63	µg/kg		GC/MS(/MS)	25
* Méthyl (2) fluoranthène		< 25	µg/kg		GC/MS(/MS)	10
* Méthyl (2) naphtalène		< 25	µg/kg		GC/MS(/MS)	10
* Naphtalène		< 125	µg/kg		GC/MS(/MS)	50

L'accréditation de la Section Essais de COFRAC atteste de la compétence de l'IDAC pour les seuls essais couverts par l'accréditation précédés par un (*). Ces résultats d'analyse ne concernent que les produits soumis à analyse. Ce document comporte 11 page(s).

Page 8 / 11

I D A C
BP 52703 - 44327 Nantes Cedex 3
Tél. 02 51 85 44 44 - Fax 02 51 85 44 50 www.idac.fr

Rapport d'analyse n° : D130700712
CAPITAINERIE DU PORT DE SCIEZ
650 Route du Port
74140 SCIEZ

Imprimé le : 30/07/2013 Date enregistrement 03/07/2013

Echantillon n° : SED004382 Référence client : Sédiments (SED_DIV)
Descriptif : MISE A L'EAU PORT
(EDITION PARTIELLE)
Prélevé le : 26/06/2013

Analyses	Résultats / brut	/ sec (MS)	Unités	Spécifications	Types méthodes	Limite de Quantification
10 ETM (ar.9/08/2006 sédiment eau douce)				arrêté du 9 août 2006 (niveaux de référence S1)		
* Phosphore	0,30	0,62	g/kg P		ICP	
* Cuivre		69	mg/kg Cu	<= 100	ICP	3
* Zinc		122	mg/kg Zn	<= 300	ICP	10
* Cadmium		< 0,40	mg/kg Cd	<= 2.00	ICP	0.40
* Chrome		22	mg/kg Cr	<= 150	ICP	5
* Nickel		20	mg/kg Ni	<= 50	ICP	3
* Plomb		32	mg/kg Pb	<= 100	ICP	5
* Aluminium		8 729	mg/kg Al		ICP	1000
* Mercure		0,13	mg/kg Hg		spectro-fluoresatom.(minéral"eau régale	0.05
* Arsenic		4,31	mg/kg As	<= 30.00	ICP-MS	0.50
PCB et HPA (sédiments d'eau douce)				arrêté du 9 août 2006 (niveaux de référence S1)		
* Acénaphtène		57	µg/kg		GC/MS(/MS)	10
* Acénaphtylène		171	µg/kg		GC/MS(/MS)	10
* Anthracène		307	µg/kg		GC/MS(/MS)	10
* Benzo (a) anthracène		1 443	µg/kg		GC/MS(/MS)	10
* Benzo (3,4)(a) pyrène		1 415	µg/kg		GC/MS(/MS)	10
* Benzo (3,4)(b) fluoranthène		1 457	µg/kg		GC/MS(/MS)	10
* Benzo (1,12)(ghi) pérylène		1 003	µg/kg		GC/MS(/MS)	25
* Benzo (11,12)(k) fluoranthène		759	µg/kg		GC/MS(/MS)	10
* Chrysène		1 786	µg/kg		GC/MS(/MS)	10
* Dibenzo (ah) anthracène		327	µg/kg		GC/MS(/MS)	25
* Fluoranthène		3 112	µg/kg		GC/MS(/MS)	10
* Fluorène		138	µg/kg		GC/MS(/MS)	10
* Indéno (1,2,3-cd) pyrène		1 194	µg/kg		GC/MS(/MS)	25
* Méthyl (2) fluoranthène		149	µg/kg		GC/MS(/MS)	10
* Méthyl (2) naphtalène		48	µg/kg		GC/MS(/MS)	10
* Naphtalène		< 125	µg/kg		GC/MS(/MS)	50

L'accréditation de la Section Essais de COFRAC atteste de la compétence de l'IDAC pour les seuls essais couverts par l'accréditation précédés par un (*). Ces résultats d'analyse ne concernent que les produits soumis à analyse. Ce document comporte 11 page(s).

Page 10 / 11

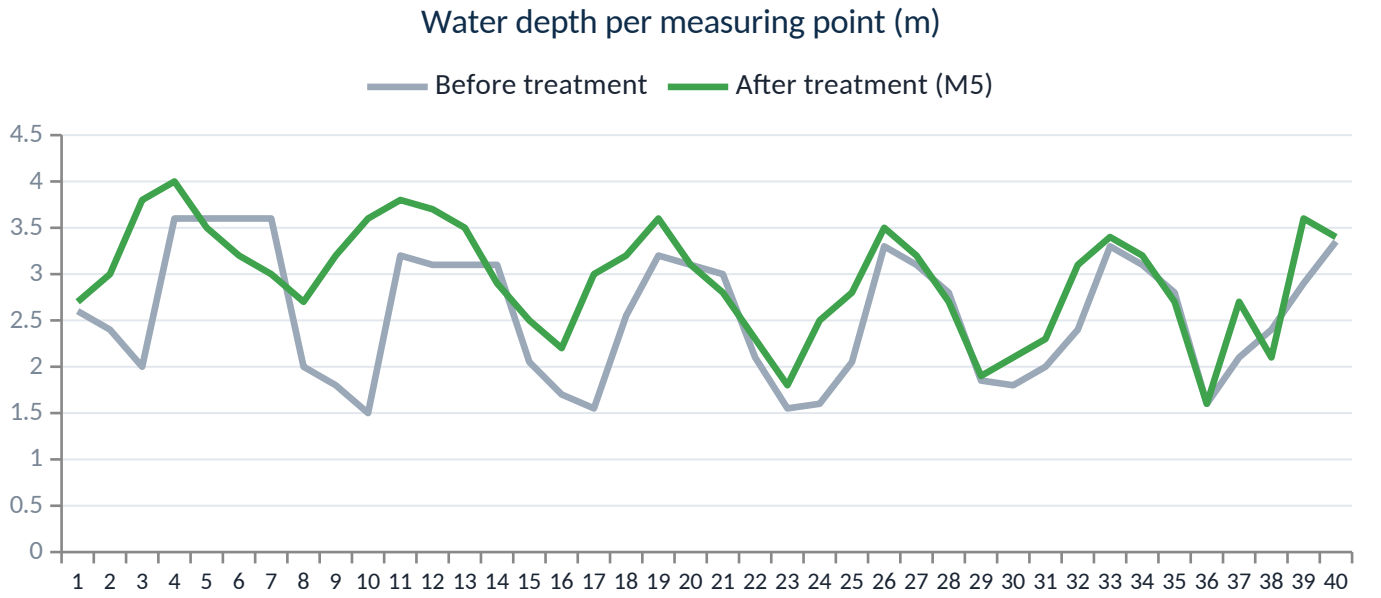
PORT · CAMILLE RAYON (06)

Port Camille Rayon: deeper water

Bathymetry by the port – before and after treatment (M5)



		25	21	17	14	11	7	4	0
AVANT	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
	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
APRES	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



390 m³
of sediment degraded
(1,000 m² × 0.39 m)

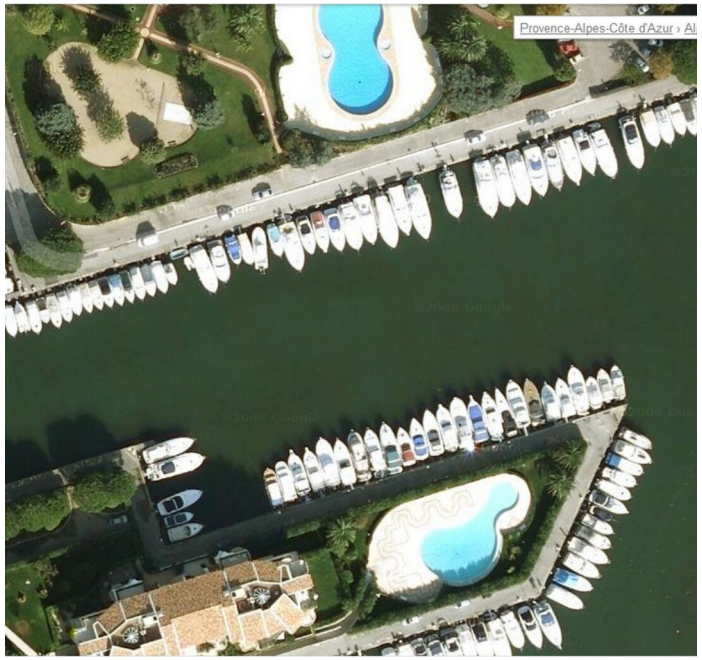
3 to 4 %
TOC (3 points)

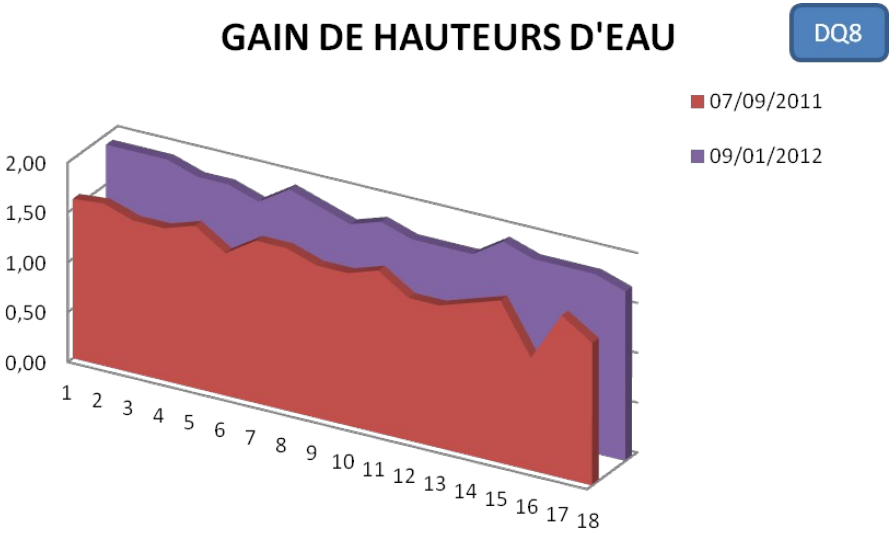
37 to 45 %
dry matter (3 points)

PORT · CANNES MARINA (06)

Cannes Marina: targets met in 3 months

Treated area DQ8 – 2 applications in September and November 2011 – bathymetry by the client





Water depth gained: 07/09/2011 → 09/01/2012

10 to 20 %
more water depth: target met

– 130 m³
of sediment approx.

53 % · 11 % · 3 %
DM · organic fraction · TOC (IDAC, Nantes)

								Surface zone traitée = 250 m2										
DQ8- Bathy	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	**Moyenne**
07/09/2011	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**
09/01/2012	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%**

Sizing a sediment biotreatment project

What we need

Areas to treat
Marked on a site plan (Google map or dimensioned drawing), with hydrology data if possible

Activities and surroundings
Port, swimming, fishing… and local surroundings

Sampling
Core samples (number to be set), a few tens of centimetres deep

Physical and chemical analysis
Sediment and/or water column: DM, OM, MM, TOC, pH, TKN, TP, grain size, density, heavy metals, TPH, PAH 16, PCB 7, TBT…

Bacteriology and phytoplankton
Faecal streptococci and enterococci, coliforms, E. coli; cyanobacteria, green algae…

Heights
Volume survey or bathymetry

Economic, practical and ecological benefits

Economic

- Far cheaper than dredging, weed cutting or uprooting, with their studies and monitoring
- Site stays in operation during treatment
- No disruption to nearby activities
- Later reuse of sediment made easier

Practical

- Easy application and raking, local labour
- No need to move pontoons, boats or chains
- No dredgers or trucks: no noise, visual or odour nuisance

Ecological

- No turbidity, resuspension or pollutant migration caused by dredging
- Mineralises and reduces silt, clears the water, prevents algae
- Reduces faecal germs, removes pollution, stops odours
- Natural products and processes

Regulations: unlike dredging, biotreatment is not covered by the French Water Act classification (article R214-1 of the Environment Code): no declaration or permit is needed from the DDTM. If dredging is done later, disposal as inert waste or reuse is made easier.

Other references and results

Treatment plants, lagoons and laboratory work



BIOSYNERGIE · biosynergiecontact@gmail.com · www.biosynergie.net

TREATMENT PLANTS

Improving treatment plant and lagoon efficiency

Refinery, petrochemical, steelworks, metallurgy and urban effluent



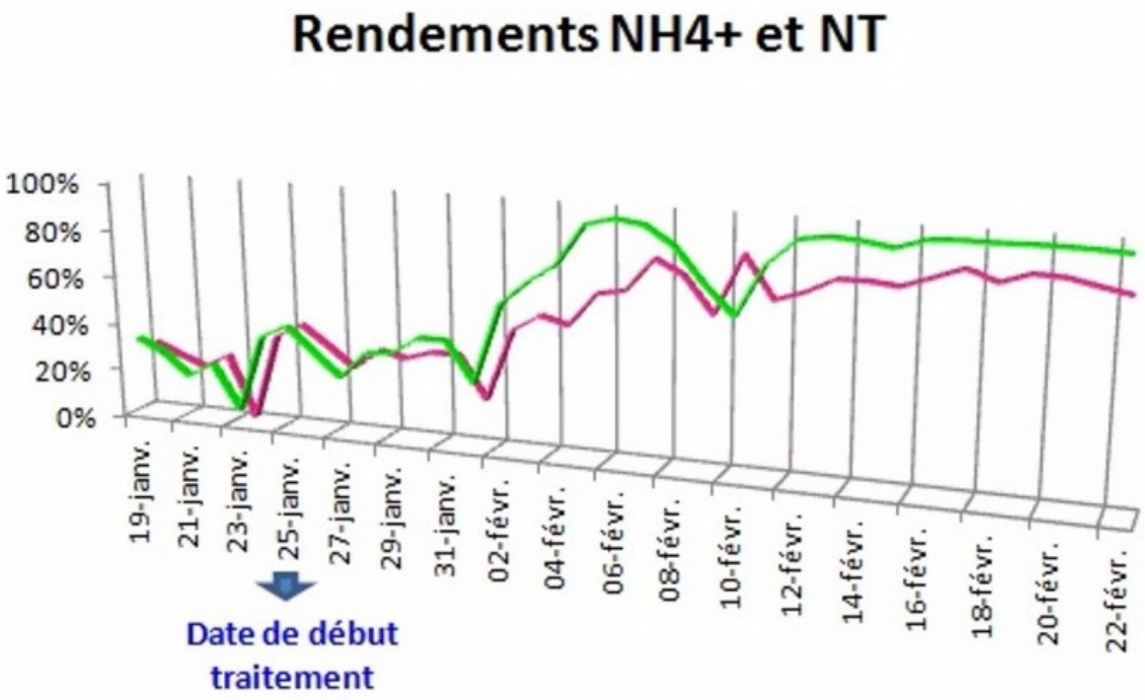
WABAG – Petrobrazi, Ploiești (Romania) – 2,000 m³/h



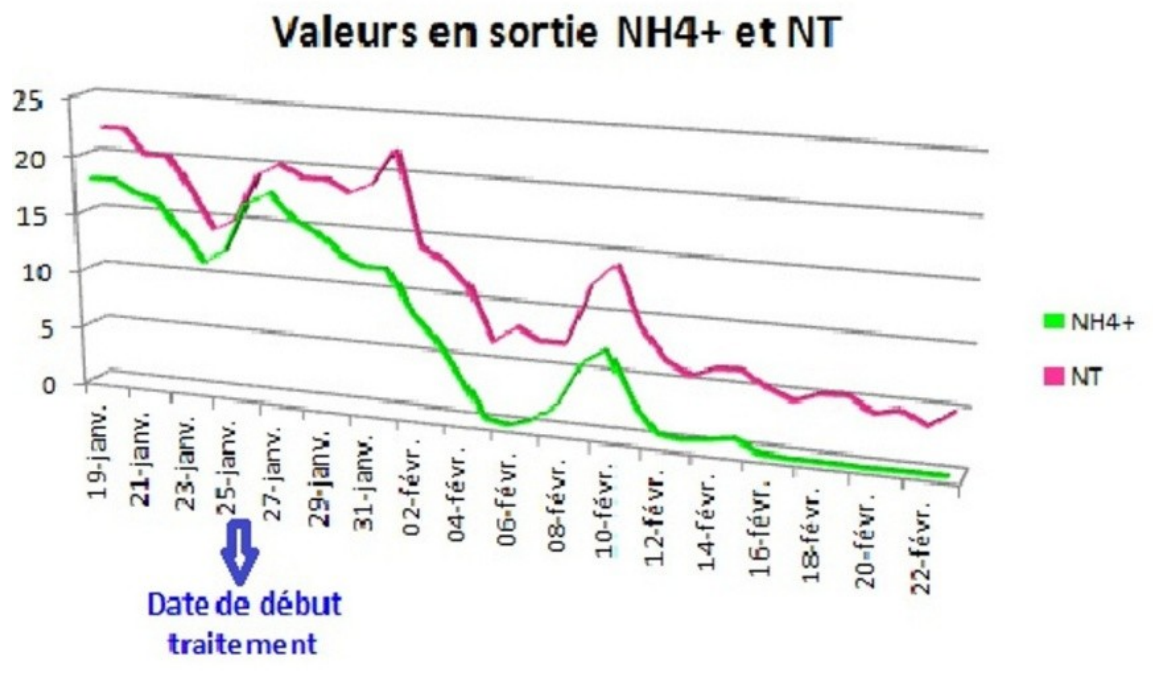
ArcelorMittal Galați (Romania)

Rompetrol Constanța (Romania): improved efficiency

Refinery, petrochemical and urban effluent – 2,000 m³/h



NH_4^+ and total nitrogen removal (%)



Outlet NH_4^+ and total nitrogen over time (mg/l)

TREATMENT PLANTS

Doljchim Craiova (Romania): improved efficiency

Chemical industry and urban effluent – 550 m³/h







Before treatment

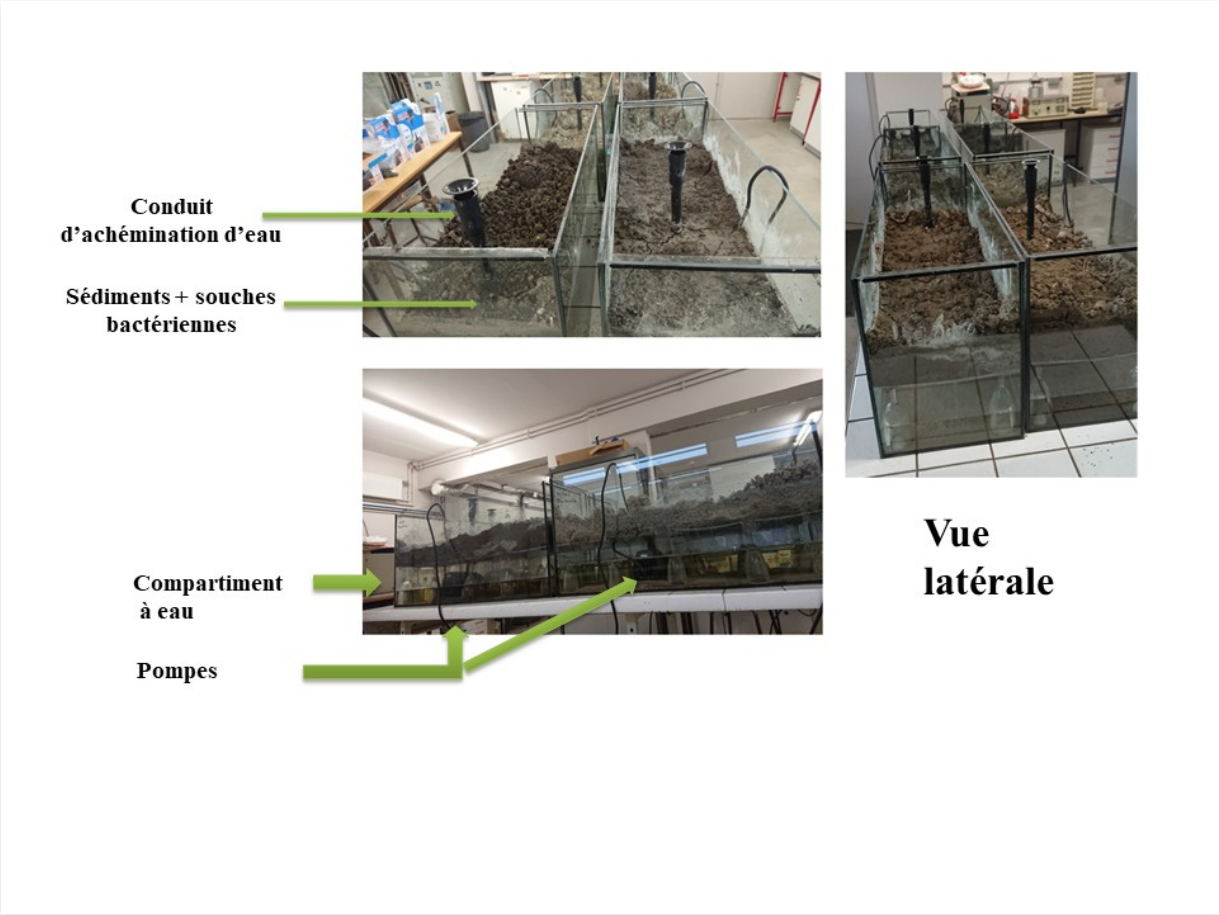


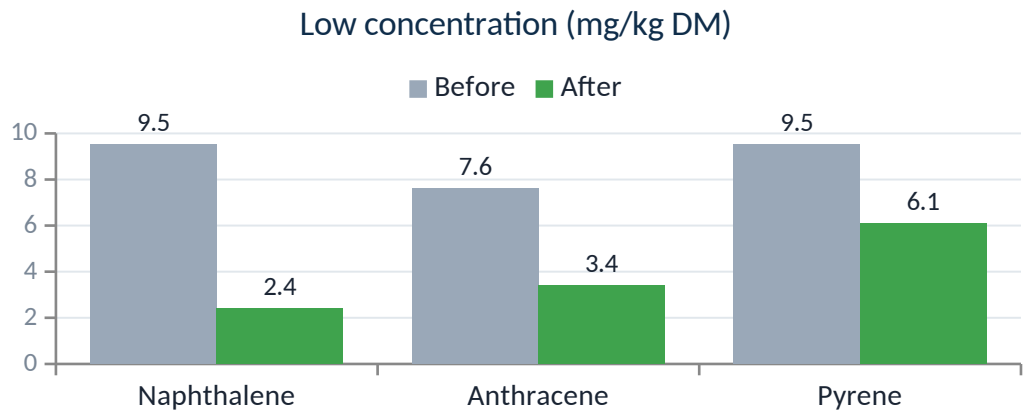
After treatment

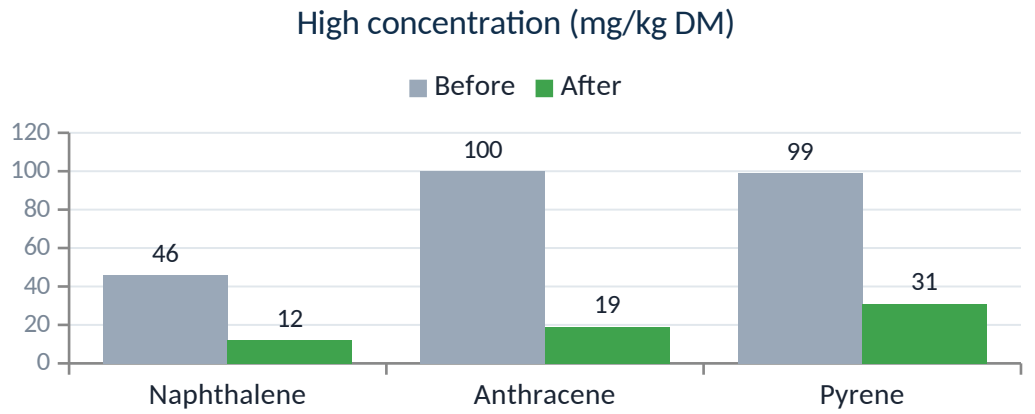
LABORATORY WORK

PAH biodegradation tests – SEDIAPHALTE agreement

Polycyclic aromatic hydrocarbons – tests run from 23 July to 27 November 2020





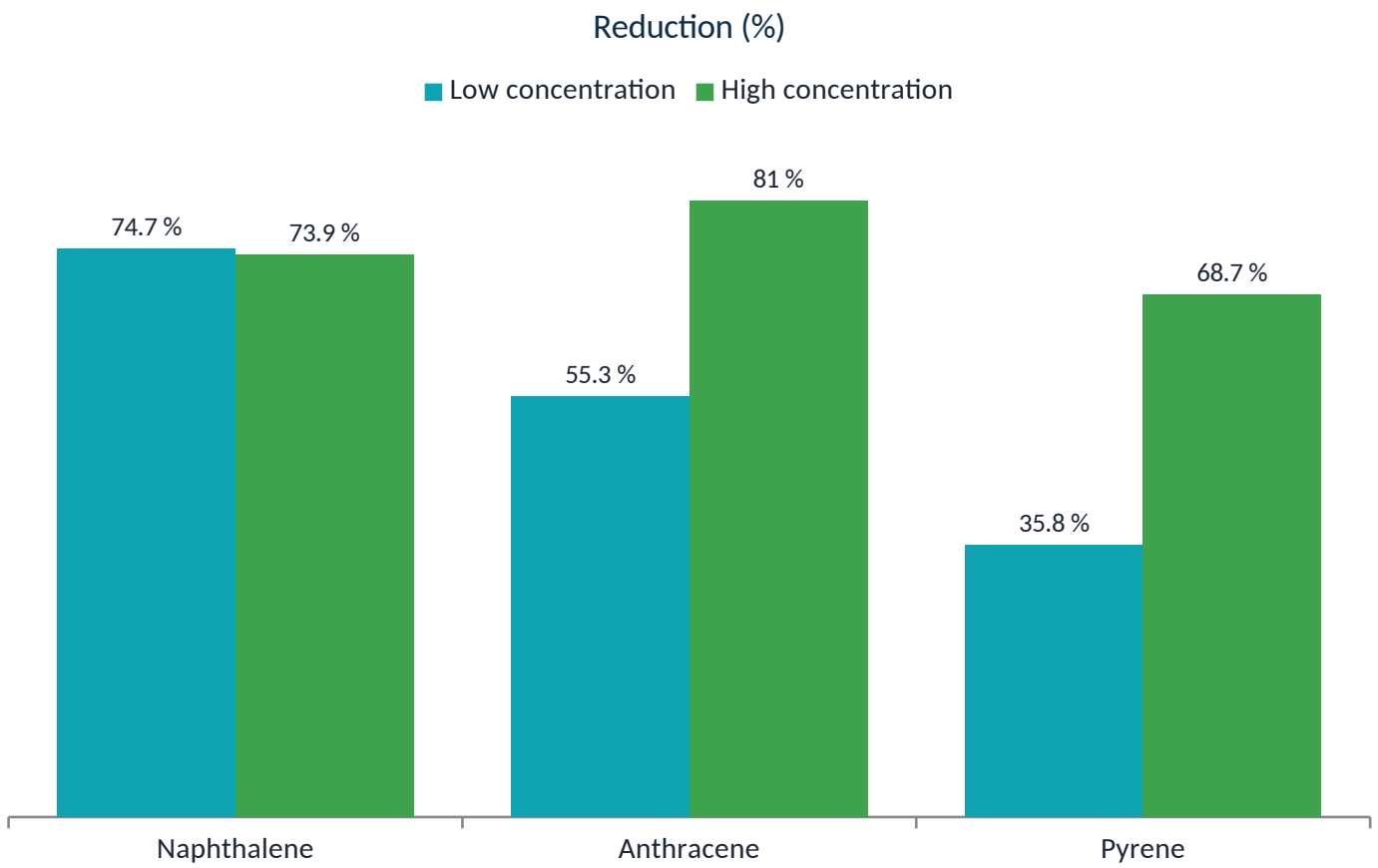


Set-up: water supply pipe, water compartment, sediment + bacterial strains, pumps

LABORATORY WORK

SEDIAPHALTE tests: reductions achieved

Drop in concentrations between the start and end of the tests (23/07 – 27/11/2020)



Reductions calculated from before / after concentrations.

– 81 %
anthracene at high concentration (100 → 19 mg/kg)

– 74 %
naphthalene, at both low and high concentration

4 months
of laboratory testing

Un projet de biotraitement ?

biosynergiecontact@gmail.com

www.biosynergie.net

Patented biological processes – water, soil, sediment

