

# Geophysical monitoring of a hydrocarbon contaminated site

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## Abstract

This paper present the preliminaries results of the resistivity surveys taken at a paint industry located in city of São Paulo. This area suffered three major episodes of contamination and to prevent the spread of the plume was installed a pump-and-treat system. We evaluate the system and the evolution of the plume comparing previous data with our fresh data.

## Introduction

The water supply is a critical concern in many cities of the world. In the city of São Paulo it's not different; the industrialization process has contaminated a large portion of the underground water and as result our major water supply it's from dams. In this paper we are evaluating the pump-and-treat system applied at a contaminated site by hydrocarbon, this site is located in a paint industry; this system is designed to stop the spreading of the contamination plume by pumping the contaminated water through wells.

This water is treated and returned to the dam.

The main episode of contamination was an explosion which was caused by a fire 30 years ago. Others causes were the incorrect storage, and accidental spills of solvents. The area is close to a major reservoir of water the Guarapiranga dam it's waters supplies a large part of the population of São Paulo city.

The site is contaminated by benzene, toluene, xylene, and organochlorine.(table 1)

## Method

We have used the electrical resistivity imaging with the dipole-dipole array. This technique consists in transmitting a electric current (I) between the A,B electrodes and the measure of the potential ( $\Delta V$ ) between the M,N electrodes. Each pair of the electrodes M,N is a deeper level of investigation.

The potential measured is then converted into apparent resistivity using the expression below:

$$\rho_a = K \cdot \Delta V / I \quad (1)$$

Where K is a geometric coefficient:

$$K = \frac{2\pi}{\frac{1}{AM} + \frac{1}{BM} + \frac{1}{AN} + \frac{1}{BN}} \quad (2)$$

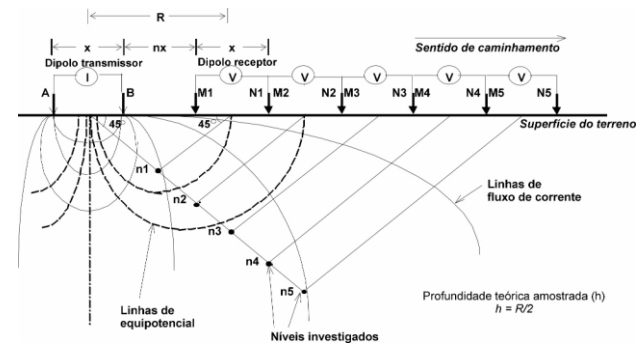


Figure 2: Dipole-dipole array (adapted from Minozzo 2009)

To analyze the data we have used the RES2DINV software, it converts the apparent resistivity into real resistivity and show the results in an image. The interpretation consists in identify at the image areas with abnormal resistivities and match them in the field.

The surveys shown here were taken at same position of the blue line in the picture below.

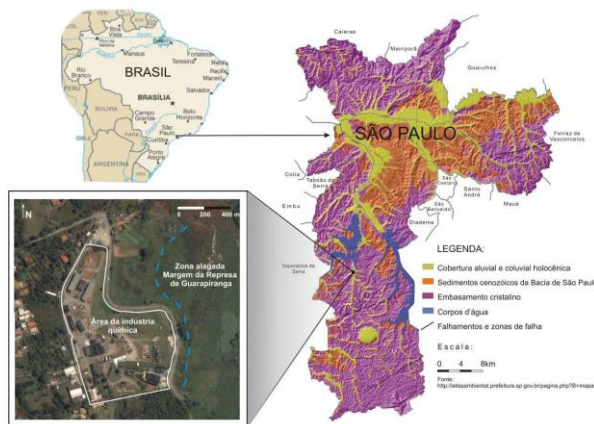


Figure 1: Location of the site (adapted from Minozzo 2009)



Figure 3: Paint industry red line, dam shore yellow line, and local of surveys blue line.

The first survey was taken at 2009, the space between electrodes were 10 meters. The second was taken at 2011 and the space was 5 meters. Our survey was taken at the beginning of this year and the space is 5 meters. The surveys were taken from north to south.

## Results

The water table is at 6 meters below at the beginning of the line and at 2 meters at the end.

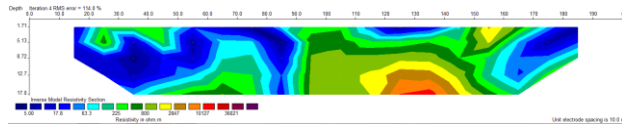


Figure 4: 2009 profile space of 10 meters.

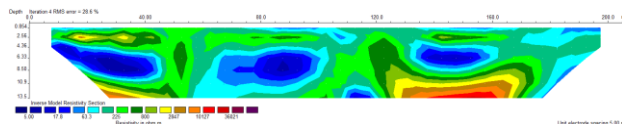


Figure 5: 2011 profile space of 5 meters.

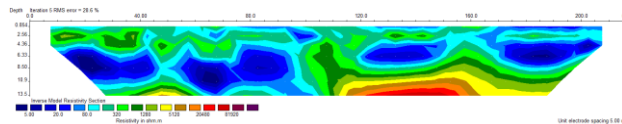


Figure 6: 2013 profile space of 5 meters.

The high values of resistivity match with the values of soil and metamorphic rock, at the right we can notice a gradual increase in the value of resistivity. Result of the remediation.

The low values of resistivity are the result of the biodegradation of the contaminants and the respective products dissolved into water.

At the left changes are smoother the general values are increasing slowly along the time. In 2011 the general values of resistivity were (63-800 ohm.m) and in the 2013 the general values were (80-1280 ohm.m).

That is caused by the flux of the groundwater of which direction is on the left of our profile (Fig 7). At the right there is less contaminants being carried by the groundwater, the treatment is more effective there. At the left more and more contaminants are coming reducing the effectiveness.

## Conclusions

- The electrical resistivity imaging is a powerful resource to monitoring plumes.
- The pump-and-treat system works well in 2 aspects: stopping the spread of the plumes and in treatment of the contaminated water.
- The differences of the groundwater flux affects the effectiveness of the pump-and-treat, therefore local adjusts are necessary in the respective wells.

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Composto Químicos	PM-01 (µg/L)	PM-02 (µg/L)	PM-05 (µg/L)	PM-07 (µg/L)	PM-08 (µg/L)	PM-12 (µg/L)	PM-13 (µg/L)	PM-15 (µg/L)	PM-20 (µg/L)	PM-31 (µg/L)	Valores de Intervenção da CETESB (µg/L)
Benzeno	80,00	240,00	ND	126,50	318,60	200,00	6,80	11,10	31,40	322,50	5,00
Tolueno	452,50	706,00	ND	1.350,00	8.232,90	7.242,00	2,30	ND	ND	4.650,00	700,00
Xilenos	525,00	3.475,00	ND	824,70	5.079,60	1.650,00	ND	ND	ND	700,00	500,00
Clorofórmio	13,50	6,70	267,90	429,50	ND	ND	ND	5,30	ND	281,64	200,00
1,2-Dicloro Etano	241,80	98,40	564,70	1.563,40	34,00	13,25	16,50	23,70	690,30	3.415,19	10,00
1,1,1-Tricloroetano	1,60	ND	7,50	257,90	ND	ND	ND	ND	ND	22,91	280,00
Tetracloroeto de Carbono	ND	ND	38,10	ND	ND	ND	ND	ND	ND	82,75	2,00
Tricloroetileno	11,10	6,80	372,30	750,30	3,30	ND	ND	15,00	23,20	140,00	70,00
Tetracloroetileno	2,80	9,10	176,70	395,30	ND	ND	ND	6,00	5,00	34,79	40,00

Table 1: Concentrations of contaminants, in the last column are the limit concentrations for each contaminant(adapted from Salles 2005).

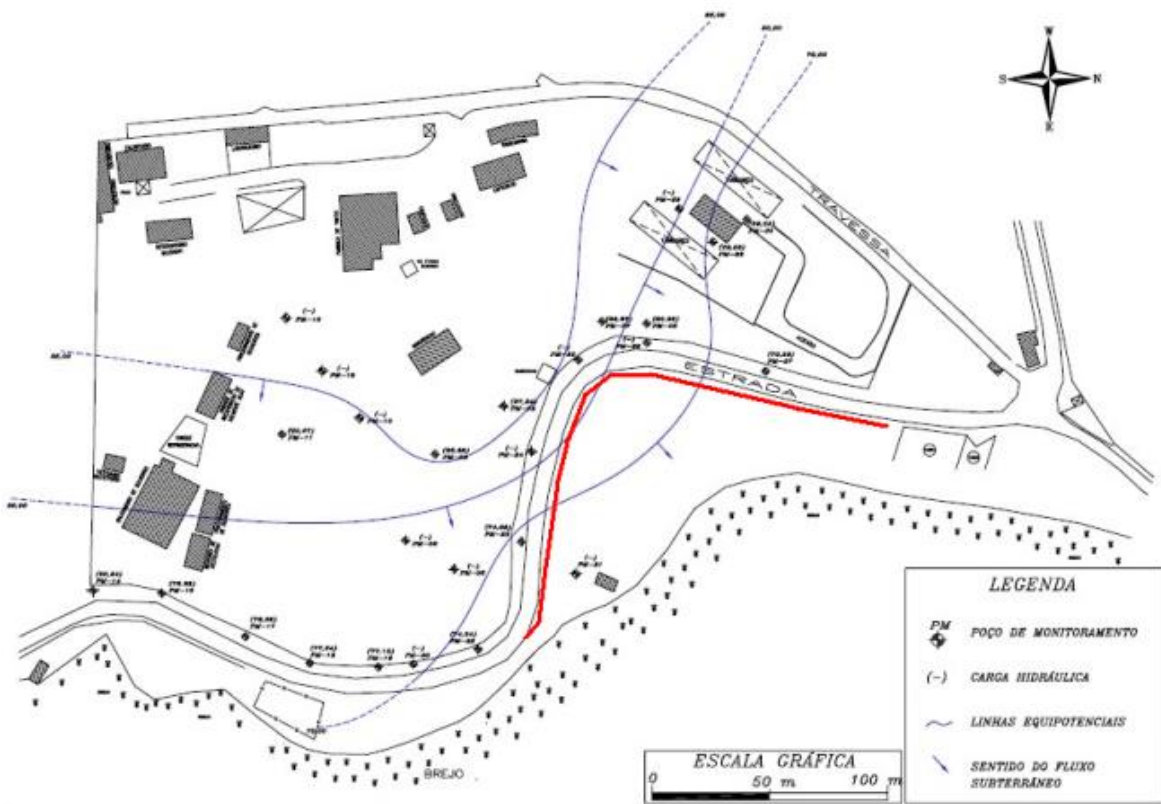


Figura 7: Blue line is the level and direction of groundwater the red line is the position of the profiles(adapted from Minozzo 2009)