

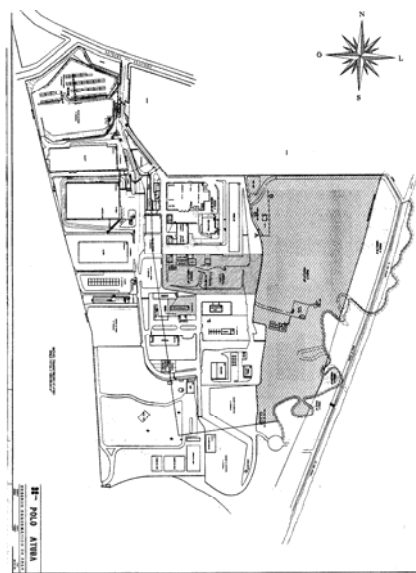
# Bioremediation Of Soils Contaminated With Transformer Oil In Brazil.

**Satya Ganti - Sarva Bio Remed, LLC Trenton, NJ, USA; Eduardo Trindade\*, LACTEC, Curitiba, Brazil\*; Paulo Fernandes, SDM do Brasil Ltda, Sao Paulo, Brazil**

(\* Current Address : Eduardo Trinadade, Ph.D; Director, Diagno – Materiais e Meio Ambiente; Rua México, # 1053; Curitiba, Parana 82510-060. Brazil)

## INTRODUCTION

COPEL is the state owned utility company supplying electricity to the entire state of Parana – Brazil, with the additional responsibility to maintain and replace electrical transformers throughout the State. The central facility at Atuba receives both new and old transformers for maintenance that includes replacing and recharging them with fresh transformer oil. The company maintains a large inventory of transformer oil at the site and that used to be stored without any shelter in a relatively unsafe manner. Over the last five decades, during storage and recharging of the transformer oil, there have been many incidents of minor releases and spills in the ground this was cleaned conventionally by absorbing the spill in the dirt which was then thrown into the open area outside the site premises. Additionally, there have been releases from the drums corroded during storage resulting in a heavily contaminated soil. The current project is to cleanup about 18,400 square meter area shown below is affected by the contamination to meet the local regulations.



**Figure 1. An Aerial view of the site for cleanup.**

With increased awareness of the environmental damage to the drinking water resulting from heavily contaminated soil, local regulators have insisted that COPEL undertake effective cleanup of the soil with a certain degree of urgency. In addition to the need to cleanup the site as effectively as possible, the geography of the site allowed little latitude to the cleanup plan. Particularly, the contaminated area that adjoins River Atuba passes between the property of the Utility Company that is located on a higher gradient and the urban area and the edges of River Atuba are identified as “Area of Permanent Protection (APP)”, ruling out excavation of soil and replacing it with clean fill was not an option. After evaluating available technology and available products, it was decided to use on-site bioremediation of the contaminated soils using AgroRemed<sup>®</sup> based on the following selection criteria. The product has been selected on the basis of the following criteria:

- Available in a ready to use form
- Non invasive treatment
- Ecofriendly
- Environmentally safe
- Restore existing nutrient conditions in the soil
- Promote healthy growth of plants

### **Background Information**

Once decision to use bioremediation of the soils contaminated with transformer oil using AgroRemed<sup>®</sup> was made, the work on collecting the baseline information of the levels of contamination was initiated. A team of geologists and hydrologists began collecting soil samples from three regions namely surface, 1 meter below ground surface (BGS) and 2 meters BGS as it was considered that much of the contaminated dirt was deposited on the surface. Soil samples were transported to LACTEC for determination of Total Petroleum Hydrocarbons (TPH) using conventional methods of extraction and analysis.

LACTEC is a multidisciplinary laboratory involved in routine analysis of petroleum products for quality control purposes and also for advising the users on the continued use of petroleum product received for test. Most of the analysis work for COPEL is carried out by LACTEC and the laboratory is well equipped with sophisticated instrumentation that includes an array of gas chromatographs. Samples of soil received from the field were analyzed and the results of the analyses are given in the Table I below.

Sample No.	Location	Surface	1 Meter Below	2 Meter Below
1	S7 + 140	0	709	663
2	S6 + 140	1155	697	380
3	S5 + 140	187	148	448
4	S4 + 140	815	738	935
5	S3 + 140	475	190	470
6	S7 + 160	2360	1471	567
7	S6 + 160	1037	1126	1606
8	S5 + 160	48820	1149	1778
9	S4 + 160	0	0	745
10	S3 + 160	1491	176	306
11	S6 + 180***	400	766965	637
12	S6 + 200	1270	1175	1099
13	S1 + 140	941	289	258
14	S5 + 180	669	287	349
15	S5 + 200	579	119	208
16	S4 + 200	664	257	301
17	S3 + 180	698	758	799
18	S2 + 120	2278	349	617
19	S3 + 200	1350	1243	1893
20	S4 + 180	950	359	608
21	S1 + 180	936	987	1199
22	S7 + 180	1624	1204	4067
23	S7 + 200	745	550	5874
	<b>Total</b>	<b>69444</b>	<b>779192</b>	<b>25807</b>
	<b>Average TPH</b>	<b>3019</b>	<b>33878</b>	<b>1122</b>

**Table I. Baseline data on the TPH (in ppm) of soil.**

Analysis of the soil samples show that the site is heavily contaminated and at some points the soil is heavily saturated with oil at a depth of 1 meter BGS, sometimes as high as **766,965** ppm recorded at sampling location S6. The analyses also indicate a trend that higher values of TPH were recorded from samples collected at 1 meter depth. The contamination was relatively less both in the surface samples and from samples of soil collected at 2 meter depth.

### **Treatment Protocol: Pump and Treat**

Regulatory authorities of the State of Parana placed additional constraints that the treatment of soil should be in-situ but bioremediation products should not be added to the soil directly as this may pollute the river along with run off water. Since excavation and treatment of soil with AgroRemed in a Biopile was not an option, it was decided to

employ pump and treat method of treatment. Rain water was channeled through pipes were laid below 1 meter BGS for collecting wash water from this depth. Following images show the construction of irrigation canals and their completion of the canals before the onset of rainy season.



**Figure 2. Construction of irrigation canals**



**Figure 3. Showing the construction of underground canals**



**Figure 4. The site after completion of irrigation canals**



**Figure 4. Location of monitoring wells at each sampling points**



**Figure 6. An array of treatment tanks**



**Figure 7. Rain water with oil treated with AgroRemed**

## Results

The pump and treat method of cleaning the soil using the natural resources of rain water was found to be very effective and it was found that the adsorbed transformer oil was effectively removed due to good rain fall. This was evident from the analysis of the soil from the previously sampled areas. Results of the analysis are given in Table II below. It is observed that there was a considerably reduction in the TPH of the treated water and the water was then discharged after treating with bleach to remove any bacteria escaping into the river water.

### TPH Values (in ppm) in soil before and after

Source	Surface		1 Meter		2 Meters	
	Before	After	Before	After	Before	After
S2 + 120	2278	490	349	774	617	12
S3 + 200	1350	741	1243	344	1893	73
S5 + 160	48820	92	1149	113	1778	585
S6 + 180	400	89	766965	72	637	32
S7 + 200	2278	4	349	91	617	0

Table II. Showing reduction in TPH in hot-spot sites in Phase I

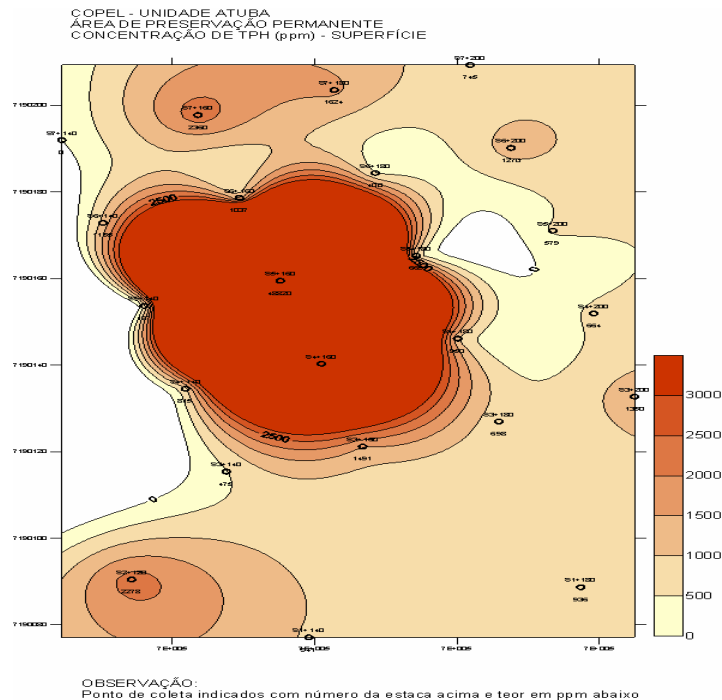


Figure 8. Contour map of the area at Atuba after Phase I

## Conclusions

Based on the new values, a new contour map has been prepared as shown above to indicate the current levels of pollution in the area. The next phase of action is to focus on new hot spots and sites of concern and treat the identified areas. It is interesting to note that the project that was considered to last for more than 5 years because of the large area and high values of contamination is almost near completion using AgroRemed in less than five years and the site is expected to be cleaned up within the timelines as stipulated by the regulators.

### Development of a new product AgroRemed BR

Spillage of transformer oil is a recurring feature at different locations of COPEL and since many of these locations are far away from the main corporate office and not always manned it is difficult to prevent vandalism or activities by miscreants. However, these areas unlike the one at Atuba are not “Areas of Permanent Protection” and AgroRemed could be directly applied on the surface of soil without an elaborate treatment protocol.



**Figure 9. A substation in Mandarituba with transformers and spills**

Photograph above shows one of the many substations with spills near the outdoor transformer storage location where direct application of AgroRemed is considered more suitable. Cost of excavation and transportation of the dirt is very high in Brazil particularly since many of these sites are remotely located. AgroRemed prepared in the US using the local bacteria is not acceptable to the regulators.

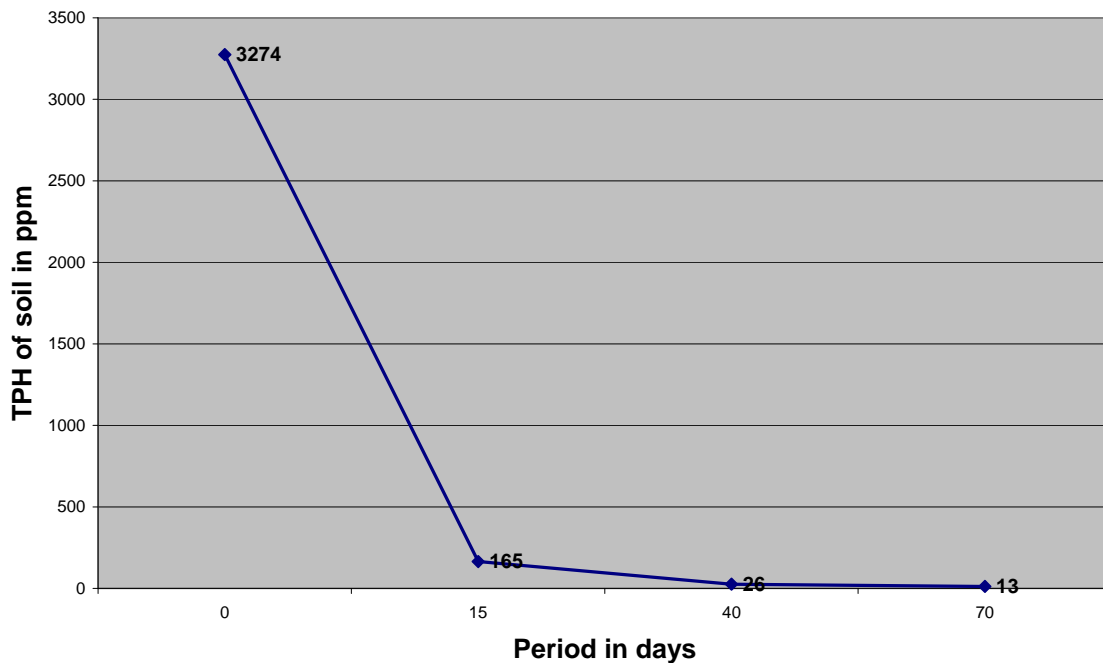
Sarva Bio Remed, LLC submitted a proposal to develop a new product for Brazil that would be used for cleanup of contaminated soils and that could be considered safe for



release in local environment. The proposal was accepted by the concerned authorities and accordingly Sarva Bio Remed, LLC isolated species of bacteria from samples of contaminated soil/water samples collected from Atuba, site of present project. The new product named as AgroRemed BR for Brazil has also shown the same level of effectiveness as AgroRemed US.

In one of the trial evaluation, diesel contaminated from another utility plant was used to evaluate the performance of AgroRemed BR. TPH of the soil contaminated with diesel and No. 2 fuel oil has been found to be reduced by more than 90 % in 20 days time and in this case, evaluation was done on 15<sup>th</sup> day, 40<sup>th</sup> day and 70<sup>th</sup> day after a single application. The graph below shows the effectiveness of the new AgroRemed BR.

**Reduction in TPH of diesel contaminated soil using AgroRemed BR**



### **Site preparation and Biopile Treatment with AgroRemed BR**

At one of the substation site the soil was contaminated with the transformer oil due to vandalism and unsafe storage practices. Local regulators required COPEL to cleanup the site and since excavation of the soil and replacing with clean fill was quite expensive, it was decided to treat the soil as Biopile with AgroRemed BR. The photographs show the preparation of the site before excavation and treatment of Biopile.



**Figure 10. Site preparation**



**Figure 11. Biopile prepared from soil excavated to 1 meter deep**



**Figure 12. AgroRemed BR being transferred into a bucket**



**Figure 13. AgroRemed BR being sprayed with a garden sprayer**

## **Conclusions**

Bioremediation of soils contaminated with transformer oils have been carried out using AgroRemed BR at a substation and the results have been very encouraging. The advantage of AgroRemed BR is the simplicity of application and effectiveness and most importantly it is a one time application. There is no supervision or repeat applications and thus reduces the cost of treatment. Treatment of soils with AgroRemed BR is considered as applicable particularly for stations remotely located where if the soil less clayey AgroRemed BR could be applied directly without any excavation.

Presently we have completed two projects involving Biopile treatment with AgroRemed BR. One project involved contamination of soil with transformer oil at a municipal garden where the cleanup was critical since the garden was used by children.

## **Acknowledgements**

Authors wish to thank the Director and members of the team at Lactec for their support and the staff of COPEL who have given time and effort in implementing the project protocol at Atuba. We would particularly like to thank Mauricio Mattoso of Lactec for his involvement in the execution of the project.