Assessment of the effects of a 3D erosion matting filled with bitumen on water quality in sensitive environments

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ABSTRACT: The goal of the study was to confirm on site the laboratory results proving the harmlessness of a geomat used for erosion control on riverbanks. Concentration analyses were performed on the same 45 molecules, some of them being identified as priority substances according to the directive 2013/39/UE of the European Community. A comparative analysis between several areas treated with this product was used to look for traces of substance diffusion and possible degradation over time from the date of the geomat installation on each site.

Keywords: riverbank, sediments, substance release, concentration analysis, harmlessness

1 INTRODUCTION

The " Sèvre niortaise" river banks are located between Niort and Marans in the "Marais poitevin" area, also known as the "Green Venice". This is a famous place in France regarding tourism and biodiversity and as such is a sensitive environment that focuses the attention of the French authorities. As part of restoration works of these riverbanks, the local authorities IIBSN developed and installed erosion control systems using geosynthetics with bituminous filling.

2 DESCRIPTION OF THE SOLUTION

In the case of this project, the 3D erosion mat is used at the river bank foot, at the mean level of the tidal range (i.e. 40 cm in length from the top of the piles up to the slope foot under the mean level of the water – see figure 1). A berm was formed in order to maintain the existing cross section of the river bed.

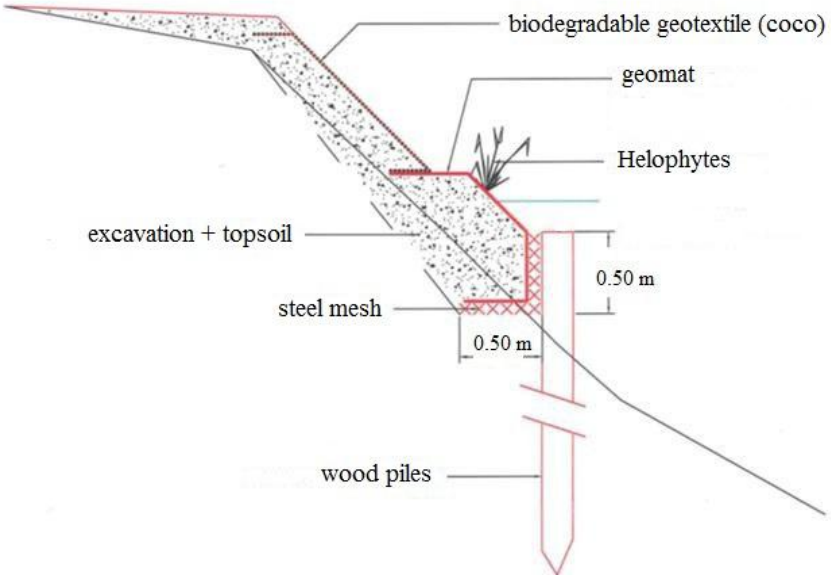

Figure 1. cross section of the solution

The erosion control system uses a 3D polyamide 6 monofilament structure filled with bitumen (picture 2) which provides the following assets:

- resistance to hydraulic erosive forces (case of the river Sèvre Niortaise: water flow velocities between 0,5 and 1,5 m/s and tidal range from 30 cm up to 1 m twice per day),
- durability,
- permeability (water exhange),
- soil retention (particule size up to 2 microns) to prevent leaching,
- quick revegetation, protection of rhizomes and bulbs root systems of implanted plants,
- prevents root damage due to grazing and burrowing animals and marine life such as coypu or crayfish,
- practicality of the global solution, due to the restricted space along the riverbank (road infrastructure and guardrails).

Picture 2. Heavy geomat Enkamat A20

This product has been used since 2000 on the banks of the river Sèvre niortaise, as required by the restoration priorities and bank geometries in the two contracts « Wet zone ». The length of restored river banks is about 8 500 lm to be compared to the total length of the river banks of the river Sèvre and its main tributaries which is about 500 000 lm (i.e. 1.7%).

3 SAMPLING PROGRAM

The goal of the study was to confirm on site the previous laboratory results proving the harmlessness of the geomat. Concentration analyses were performed on the same 45 molecules, particularly on the following molecules groups: metals and metalloid (Metox), phenols, organohalogen compounds (AOX), HAP, PCB, TBT. Some thresholds, being aggregated within an index, are defined by French regulations [1][2] related to discharges in surface water or from marine, estuarine sediments or sediments extracted from watercourses or canals. Moreover, other comparison values were considered for identified substances in the sampling, these values are defined by the European Community through the directive 2013/39/UE modifying directives 2000/60/CE and 2008/105/CE regarding the priority substances in its water policy that establishes Environmental Quality Standards (EQS) for these 45 substances.

3.1 *Sampling areas*

For the needs of this study, several sampling areas were defined according to the following criteria: riverbank restored less than one year ago (zone 1), from 1 to 5 years ago (zone 2), more than 5 years ago (zone 3).

On each site, three samples were taken in the river, at a distance of 2 meters from the edge of the riverbank, for concentration measurements in the aquatic environment (samples A): the first one is located 200 m upstream of the restored area, the second one in front of the restored area (in the middle), the third one was located 200 m downstream.

In the event that release levels might be very low in comparison to the background noise of the receiving environment (similar contaminants may already preexist in infinitesimally small doses within the water), one sample of groundwater was taken per site (samples B) in the soil of the riverbanks close to the geomat. Moreover, a sample of reference soil was taken on a riverbank area located upstream of the 3 sites (zone 4), where there is no impact of the geomat.

In total, the sampling and analysis concerned 13 samples as follows:
- samples of free water (samples A) : 9 analyses.
- samples of pore water (samples B) : 4 analyses.

3.2 *Sampling schedule*

Sampling was done during the summer 2014, on the 20th of August, i.e. in the worse conditions:
- highest UV and heat exposure of the geomat
- warming waters
- lowest water flow velocities
- highest ratio geomat area/volume of water

These samples were deposited on the same day in the laboratory LCA in La Rochelle, an accredited laboratory for assays of sludge and leachate.

4 ANALYSIS RESULTS

4.1 *Surface water analysis*

AOX, Phenol, HAP, PCB, TBT indexes are located underneath the detection limits in all sites and therefore underneath the limits of the French regulations of the 9th august 2006. So, it can be concluded that they fulfill the French regulations' requirements.

Table 1. List of the studied indexes

	Laboratory results	**French regulations of the 9th august 2006**
AOX	**X**	**X**
Phenol	**X**	
METOX	**X**	**X**
HAP	**X**	**X**
PCB	**X**	
TBT	**X**	

Metox index was calculated as follows in accordance with the current rules:

METOX = (10*Arsenic) + (50*Cadmium) + Chrome + (5*Copper) + (50*Mercury) + (5*Nickel) + (10*Lead) + Zinc
The main part of the METOX substances were measured with a concentration level lower than the detection threshold, the threshold values were therefore used for the index calculation, but the calculated index probably doesn't reflect reality in this case.

Among the considered parameters, 10 of them, listed in table 2, are priority substances as mentioned in the European directive 2013/39/UE. Among these 10 substances, 8 substances concentrations don't reach the detection threshold for any site or area. So, it can be concluded that they fulfill the European regulations requirements.

Table 2. Concentration level of priority substances (Directive 2013/39/UE)

Directive 2013/39/UE parameters	**Concentration level lower than the detection limits**
1,2 dichloroethane	**X**
Benzene	**X**
Cadmium	**X**
Mercury	
Naphtalene	**X**
Nickel	**X**
Lead	
TBT	**X**

Tetrachlorethylene	**X**
Trichloroethylene	**X**

Regarding mercury and lead, results are non-homogeneous and no effect of the geomat can be highlighted:
• too high levels of mercury and lead concentration were observed on zone 3, but upstream of the restored area only,
• high levels of mercury concentration were observed downstream of the restored area on sites bordered either by a high traffic road (zone 1 – picture 3) or by leisure houses without efficient sanitation nor rainwater collect system (zone 2). Furthermore, similar levels have been observed during the continuous water quality control carried out on the river "Sèvre Niortaise".

Picture 3: treated riverbank bordered by road

4.2 *Pore water analysis*

Considering sediment analysis, the standards, as defined by the French regulations of the 9th august 2006, refer to concentrations measured on dry sediment samples. However, the methodology used allows sampling of pore water only, therefore, comparison is not relevant.

Regardless of this, a large majority of the measured concentrations remain underneath the detection limits and/or very close to the sample of reference soil (where there is no impact of the geomat). Moreover, influence of the nearby environment (roads, buildings, agricultural areas, …) was not taken into account in this study.

4.3 *Comparative analysis*

4.3.1 *Between sites*

The goal of the comparative analysis between sites is to look for traces of substance diffusion depending on the date of the geomat installation and therefore its possible degradation over time.

45 parameters were studied, 21 of them don't reach the detection threshold for any site or area and could not be used for the impact assessment. It can therefore be concluded that there's no effect of the geomat regarding these parameters.

15 parameters were selected for the comparative study, the other ones being too close to the detection threshold or uniform on all sites:

Aluminum	Elec. conductivity	Nitrates
Ammonium	TOC	Lead
Barium	Copper	Metox
Boron	Iron	Sulfate
Chloride	Manganese	Zinc

This comparative study doesn't highlight any tendency of increasing concentrations of these 15 parameters which could reveal a potential degradation process of the geomat with time.

4.3.2 *Between upstream and downstream areas*

The analyses of 44 parameters completed with the individual analysis of each substance included in the Metox index don't show any increasing concentration between upstream and downstream areas of each site. More generally, this sampling program doesn't reveal any degradation process of the water quality downstream of the restored areas.

5 CONCLUSION

On the basis of official requirements and comparative analysis performed on several sites of the river « Sèvre Niortaise », it can be concluded that there's no impact of the installed erosion control geomat over the natural environment. There was no measurable release regarding 21 substances (including AOX, phenol, TBT, HAP, PCB), no correlation was found to link geomat use with an increase of substances concentrations (downstream vs upstream) and finally, no geomat degradation in time was highlighted by the measured substances concentrations on several work phases.

Regarding the performances of the erosion control system, the reliability of the solution was proved, the revetments which were installed 12 years ago are nowadays perfectly stabilized and very well integrated locally.

6 REFERENCES

European directive 2013/39/UE modifying directives 2000/60/CE and 2008/105/CE regarding priority substances in water policy

French decree of the 9th of august 2006, levels to be considered in surface water analysis

French decree of the 23rd of december 2009 : levels to be considered in surface water analysis / complement to the decree of the 09th of august 2006 (thrusholds applicable for TBT)