ENVIRONMENTAL HOUSEKEEPING AROUND THE REFINERY

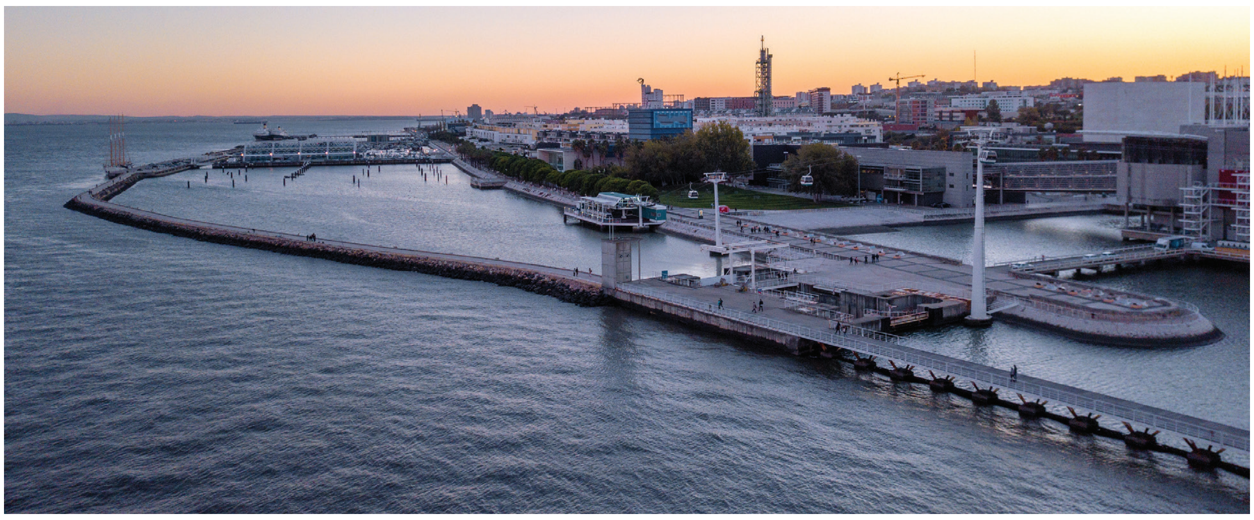
Putting the costs of crude oil and other essential chemical inputs to one side, a high proportion of the residual refinery operating costs will be in the areas of labour, utilities, insurance and laboratory expenses. Within the utilities bill, the costs of process waste-water and site rain water run-off management will appear. And, in the laboratory costs there will be product assay in addition to multiple environmental related analysis work to be done. So, putting it all together, the price-tag for environmental management on the refinery can be significant.

All around the houses

Environmental monitoring on the refinery has implications all around the facility and in all three physical states: air, soil and water. For example, most refineries will have smokestack emissions from combustion processes which are monitored for regulatory compliance. The most common solution is to use a continuous emissions monitoring system (CEMS) to ensure that the air pollution is controlled within defined emissions limit values (ELV's) for species such as NOx and CO, as laid out in the EU Industrial Emissions Directive. Direct-read Fourier transform infra-red (FTIR) and non-dispersive infra-red (NDIR) instrumentation with a high up-time target are commonly employed for this CEMS application. After the initial capex related to the equipment purchase and installation, the cost of CEMS operation is low because the system is automated and requires only occasional maintenance and calibration, perhaps through a service contract from the instrumentation supplier.

Perimeter ambient air quality monitoring is also regularly undertaken. In this case, it is common to collect air samples intermittently and take them off-site to a highly specialised contract laboratory for analysis using a gas chromatograph with a flame ionisation detector (GC-FID). This device can speciate and detect very low levels of volatile organic compounds (VOC's) which are a typical air-born environmental concern associated with hydrocarbon processing operations. Often, the services of an environmental contractor will be used for this type of environmental monitoring. The samples must be transported in specially designed gas containers that have an extremely inert internal surface treatment to ensure that the collected sample is delivered correctly to the gas analysis instrumentation without any of the pollutant molecules adsorbing to the surface of the gas container.

Tank farm



Lisbon TCC tower - old refinery site

Water quality monitoring will focus on core issues such as pH and total organic carbon (TOC). pH measurement equipment is perhaps the most simple and robust type of of the water quality instrumentation. TOC analysers, on the other hand, are a sophisticated black box that will use an oxidation process (eg chemical oxidation with hydroxyl radicals or catalytic combustion) to convert the organic chemicals to carbon dioxide, which is then measured using a gas-phase instrument such as an NDIR sensor. Additionally, for refinery effluent the possibility exists that certain carcinogenic aromatics, such as benzene, may be present in the water. So, additional specific checks for chemicals within the BTEX (Benzene, Toluene, Ethyl-Benzene and Xylene) group may also be undertaken.

Analysis of soil samples can have much in common with water analysis, and it is often the case that soil is mixed with water in the laboratory and the eluate is analysed, in addition to the soil solids. The relationship between soil contamination and groundwater pollution also binds the water and soil environmental issues. When conducting environmental soil analysis, it is therefore common to run similar tests to those conduced on water. Additionally, the scope for soil will generally include a search for trace metals such as lead and mercury and salt ions such as cyanide and sulphates.

For the trace metal species, inductively coupled plasma with various detectors such as mass spectrometry (ICP-MS) or atomic emissions spectroscopy (ICP-AES) is often used. The flame technique known as atomic adsorption spectroscopy (AAS) is an alternative. Various methods will be used for measuring the range of salts. One standard method for total cyanide analysis, as laid out in the US EPA Contract Laboratory Program (CLP) document

Refinery with water treatment in the foreground

ILM05.3 - Exhibit D, references a type of liquid phase colorimetry known as UV-VIS spectrophotometry. This CLP document also covers mercury measurement using AAS and gives guidance on the ICP-AES and ICP-MS techniques.

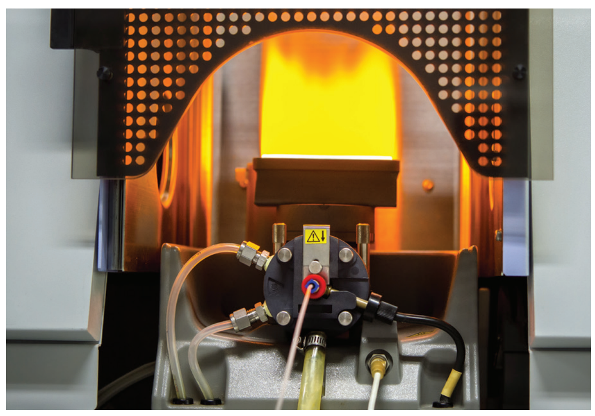
Groundwater well

DIY?

With so much measurement to be done, the trade-off between using an on-site laboratory versus outsourcing is extensively debated. The inputs to the decision making generally focus around cost which are driven by the complexity and frequency of the measurement and the capital cost of the instrumentation. For risk mitigation, insurance or legal reasons, it might also be prudent, or required, that an independent accredited third-party laboratory make the analysis.

The idea that a tank farm would have the sophisticated, expensive instrumentation required to complete a full groundwater analysis or perimeter air quality analysis is unrealistic. The expertise required to conduct the analysis is also highly specialised and with a low frequency of measurement, retaining staff with this level of competence is simply not cost effective. And, even in larger refineries the specialism towards organic analytical chemistry for hydrocarbon analysis would generally mean that they would have neither the inorganic analytical equipment nor expertise to

Ground water samples



AAS instrument flame

conduct the broad range of soil and water sample analysis that may be required. So, this work is also often outsourced to an environmental contract laboratory by major refineries.

Got the builders round?

Another ad-hoc reason that environmental monitoring analysis is undertaken is when modifications and site improvements are taking place on the refinery. In these cases, soil is often excavated to lay new foundations and there is often the requirement to analyse the soil prior to disposal or re-use. Local regulations will dictate what chemicals must be analysed for, the appropriate measurement technique and various limits that will govern how the soil may be re-used or whether it may be taken for land-fill or must be sent for remediation.

Soil samples

Cleaning up

Despite all the technology and good operating practices that refineries, tank farms and fuels distribution operators invest in to avoid leaks, some occasional spillages do, unfortunately occur. There is often a chain of events put into place after such a spillage which is designed to contain and mitigate the environmental

BTEX bottles

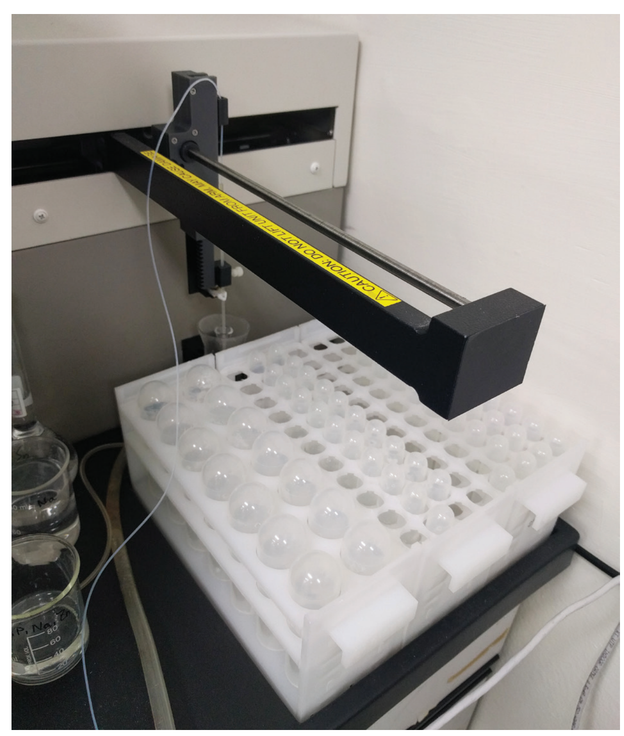
impact. Excavation of soil in the immediate area of the spillage will often be required. Analysis of the extent and type of contamination will then determine how the soil may be cleaned up. Perhaps washing may be sufficient, alternatively a biological remediation may be appropriate. Or, it might require combustion of the soil to burn off the hydrocarbon contaminants.

The long-term consequences on the local ground water will also need to be assessed. It might, for example, be necessary to drill a groundwater bore-hole and then extract samples for analysis at regular intervals to ensure that chemicals released during the spillage are not permeating through the soil and sub-strata into local water courses.

Closing shop and moving on

It is often the case that oil refineries were built many years ago in locations that were, at that time, close to an important market, but seemingly remote from a major city. As the urbanisation of our landscape has increased, the buffer between the refinery and the expanding housing has often shrunk. In such cases, there may be environmental pressure and a financial incentive for the refinery to simply shut up shop and move to a new location. Re-investment in modern equipment may also reduce operating costs and align better to the fuel mix of the day. In such events, one of the greatest un-knowns in the site de-commissioning cost budget will be the soil remediation cost.

One example of land re-use was the closure of Portugal's first refinery, the Cabo Ruivo Refinery in Lisbon. The site was subsequently visited by more than 10 million people during Expo '98. The tower from the thermoform catalytic cracker (TCC), which was once known for its smell and flame, is now a historical landmark and still stands in the Parque das Nações, now a premium residential area. In cases such as these, it is imperative that the soil is responsibly cleaned up. A task which relies heavily on the analysis of soil samples to determine firstly what needs to be done and subsequently to confirm when the required levels of soil quality have indeed been achieved.



ICP MS instrument sampler

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