OPERATIONAL USE OF A MOBILE SAND-WASHING PLANT FOR CLEANING PEBBLES: THE AMAZZONE OIL SPILL

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ABSTRACT: On January 31, 1988, the Amazzone spilled about 1,500 tons of a highly paraffinic medium fuel oil (having a pour point of 36°C) along a distance of 300 km off the coast of Brittany. Due to very rough sea conditions, no offshore recovery operation could be carried out. Most of the pollution was beached as scattered patches on numerous sites, including pebble beaches in south Finistère, which had been especially difficult to clean during previous spills. In this area, the pebble banks that protect the dunes are relatively exposed to erosion. It was therefore decided to try cleaning these pebbles on site using the mobile plant that was designed for washing polluted sands and tested in 1985. The plant prototype was put in working order and conveyed to the site on the Baie d'Audierne. The equipment was very easily adapted to washing the pebbles polluted by a mixture of sand and fuel oil emulsion. A total of 1,400 m³ was cleaned during 10 days at the end of March. The plant worked smoothly with a load of 20 to 25 m³ of pebbles per hour and using a petroleum solvent as a washing agent. Because the ambient temperature was rather low (around 5°C), cleaning was performed with warmed water. Compared to other techniques that could be used to clean polluted pebble beaches, the washing plant proved very effective (providing good cleaning and high throughput) and competitive (costing less than quicklime treatment, for instance). Another advantage of this technique is that cleaned pebbles are returned to the beach, helping the pebble bank to keep its anti-erosion function. Compared to other techniques that could be used to clean polluted pebble beaches, the washing plant proved very effective (providing good cleaning and high throughput) and competitive (costing less than quicklime treatment, for instance). Another advantage of this technique is that cleaned pebbles are returned to the beach, helping the pebble bank to keep its anti-erosion function.

Spread of the spill. Rough west winds and sea conditions caused the oil to come ashore all along the coast of the western part of Brittany. Scattered patches of oil beached on numerous sites. Nature of the pollutant. The spilled oil was a highly paraffinic medium fuel oil, with a pour point of 36°C. However, after being pushed about at sea, it came ashore as a water-in-oil emulsion (65 percent water). Polluted pebble beaches. Among the polluted sites, two areas were of particular concern because they were pebble beaches, which had been especially difficult to clean during previous spills. These areas, Tréguennec and Plovan, are shown in Figure 1. On both of

Pollution caused by the tanker Amazzone

The Amazzone incident. On January 31, 1988, the Amazzone, carrying 32,000 tons of medium fuel oil from Libya to Belgium, was caught in a rough storm off the coast of Brittany (the westernmost part of France). Due to the action of strong waves breaking onto its deck, the ship was damaged, resulting in a continuous release of oil. A total of about 2,000 tons of oil was spilled at sea for the distance of about 300 km traveled by the damaged vessel.

Western Brittany
these beaches, a pebble bank protects the dunes against erosion by the sea (Figure 2). This part of the coast is extremely open to very rough sea conditions, especially during winter and spring. One of the pebble beaches in Tréguennec is particularly exposed to erosion. The amount of polluted pebbles was roughly estimated at 1,800 m³ at Tréguennec and at 2,000 m³ at Plovan.

Test cleaning runs at the Tréguennec site. During several days following the oil's beaching, strong winds incorporated additional sand into the pollutant. Therefore cleaning operations had to deal with a mixture of sand and emulsion.

The first response to this accident was to recover manually (using shovels) the largest patches that landed on top of the pebbles. However, this response became rapidly impossible. Indeed, due to the sea's action, the pollutant was mixed with the pebbles within a layer of several tens of centimeters.

Because of the fragile nature of the pebble bank, and taking into account its important anti-erosion function, it was decided that any technique used to clean the bank had to include three steps:
1. Removing the polluted pebbles from the bank
2. Washing the pebbles
3. Rapidly returning them to the bank

A few test runs were performed to carry out the cleaning in this way. The tested techniques used "traditional" means such as hot water pressure cleaners.

The test results showed that the output of the cleaning operations would be very low in this way (around 1 m³/h). In light of the quantity of pebbles to be cleaned, these traditional techniques would have led to long and expensive operations. It was therefore decided to abandon these techniques and to try to use the mobile washing plant, which had been successfully used to wash polluted sand in 1985.

The mobile sand washing plant

Chronological account of how the plant was designed. The mobile plant was designed within the framework of a research program undertaken with the support of the European Economic Community
and the French Ministry of the Environment. The aim of this program was to develop a technique for treating polluted sands that remained on beaches after the bulk of an oil spill had been removed from the surface using mechanical means.

After a scale model was tested in the laboratory, a real plant was built for testing. Trials were performed in 1985. They showed that sand polluted with 2.3 percent oil could be effectively cleaned with an output of around 20 tons/h. The final content of oil in the sand, after washing, was around 0.2 percent (2 g/kg), which is small enough so the sand can be returned to the beaches without any major ecological effects.

**Working principle of the mobile plant.** The plant’s working principle is derived from that of equipment used to wash sediment in quarries for use in public works construction (e.g., roads).

Figure 3 shows the general scheme of washing operations in the plant. (A general view of the plant is shown in Figure 4.)

The contaminated sand is fed into a hopper by means of a shovel loader and then taken by the conveyor belt up into a drum scrubber. At the drum intake, heated water and cleaning agents are added. The water is heated by a steam generator, which delivers hot steam to a heat exchanger through which water to be warmed is recycled. Sand passes through the drum in about 10 to 18 minutes.

At the drum’s exit, the mixture of polluted sand, warm water, and cleaning agents is screened on a trommel. The biggest pieces (over 5 mm), such as pebbles and algae fall onto a conveyor belt, which then discharges them, into a dump truck, for example. The smaller elements—water, cleaning agents, and sand—are recovered in a tank and pumped toward a hydrocyclone, where a separation of solids and liquids takes place: wet sand is dewatered on a vibrating drainer, and the dry sand falls onto a conveyor belt to be transported back onto the beach, while a mixture of water and cleaning agents is taken to decantation tanks. This mixture also contains thins (less than 200 mm). After decantation, oil is recovered and the water is recycled in the plant.

**Cleaning the polluted pebbles in Tréguenec**

**Adapting the plant to clean pebbles.** As mentioned earlier, up to 1988, the mobile plant had only been used for cleaning polluted sand. However, its working principle was such that it could be expected to clean pebbles without any major problems. In fact, the only major adaptation that seemed necessary was to install a rinsing device at the exit end of the drum scrubber to rinse off the thin film of oil and cleaning products as the pebbles passed through the trommel. To perform this rinsing operation, three fire hose nozzles were attached to a bank at the output of the trommel (Figure 5). The rinsing nozzles sprayed recycled water coming from the decantation tanks.

**Installation of the mobile plant at the working site.** The plant’s mobility is possible, because most of it is installed on a truck-trailer chassis. To transport the entire plant to the site, it was necessary to use four truck-trailers, one carrying the main part of the plant (mounted on the trailer), the other three carrying all the accompanying parts of the plant (e.g., conveyor belts, decantation tanks, hoppers, hoses, and pumps).

An appropriate site was chosen based on the following advantages: being at a distance from any inhabited area, being close to the polluted pebble bank, providing access to agricultural tractors to the beach, and being located close to a deserted quarry, which was filled with runoff water at this time of year. The water needed for the washing operations was pumped directly from the quarry.

A crane was employed at the site, to install the various plant elements (Figure 6). The plant was set up in two hours on February 23, 1988. It took an afternoon’s work to connect all the hoses and pipes. In all, it took four men an entire working day to set up the plant. For security reasons, we asked a private company to verify and turn on the electrical installation and its protective system. The first tests for adjusting the plant took place on the afternoon of February 24, 1988.

**Cleaning tests.** Laboratory tests were run before using the plant on site, and they indicated that the product to be used as a cleaning agent should be composed of a solvent and demulsifier. Used in applications equaling 5 percent of the pollutant, this cleaning agent enabled us to obtain a good separation of the various solids and liquids (sand, water, and emulsion), and to break up the emulsion partially. The emulsion that remained at the end of the cleaning operations contained only 20 percent water as opposed to 65 percent at the start of pebble cleaning.

Several new parameters needed to be considered at the site itself. Mixing in the cleaning plant’s scrubbing drum is better adapted to cleaning than laboratory mixing in a glass beaker, especially because of the pebbles’ action of rolling upon themselves. The pebbles to be...
cleaned were also less polluted than the samples taken for laboratory analysis. A high tide had diffused the pollutant to a greater depth in the pebble bank.

It was therefore decided to run a new series of cleaning tests to determine an appropriate procedure as well as to test the mechanical functioning of the plant. Test conditions included the following:
- Cleaning in cold water
- Cleaning in hot water
- Cleaning in hot water with an additional solvent (petroleum cut)
- Cleaning in hot water with an additional solvent and demulsifier using the proportions determined in laboratory experiments
- Dry cleaning using this same solvent-demulsifier mixture, followed by complete rinsing.

The results of these on-site tests are presented in Table 1.

**Conclusion of the preliminary tests.** The results of the on-site tests showed it possible to clean 20 m³/h of polluted pebbles. In light of the on-site conditions (type of pollutant and degree of pollution) two operating procedures seem best adapted to this particular situation:
- Washing with only hot water. For this method it is necessary to have a more powerful hot water heater (1.5 t/h). Under the test conditions (washing temperature of 17°C), washed sand is clean. It contains 18 percent water and less than 1 g/kg of oil, and may, like the pebbles, be returned to the beach.
- Washing in hot water with the addition of an oil solvent. In test conditions this technique is the most appropriate (with respect to optimal washing effectiveness, quality of decantation, and cost of the cleaning solvent). The washed sand is also clean. It has 20 percent water and less than 1 g/kg of oil remaining.

It must be noted that in either use of these two procedures the recovered pollutant is easily pumped, but it remains nevertheless a water-in-oil emulsion containing 70 percent water. The use of a demulsifier is advised when skimming the decantation tanks to reduce the volume of pollutant to be transferred to the recycling center.

**Logistical and economic considerations**

Organization at the cleaning site requires a number of activities: removing the pebbles from the polluted bank, transporting them to a storage area close to the washing plant, feeding the pebbles into the cleaning plant by means of a shovel loader, washing the pebbles, and transporting the cleaned pebbles and sand to their original locations on the pebble bank.

**Means of removing and transporting the pebbles.** The amount of pebbles that needed to be carried to the cleaning plant was about 100 to 150 m³/day. To maintain this rhythm, three teams were needed, each equipped with an agricultural tractor-trailer. The trailers used to carry the polluted pebbles could not be used to carry clean pebbles, because the trailers would probably be soiled. Therefore, three other teams were needed to carry the cleaned pebbles back to their original location.

**The plant itself.** Tractor-trailer trucks were needed to transport the plant and all its accessories. The necessary equipment included feeding and evacuation loaders, decantation tanks, a feeding hopper, a heat exchanger, storage tanks for the cleaning agents, an application pump for the cleaning agents, pipes for water circulation and all their accessories (e.g., joints and faucets), and pumps for applying water in the washing cycle (at the entrance and the scrub drum) and in the pebbles' rinsing cycle on the trommel. Additional equipment needed included a generator for electric power, a hot water heater to supply steam for the heat exchanger, equipment for skimming the decantation tanks, and machines for moving the conveyor belt and for removing the recovered pollutant.

Installing the washing plant also required two hours of crane work and four technical engineers for one-half day. Closing down a sand washing plant requires the same amount of time and equipment.

**Financial assessment of the operating costs.** The present evaluation concerns all necessary work: transporting the plant to the working site, setting up the plant, round-trip transportation for the polluted pebbles (from the beach and back again, and shutting down the site. In addition, this evaluation is based on the true expenses incurred during the cleanup operation after the *Amazone* accident. It is for this reason that the costs depend on the quantity—1,800 m³—of pebbles, because this was the actual amount washed.

Table 2 shows the assessment of the costs of the washing operations. In the case of washing 1,800 m³ of polluted pebbles at the speed of 120

<table>
<thead>
<tr>
<th>Operation</th>
<th>Cost (US$)</th>
<th>Quantity (m³)</th>
<th>Cost (US$/m³)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Fixed costs</strong></td>
<td></td>
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<tr>
<td>Installing and closing down the</td>
<td>4,000</td>
<td>1,800</td>
<td>2</td>
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<td>plant after use</td>
<td>16,000</td>
<td>1,800</td>
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<td><strong>Subtotal</strong></td>
<td></td>
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<tr>
<td><strong>Functioning costs</strong></td>
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<td></td>
<td></td>
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<tr>
<td>Transporting pebbles (e.g.,</td>
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<td>120</td>
<td>13.3</td>
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<td>loading equipment</td>
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<tr>
<td>Fuel</td>
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<tr>
<td>Personnel</td>
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<td>120</td>
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<td>Cleaning agents</td>
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<td>Eliminating recovered oil</td>
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<td>3</td>
</tr>
<tr>
<td><strong>Subtotal</strong></td>
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<td>39</td>
</tr>
<tr>
<td><strong>Total</strong></td>
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<td>50</td>
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</table>
m³ per day, the costs (fixed costs plus functioning costs) were 50 US$/m³. These costs are the real expense of the pebble washing operations. If this job were to be done by a private company, it would be necessary to add the profit margins and overhead costs.

Conclusions

The washing tests on polluted pebbles from the bank at Tréguennec suggest that the technique used is entirely feasible. The tests enabled us to conclude that the washing plant was effective when used to clean shingle/pebble beaches, with no significant modifications. The results obtained using hot water and solvent are adequate, and the speed of handling (20 m³/h) demonstrates the plant’s competence, especially when compared to other available methods of cleaning pebbles.

The cost, approximately 50 US$/m³, is competitive when compared to the cost of treating waste with lime, for example (at about 63 US$/m³).

The plant washing prototype was given over to a private enterprise so that the other 1,400 m³ of pebbles polluted by the Amazzone could also be cleaned. The company was able to clean 22 m³/h, and spent a total of two weeks on the job. This fact also showed the value of the plant for use in washing pebbles.

Following the trials and the use of the plant in real conditions, some minor improvements were suggested (integration of the accessory equipment, control of the various water levels, etc.) to make the plant even more effective. The realization of these improvements will permit the use of the plant on a larger scale.

Bibliography
