

# RESPONSE AND REMEDIAL ACTIONS FOR A LARGE AREA AFFECTED BY A ROAD TRANSPORTATION INCIDENT INVOLVING PHENOL

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## ABSTRACT

This activity report intends to show the response and the serious consequences generated by a hazardous material incident involving phenol in a road transportation accident near São Paulo, Brazil, on December 7, 1992.

Since the carrier and the phenol manufacturer were not efficient in responding to the emergency, serious damages have been caused to the environment such as: a high rate of fish mortality in a nearby lagoon, contamination of a river 1,100 m from the scene of the incident and contamination of about 150 m of the roadside soil.

One year later, the remedial actions are continuing, since the phenol has infiltrated into the soil and the recommended maximum concentration has not been reached yet. Among others, the remedial actions taken by the carrier and the manufacturer include: blockage of the road drainage system, partial roadside soil removal, interruption of the use of the river as a water supply, usage of activated carbon for phenol adsorption to avoid lagoon contamination, aeration of the lagoon and phenol oxidation with hydrogen peroxide.

This report shows the responsibility of a polluter to respond to a hazardous material incident in an efficient way as well as the infrastructure of CETESB, the São Paulo Environmental Protection Agency, in dealing with this kind of emergency.

## THE ACCIDENT

At 4:45 a.m. on December 7, 1992 CETESB, the Environmental Protection Agency for the State of

São Paulo, was summoned by the Highway Department (DERSA) to respond to a hazardous material incident which had occurred during a road transportation of 27,780 liters (7,340 gal.) of molten phenol at km 31 of the Bandeirantes Highway near São Paulo.

The truck tank trailer turned over and 22,000 liters (5,812 gal.) of phenol were spilled from the truck top loading/inspection port onto the roadside soil. Part of the spilled product had drained over 150 m (450 ft) of the roadside soil and had reached the road drainage system which, according to DERSA, drained directly into the Juquery River (1,100m/ 3,670 ft away), while another portion of phenol had infiltrated into the soil (Figure 1).

## EMERGENCY RESPONSE

The CETESB emergency response team arrived at 6:00 a.m. and, along with the Fire and Highway Departments, made an initial evaluation of the incident in order to size up its consequences. During the inspection, it was observed, among other things, that:

- there were a lot of phenol pools on the roadside soil;
- there was a high level of phenol vapor in the atmosphere, measured by a gas detector;
- there were still about 10 ton of phenol inside the tank;
- part of the spilled product had already reached the road drainage system.

Therefore, the coordination group formed by CETESB and the Fire and Highway Departments took the following actions immediately:

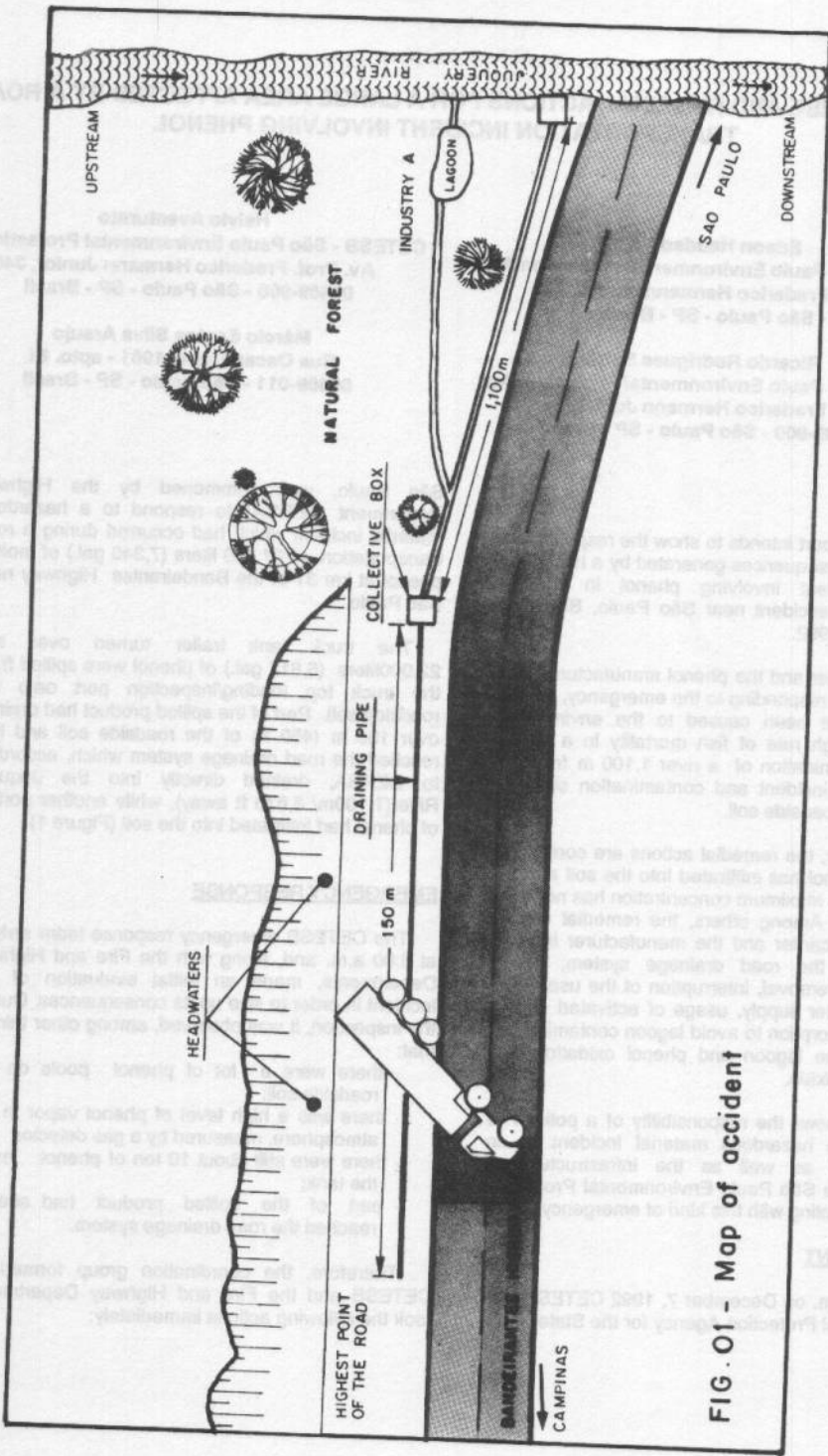


FIG.01 - Map of accident

- construction of a sand dike around the collective box of the drainage system;
- contacting with the manufacturer and the carrier, requesting that they provide human and material resources to face the emergency, including trucks and pumps to recover the spilled product as well as to remove the contaminated soil;
- expansion of the initially isolated area;
- notifying people who lived near the Juquery River to make no use of the water until further notice.

The carrier arrived at 10:00 a.m. and after their initial evaluation, it became apparent that it would not be possible to transfer the product inside the damaged tank to another one because of the small quantity of phenol, about 8,000 kg (17,660 lb), the position of the tank and mainly because of their pump which was not the most adequate for that particular chemical.

The manufacturer contracted three vacuum trucks in order to remove the phenol contained in the tank as well as to recover the phenol pools on the soil. These vacuum trucks arrived at 12:00 p.m. and the transfer of the phenol from the damaged tank was carried out by the Fire Department personnel who had to wear fully encapsulating suits. It ended at 2:30 p.m. and about 7,200 kg (15,900 lb) of the phenol were recovered and used to make resins.

Simultaneously, the other two vacuum trucks were carrying out the recovery of the phenol pools spread over the roadside soil. In order to make this activity easier, water from the Fire Department truck was used to rinse the soil while suctioning off the chemical into the trucks. Eighteen thousands liters (4,755 gal.) of a 15% water/phenol solution were recovered which was treated as residual water at the manufacturing plant.

There was another task to be done, which was the removal of the contaminated soil. Despite the CETESB weather forecast about the possibility of rain, which would have complicated the emergency, the manufacturer and the carrier did not mobilize the required resources, so the Highway Department sent four trucks to transport the contaminated soil, but this number was insufficient. About 24 m<sup>3</sup> (890 ft<sup>3</sup>) of residue were sent to the manufacturer and stored in plastic bags in drums for future disposal.

It is important to say that the layer which was removed was only 0.2 m deep and 60 m long, which

was not nearly enough. Therefore, the coordination group decided to build two dikes in order to protect the collective box of the road drainage system from rain water carrying phenol.

Finishing the activities of that day, the damaged tank was righted, the affected area covered with a plastic sheet and the São Paulo Civil Defense released a bulletin notifying people to make no use of the Juquery River.

On the 9th, CETESB sampled the Juquery River water upstream and downstream from the point where the road drainage system emptied into it and the results (0.59 mg/L for both) showed the river contamination had occurred at another place, since the normal concentration in this river was 0.001mg/L, which is the maximum permitted by Brazilian law.

On the same day, an industry (here called A) located 1,200 m (4,000 ft) from the incident notified CETESB a high rate of fish mortality in its lagoon (about 500 carps), along with a strong phenol odor.

Only with this information and after a careful inspection of the natural forest existing between the spill and the industry A, was it possible to discover the actual path taken by the spilled product. After it reached the road drainage system, the phenol traveled to the industrial lagoon, which drains into the Juquery River. New samples were taken which confirmed the lagoon contamination (182 mg/L) and the way in which the Juquery River had been reached (Figure 1).

Despite CETESB's repeated requests to the manufacturer and the carrier to remove the contaminated soil, they only complied on December 10. Throughout that day, 60 m<sup>3</sup> (2,222 ft<sup>3</sup>) of residue were removed and transported to the manufacturing plant. However, because of the rain on the 8th and 10th of December, the phenol infiltrated into the soil and therefore a greater depth of soil was contaminated and could not be subsequently removed, once this could have compromise the road structure.

#### SITE CHARACTERIZATION

The accident occurred at the foot of a hill where two headwaters are located. This water drops to on the roadside soil and after seeping through four meters, it reaches a draining pipe which carries the water to the road drainage collective box. This

drainage system goes to the industrial lagoon and after that, to the Juquery River.

The roadside soil is formed, basically, of crushed rock which permits a high level of penetration in a reduced time span.

An investigation enabled the team to conclude that most of the spilled phenol infiltrated at the foot of the hill through the crushed rock. This investigation also showed that the underground water (40 m/133 ft deep) was not affected by the incident.

#### REMEDIAL MEASURES

Ten days after the incident, the phenol levels were still above the recommended limit. CETESB met with the manufacturer and the carrier and decided that the following actions should be taken:

- blockage of the road drainage system and removal of the headwaters that flow through the draining pipe;
- phenol oxidation with hydrogen peroxide;
- aeration of the industrial lagoon;
- usage of activated carbon for phenol adsorption before the lagoon.

Both companies committed themselves to aiding CETESB and on December 18 these measures were taken.

Thirty-two hundred liters (845 gal.) of hydrogen peroxide (120 vol. -35%) and 1,055 kg (2,329 lb) of ferrous sulfate for the phenol oxidation were used. Before it has been used, the phenol concentration was 200 mg/L against 1,240 mg/L after hydrogen peroxide application. Anyway, this high concentration has lasted only for a few hours.

On December 21, after a rainy night, the phenol concentration in the draining pipe reached around 1,200 mg/L again. Therefore, it meant that all the hydrogen peroxide has reacted with the phenol, and soil also, while another amount of phenol was carried out by the rain. This fact, explained why the phenol concentration had gone up to 1,240 mg/L after the hydrogen peroxide application and also the rain. For that reason, a new application was performed on December 22 and the results have been satisfactory as well.

On December 23, the manufacturer constructed a dike upstream of the industrial lagoon and cotton bags of activated carbon plus sand (2:1) were placed to percolate all the feeding water coming from the

contaminated area to reduce phenol levels. It was possible to reduce the phenol concentration from 1,200 to 78 mg/L. This job was performed for 3 months and the use of the lagoon was liberated when the phenol concentration reached 0.004 mg/L.

A new hydrogen peroxide application was performed on December 30, but this time the roadside soil was revolved to make its infiltration into the soil easier. About 30 trenches were dug (1 meter/3 ft deep) for this purpose.

On December 31, the carrier installed a pump in the collective box of the road drainage system in order to remove full time the contaminated water, which was pumped into a tank truck.

Instead of another hydrogen peroxide application, which was expensive, the carrier and the manufacturer decided to use water to remove the phenol. A sample collected after the usage of water showed 1,370 mg/L of phenol. Later, hot water (90°C - 194°F) was used many times for this operation and the results were better.

On January 7, a pump was installed in the lagoon in order to aerate it.

By January 26, 500 m<sup>3</sup> (18,520 ft<sup>3</sup>) of water had been removed from the drainage system collective box (which was blocked).

On January 28, the manufacturer asked CETESB for authorization to use foreign microorganisms (bacteria) in order to accelerate the roadside soil recuperation. However, CETESB did not agree with its use since they intended to use foreign microorganisms which could have been dangerous due to possible unknown effects on that habitat. CETESB sent them a proposal on bioremediation with local bacteria, but they rejected it (too lengthy and expensive).

Throughout February only a mixture of hot water and 10% sodium hydroxide was used to induce the solubilizing of the phenol and, consequently, its removal from the soil. It was ultimately recovered from the blocked collective box. By the end of February, the phenol concentration was 150 mg/L.

By the end of February, the 3 last samples from the Juquery River, showed that phenol concentration was less than 0.001 mg/L and the São

Paulo Civil Defense released a bulletin notifying that the Juquery River had already reached its normal phenol level and that, therefore, it could be used again by the population.

To reduce the volume of water pumped out, the carrier and the manufacturer have been recycling the water from the collective box and reutilizing it to rinse the roadside soil.

On October 5, new samples were taken which confirmed that both the Juquery River and the industrial lagoon were not contaminated anymore (<0.001 mg/L). However, the phenol concentration in the roadside soil was about 3 mg/L, which still was above the recommended maximum limit.

Thirteen months after the incident, the phenol in the roadside soil has been reduced to 0.01 mg/L, which leads us to believe that the activities there are about to be ceased.

### POLLUTER OBLIGATIONS

Responding to a hazardous material incident is not as simple as it might appear. It is not enough to have extra truck tank trailers and people as resources. It is necessary to have a trained team equipped with adequate protective gear, a rescue team and resources such as pumps which can be mobilized at any time for any location. The Brazilian law for road transportation of hazardous materials requires this.

This accident became worse as the carrier response was not efficient. They were slow and poorly equipped for this situation.

The consequences to the environment were serious. The fish mortality, the roadside soil contamination and the interruption of the use of the river as a water supply, among other things, illustrate the graveness.

The manufacturer estimates that 13,880 liters (3,677 gal.) of phenol had remained infiltrated in the soil after the incident.

The expenditures of all entities involved were enormous. CETESB performed hundreds of laboratory analyses. Its technical staff was mobilized for hundreds of hours. The carrier kept 3 people working 24 hours per day for 2 months to remove the water containing phenol from the draining pipe.

They replaced 500 carps in the industrial lagoon as well.

About 113 ton (250,000 lb) of all residue removed will be incinerated in a Cement Company's furnace. It will cost US\$ 50,000.00. The total expenses have already reached US\$ 150,000.00 and it has been supported by the carrier.

It would certainly have been less tedious if the carrier and the manufacturer had contracted some trucks to transport the contaminated soil as soon as the accident occurred and before it rained.

This sad occurrence has become an example to other carriers which, we hope, will be adequately preparing themselves for future emergencies.

### CETESB'S INFRASTRUCTURE FOR ENVIRONMENTAL ACCIDENT ASSISTANCE

Since 1978, CETESB has been acting on accidental emissions of hazardous materials generated either in the industry or during transportation or storage in São Paulo State. CETESB has been responding to an annual average of 200 incidents. This number does not represent all the accidents that occurred in São Paulo State, but rather only those in which CETESB was involved. Most of these accidents occur on the road when hazardous materials are in transit and most of them involve flammable liquids and are due to human error.

The area responsible for these activities is the "Divisão de Tecnologia de Riscos Ambientais" (Environmental Risk Technology Division), which is divided into two "Sectors": the "Setor de Operações de Emergência" (Emergency Operation Sector) and the "Setor de Análise de Riscos" (Risk Analysis Sector). This Division permits the handling of both preventive and corrective aspects of accidental pollution.

CETESB keeps a four-person intervention team on permanent stand-by for emergency response to incidents in Sao Paulo State compound by namely: one coordinator, one chemist, one engineer or biologist and one technician (driver).

To contact this team, CETESB maintains at its headquarters an assistance center to attend to the population's calls to orientate the community and other entities on problems related to accidental

pollution and to serve as a base for the stand-by intervention team.

Furthermore, CETESB has developed and implemented some data bases among which are the Data Bank on Chemical Products, presently registering 850 substances, and the Environmental Accident Data Bank (CADAC), from which the statistics mentioned above have been extracted.

For accidents involving chemical products, CETESB counts on a properly equipped Mobile Unit for Environmental Accident Assistance, which contains, among other things, a communication system, chemical protective clothing, field analysis kits, combustible gas indicator, oxygen indicator, gas detector, pH indicator, SCBA and others.

Due to the increase in the number of solicitations that CETESB receives from the population, industries and other governmental offices, it is possible to say that it is well-structured to respond to accidents generated by hazardous substances. However, it is worth stressing that, because of the dynamics with which an accident happens or develops, there is a need for the implementation of a program of information exchange and technical renewal with other organizations, in order to obtain a broader knowledge. This would promote a constant upgrading of the CETESB staff.

#### SÃO PAULO STATE'S ENVIRONMENTAL ACCIDENT ASSISTANCE SYSTEM

The great incidence of environmental accidents involving chemical products in the last years, made obvious the need to adopt preventive and corrective measures aiming both to diminish the probability of occurrence of such episodes and to quickly mobilize all participating agencies.

In 1986, the "Coordenadoria Estadual de Defesa Civil" - CEDEC (Civil Defense State Coordination) implemented an "Integrated Communication System" that links around thirty agencies, among which may be highlighted: the CEDEC, the Fire Department, the Highway Patrol, the Military Police, the São Paulo County Administration, CETESB, the State Water and Sewage Company, the Brazilian Chemical Manufacturers' Association, the National Association of Cargo Transportation Companies, the Traffic Engineering Company, the Civil Defense Municipal Commission, etc. It is a four-digit telephone number

which is connected with a network of operational centers, making contact and mobilizations in emergency situations. It is operative 24 hours a day, 365 days per year.

Because most environmental accidents happen in São Paulo County and during road transportation, the agencies above elaborated an "Emergency Plan for Accident Assistance in Road Transportation of Hazardous Materials in São Paulo County". In this plan, the attributions and responsibilities of the integrating agencies are defined. Furthermore, the handling of issues referring to road transportation in São Paulo County includes the following activities:

- preparation, implementation and publicizing of the Emergency Assistance Plan;
- survey and registration of material resources;
- classification criteria for substances that are potentially dangerous for road transportation;
- execution of theoretical and practical training programs for the staff;
- preparation of studies for the definition of alternative routes and timetables for hazardous materials transportation in São Paulo County.

In addition, it establishes that the field coordination during an emergency is the responsibility of the Fire Department, CETESB and the Traffic Department, while the remaining agencies must give support when required.

This plan has just been implemented and, at this moment, it is under tests and evaluation.

Therefore, the need for permanent improvement of assistance systems for emergency situations caused by chemical product incident is clear. Quick and efficient response when these events occur, as well as a good integration among all involved agencies, are the means to guarantee security to the population and to the environment.