Bench-test and Pilot-scale Bioaugmentation of Hydrocarbons Contaminated Site by a High Performance

Group 1

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Introduction and Objectives

The study was developed in two selected areas of an industrial site located in Cubatão, SP, Brazil, contaminated by coal tar. Area#1 (290 m²) main hydrocarbon contamination is found in retained phase and Area#2 (68 m²) main contamination is in the dissolved phase.

The objective of the tests was to evaluate the efficiency of bioremediation using a selected bacteria consortium in soil and groundwater contaminated.

The selected bacteria consortium was Bio Liq HC, a product registered by IBAMA (Federal environmental agency in Brazil) as a hydrocarbon remedy for soil and groundwater. This consortium was composed of six different types of bacteria aiming to facilitate synthetizIng biosurfactants and different enzymes, allowing for a higher efficiency of target contaminants degradation.

Keywords: Bioremediation, bioaugmentation, hydrocarbon contamination, retained phase, dissolved phase, bacteria consortion.

Materials and Methods

Bench Tests:

Six sets of treatability tests were performed simultaneously. In order to avoid interference, it was decided to carry out the tests with the soil and water matrices separately.

Frame 1 presents the breakdown of how the tests were set up and the number of

Frame 1 - Sample division scheme and treatability test conditions

AREA	MATRIX	TIME (DAYS)	CONDITIONS	QUANTITY OF TEST BODIES
AREA #1	Soil	0	Gross	2
		22	Control	2
		22	Treated	2
	Groundwater	0	Gross	2
		22	Control	2
		22	Treated	2
AREA #2	Soil	0	Gross	2
		22	Control	2
		22	Treated	2
	Groundwater	0	Gross	2
		22	Control	2
		22	Treated	2

The tests were carried out at room temperature, without agitation, without aeration, with the flasks closed with a screw cap and wrapped in aluminum foil. The parameters analyzed were BTEX, PAH, fractional TPH, microbiological count, pH and redox potential (ORP).

Pilot Tests:

The size of the bacterial consortium volume for the pilot test in areas #1 and #2 were defined according to **Tables 1 and 2**.

Figure 1 shows the timeline of the pilot test.

Table 1 - Data used in the dimensioning of AREA #1

In situ treatment Trench

Area (m²) 290

Depth 2

Sum of PAH (mg/L) 2,376.25

pH between 6 and 12

ORP (mV) between -460 and +110

Soil Clayey landfill

Table 2 - Data used in the dimensioning of AREA #2				
In situ treatment	Pressure well injection			
Area (m²)	68			
Depth	2			
Naphthalene concentration (mg/L)	5,000.00			
рΗ	9			
ORP (mV)	between -388 and +20			
Soil	Sandy clayey landfill			

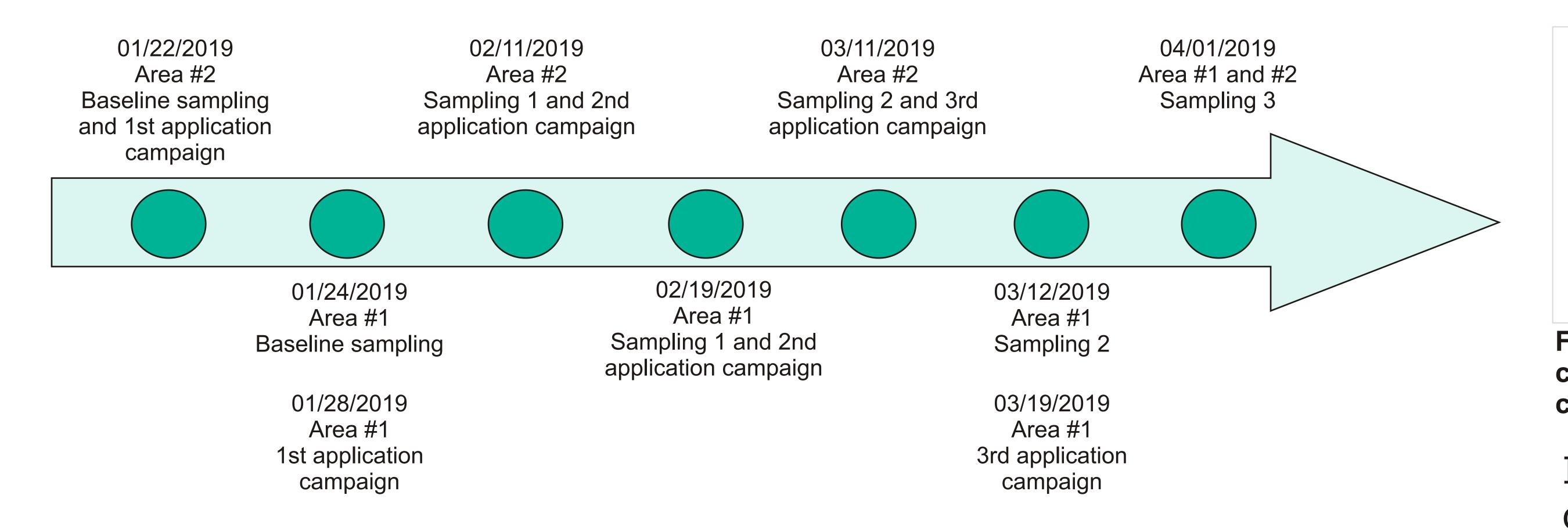


Figure 1: Pilot test timeline

Table 3 - Volume of Bio Liq HC product applied per campaign

Areas	Area #1	Area #2	Table 3 presents the	
Product	Bio Liq HC plus (L)	Bio Liq HC (L)		
Campaign 1	1470	120	volume of Bio Liq HC	
Campaign 2	945	120	applied percampaign	
Campaign 3	640	100	applied per campaign.	
Total volume	3055	340		

Results and Discussion

Bench test results varied according to the selected area. For Area#1, they indicated favorable conditions for microbiological degradation (pH between 6 and 8 and ORP>0). The number of bacteria increased 10,000 times, degradation of the lighter and naphthenic compounds was observed, varying from 11 to 79% below the obtained results for the control sample; no significant change for medium and heavy TPHs was observed.

Pilot test in Area#1 indicated an increase of bacteria activity (ten times) after the first injection (**Figure 2**). However, there was a decrease of bacteria counting from the second injection, followed by a significant increase of PAHs (**Figures 3 to 6**). This observation can be justified by the technique selected to test (trenches) once a biosurfactant has the potential to mobilize PAHs from soil to groundwater.

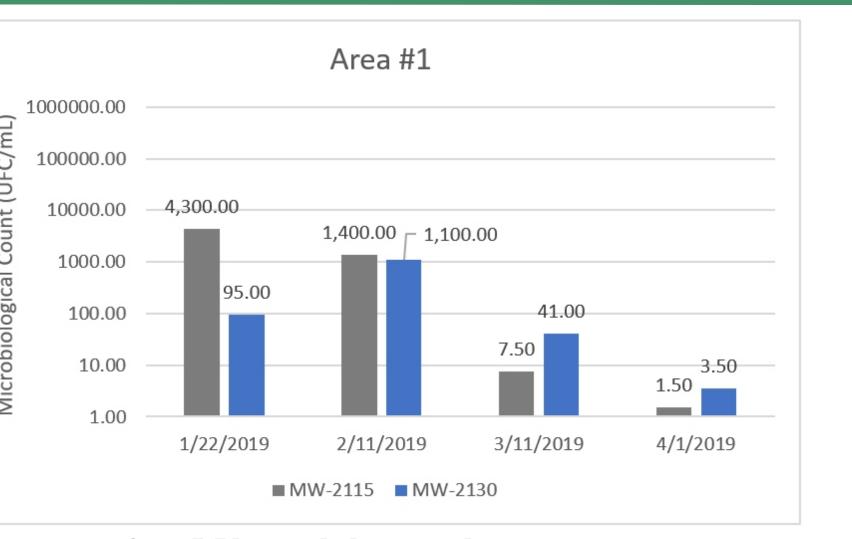


Figure 2 - Microbiological count during applications - Area #1

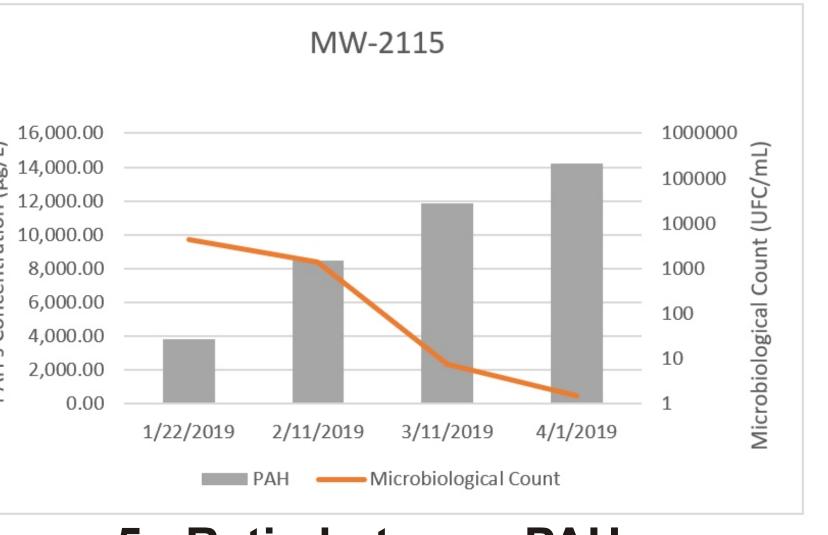


Figure 5 - Ratio between PAH concentration and microbiological count throughout the pilot - MW-2115

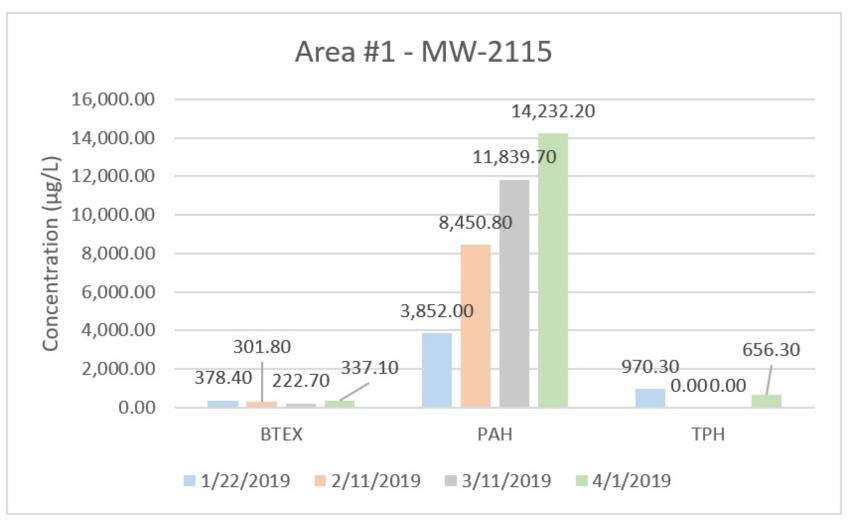


Figure 3 - Sum of BTEX, PAH and TPH concentrations in MW-2115

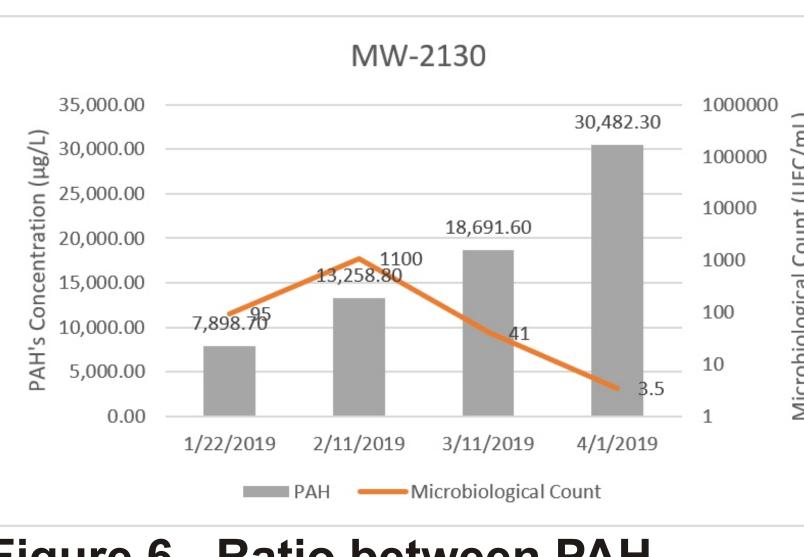


Figure 6 - Ratio between PAH concentration and microbiological count throughout the pilot - MW-2130

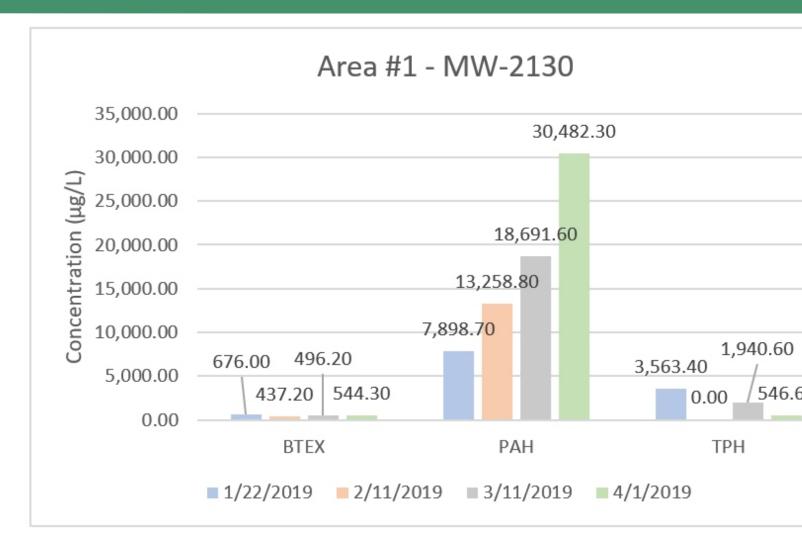
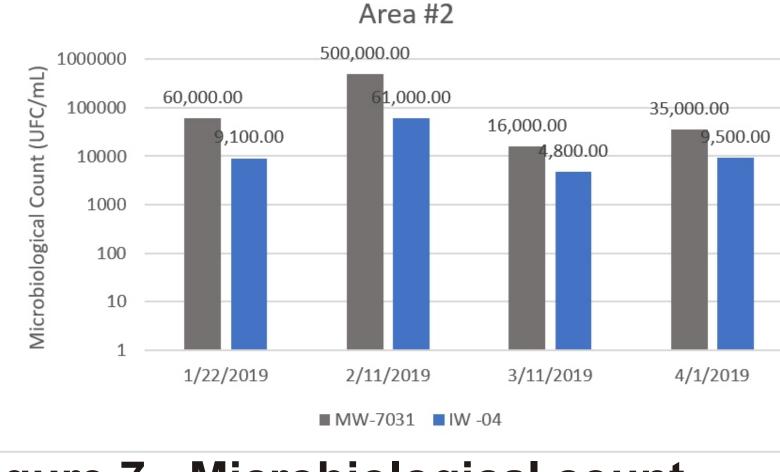


Figure 4 - Sum of BTEX, PAH and TPH concentrations in MW-2130

Area #2 also showed an increase in the microbiological count (ten times) after the first application, followed by reduction and increase, remaining in the same log.(Figure 7).

In well IW-04, an increase in the sum of PAHs was observed after the first application of the remedial product, and after the two subsequent applications, a reduction of 71.5% was observed in the concentrations between baseline and the last application campaign (**Figure 8**). In well MW-7031, a 58% reduction in BTEX concentrations and a 120% increase in PAH sum were observed, with naphthalene being the predominant compound (**Figure 9**).





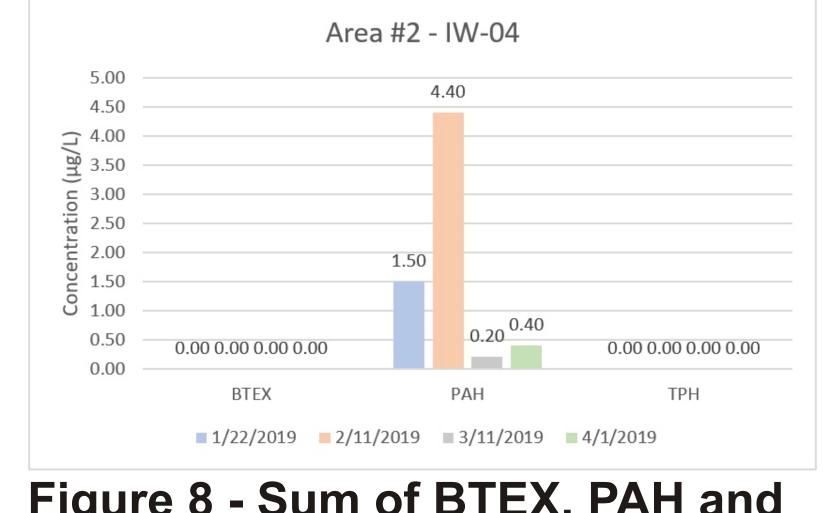


Figure 8 - Sum of BTEX, PAH and TPH concentrations in IW-04

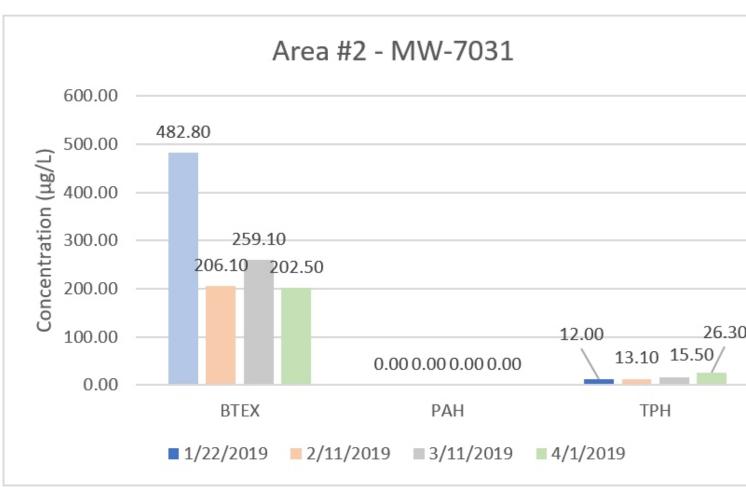


Figure 9 - Sum of BTEX, PAH and TPH concentrations in MW-7031

Conclusions

Physicochemical conditions in the groundwater may have reduced the performance of the microbial activity of the consortium. The pH correction and actions that promote the oxygenation of the environment are measures to ensure the maximum biodegradation potential of the contaminants. The solubilization and biodegradation processes occur concomitantly, that is, at the same time that the enzymes degrade the compounds, more compounds are being solubilized in groundwater.

The increase in the microbiological count in the monitoring wells demonstrates the effectiveness of the pressure injection technique in a well 3m away from the monitoring wells.