The Taparura project, part of an action programme designed by Tunisian government authorities and supported by the European Investment Bank, is an effort to rehabilitate a port area which had been heavily polluted by industrial development. The Taparura project focuses on the sustainable socio-economic remediation of the coastal area around the city and harbour of Sfax, Tunesia’s second most populous city. Since the 1960s commercial and industrial development at Sfax in the southern part of Tunesia had been emphasised and the coastal area had been neglected. Especially the processing of phosphates to produce fertilizers had left stockpiles of phosphogypsum which are 6 metres above the sea level and cover 50 hectares. The objective of the rehabilitation is to construct a mixture of public and private spaces, including residential areas and to restore several kilometres of the coastline and create new beaches, reconnecting the city of Sfax to its beaches and encouraging the development of tourism.

The Taparura project is divided into two phases: 1) decontamination of the area and development of land in the sea (420 hectare); and 2) development of the area and construction a new urban centre. The first stage of the project, which entailed the decontamination and the rehabilitation of the entire site, is now completed. This was a complex multidisciplinary project and as such provided a challenge for everyone involved including the financiers, managers, engineers, environmentalists, contractors, consultants and government authorities.

**ABSTRACT**

The Taparura project, part of an action programme designed by Tunisian government authorities and supported by the European Investment Bank, is an effort to rehabilitate a port area which had been heavily polluted by industrial development. The Taparura project focuses on the sustainable socio-economic remediation of the coastal area around the city and harbour of Sfax, Tunesia’s second most populous city. Since the 1960s commercial and industrial development at Sfax in the southern part of Tunesia had been emphasised and the coastal area had been neglected. Especially the processing of phosphates to produce fertilizers had left stockpiles of phosphogypsum which are 6 metres above the sea level and cover 50 hectares. The objective of the rehabilitation is to construct a mixture of public and private spaces, including residential areas and to restore several kilometres of the coastline and create new beaches, reconnecting the city of Sfax to its beaches and encouraging the development of tourism.

**LOCATION AND HISTORY OF THE POLLUTION**

Located 270 km southeast of Tunis, the city of Sfax was founded in AD 849 on the ruins of Taparura and is the capital of the Sfax governorate. It is a Mediterranean port on the Gulf of Gabes, a gulf on Tunisia’s east coast in the Mediterranean Sea (Figure 1). The gulf is 600 kilometres long, with the Kerkena...
Islands on the northeast and Djerba Island on the southeast. It has a large tidal range, 2.0 metres at spring tides. Sfax municipality, often described as Tunisia’s second city, has a population of 260,000 inhabitants and is an industrial centre for processing phosphates. The port is the largest in Tunisia and specialises in the export of phosphates from big mining complexes in the region. The coastal area, some 150 hectares, is adjacent to the harbour and has suffered pollution from various types of solid and liquid wastes for years. Especially phosphogypsum, the residue from phosphate treatment, has been stored in an unregulated manner along the coastline, covering a surface area of 50 hectare piled 6 metres high. The pervasive pollution from this site was threatening the beaches and coastal waters of Sfax, hampering further development and economic growth, such as tourism, as well as presenting a health problem.

**THE TAPARURA PROJECT**

The Taparura project forms part of a global action programme developed by the Tunisian authorities to tackle the sources of pollution and to improve the overall environment of the Sfax region. The project promoter is the Tunisian Ministry for Equipment, Housing and Land Use Planning and the actual client is “Société d’Étude et d’Aménagement des Côtes Nord de la Ville de Sfax”, an autonomous government company under supervision of the Ministry for Equipment, Housing and Land Use Planning. This company is responsible for continuing the policy of pollution abatement and development of public and private industrial parks. The beach and landfill restoration will create a mixed space for new public and private activities, such as recreational complexes of beaches, parks and sports grounds, and educational, health and museum infrastructures, as well as the implementation of social housing programme.
A detailed site investigation both on- and offshore.

- The excavation of approximately 1.7 million m³ on land, including 1.25 million m³ of phosphogypsum plate around the toe of the landfill (Figure 4).
- Dredging of approximately 450,000 m³ contaminated sediments below sea level, with a water depth of approximately 0.5 to 1.5 metres. All wet polluted material was stockpiled and dewatered in a specially designated area on top of the existing landfill (Figure 5).
- The rehabilitation of this pyramidal phosphate dome comprises the reshaping of the slopes, the installation of a vertical bentonite-HDPE (high-density polyethylene) screen along the perimeter in order to create a confined area, including the installation of a cover layer with land-based material and a new topsoil layer.

The remediated area was reclaimed with 6.75 million m³ of sand, dredged by means of trailer suction hopper dredgers with material sourced at a distance of approximately 18 km (Figure 6).

The entire contract period was set at 2.5 years with an approximate project value of 73.5 million euros. The European Investment Bank (EIB) contributed approximately 50 percent of the financing with the other 50 percent coming through export credit facilities sourced from Belgium and France. These included a concession and a direct commercial loan.

The three stages during the implementation were: Site investigation, remediation works and rehabilitation and civil works.
During the first stage, site investigation, various surveys and samplings were conducted on land and offshore, for instance in the Kerkennah Channel, along the coastline of the beach and on the whole beach itself. Borings were also executed along the toe of the existing landfill to the depth of the impermeable layer. All samples were sent for analyses to a laboratory in Belgium. At the end of the site investigation stage, detailed excavation and dredging plans were elaborated and were entered onto the computers onboard the dredging equipment.

During this time, all land and offshore equipment was mobilised. These included dumpers, excavators, pontoons and other auxiliary equipment. Also prior to the start of the dry excavation and the dredging activities, the necessary infrastructure and road access was built. Once all this had taken place, remediation of the area began.

Dredging was performed in shallow water (water depth 0.5 to 1.5 metres). With storage space for contaminated sediment at a premium, over-dredging was held to a minimum by high accuracy dredging and close attention to the environment. A high precision backhoe fitted with an environmental bucket was used. The dredged sediments are temporarily stored on top of the existing landfill, where they are dewatered. Then the dry sediment is used to re-shape the confined disposal facility (CDF). During the remediation works, insertion, depot with sand fill.

Figure 5. Aerial view during the excavation works.

Figure 6. Dry excavation of the contaminated material via bunds.

Figure 7. Connecting floating pipelines to the TSHD James Cook for the rehabilitation works.
stage, some civil works were performed including the creation of embankments, a drainage canal and a vertical screen surrounding the CDF. The screen was constructed from cement-bentonite slurrywall with a high-density polyethylene (HDPE) foil. The remediated area onshore was reclaimed with sand pumped from the Kerkennah Channel using two TSHDs, the James Cook and the Alexander Van Humboldt (Figure 7).

The remediation of the area by removal of the phosphogypsum offered immediate health and safety improvements as the sediment contained arsenic, lead, cadmium, chromium, fluoride, zinc, antimony and copper at levels dangerous to human health (Figure 8).

Figure 9 shows the site at the beginning of the works. With the completion of the remediation, the next phase is ready to start: the development of the urban centre Taparura (Figure 10).

CONCLUSIONS

After years of studies in the 1990s to determine the feasibility of a clean-up project in the city of Sfax, the conclusion was reached in 1997 that the so-called Taparura project would be cost-effective and technically possible and that the benefits to the community in the southern Tunisian city of Sfax would be significant and long-lasting. The aim of the Taparura project is to transform the North coasts of the town of Sfax, affected by the industrial wastes, into an urban quarter where life could be pleasant and in which all sources of pollution have been eliminated or made neutral. Moreover, the project will ensure that the town of Sfax will be reconnected with its coastline through the creation of new beaches.

The ecological aspects of such a project in and around port cities is always a major challenge to all those involved: planners, financiers, engineers, environmentalists, contractors, consultants, authorities and many others. The execution of the remediation project took 2.5 years from mid-2006 to 2008 and laid the groundwork for the following phase to begin. The development phase for the Taparura urban centre, 420 hectares of reclaimed land with parks, a 5-kilometre-long beach and a residential area with housing for more than 20,000 people is now underway. The socio-economic benefits for the community and the city of Sfax are clear and will provide a significant improvement in the quality of life for its citizens as well as an economic boost through increased tourism.