NICOLE
A Network for Industrially Contaminated Land in Europe

A note on proposals for increased soil and groundwater monitoring under the proposed new IPPC Directive

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Background

At a recent meeting between DG ENV IPPC officials and the NICOLE Steering Committee, the Commission set out its views on the need to expand the current approach to monitoring incremental pollution at permitted facilities during the lifetime of the permit. The draft Directive currently proposes:

- A baseline report on soil and groundwater
- Monitoring of soil & groundwater every 7 years
- Remediation to baseline conditions at the permit cessation, thereby requiring an exit survey of soil and groundwater conditions.

This approach is intended to form part of the Better Regulation agenda, but may lead to substantial additional cost with little, if any, environmental improvement. The reasons for this are set out below.

Theoretical and practical challenges to using intrusive investigation as a measure of incremental pollution

The design and operation of modern industrial facilities aims to avoid new pollution and the IPPC Directive provides regulations to support this aim. There are a number of ways this can be done, but by far the best is to promote active management of facilities to prevent loss or leakage in the first place. This approach is supported by a number of regulatory bodies, for example the UK Environment Agency.

Pollution usually occurs by one of two means:

- A sudden large loss associated with catastrophic event, e.g. tank split and secondary containment failure:
- A gradual longer term loss from below ground pipes or tanks.

The former is normally visible and readily comes to light, whereas the latter may occur without any obvious outward sign, and may last for some time before inventory checking or other activity reveals a loss.

It is therefore the latter event which is of most concern when formulating the best means of checking for such pollution. Periodic soil and groundwater surveys have a number of inherent problems in delivering a solution here:

- They provide a false sense of security that they will identify a localised leak;
- They may not identify such a leak until seven years (under current proposals) after it has occurred;
- Most existing IPPC permitted sites have a long industrial history and distinguishing historical contamination from more recent pollution is usually quite problematic;
- Brownfield policies in Europe are tending to steer new industrial facilities towards Brownfield sites, so the confusion over historical pollution increasingly applies to new sites;
- Unless the surveys are comprehensive, they will not be successful in identifying any or all pollution;
- Undertaking surveys is very much an “end of pipe” solution to checking for incremental pollution, and is rather like shutting the stable door after the horse has bolted.

Groundwater sampling and testing

It is generally accepted that groundwater monitoring will provide valuable management data during the lifetime of a permit, and confidence that unacceptable impacts from site activity are being controlled. Such sampling can return each time to the same well, and location, and will provide a measure of consistency when comparing datasets, with in-situ measurements providing real-time data as well as sending samples for laboratory testing. However, a note of caution must be sounded here, as groundwater bodies are subject to change and variation from many external factors:

- from seasonal variations in groundwater level and quality;
- from heavy rainfall events and flooding; and
- from other pollution sources remote from the PPC site.

These will all influence judgements about whether groundwater data is showing representative evidence of true incremental pollution.

Soil sampling and testing

Soil is rather like a fruitcake. It appears to be one solid mass from above, but contains numerous different things, with different properties inside. If I sample a small crumb of cake, I may decide it's a cherry, or a currant or sponge-like. One sample can be very misleading, and I would need a lot of samples to characterise it effectively. At Site A, in the case studies appended, there were five different types of fill material, and six different types of natural ground in the upper 4 metres. All of these are affected in different ways by contamination, and the contamination would show itself at different concentration levels, and may pass through rapidly, or very slowly.

In order to sample soil and have meaningful data about contaminant concentrations in the soil mass over long periods of time (25 years or more), we need to deal with uncertainty and variability in:

- Ensuring we take samples from the same types of soil for comparison;
- Ensuring consistent sampling method;
- Sample preservation and transport to the laboratory without deterioration;
- Laboratory test methods, and the changing technology of testing over the years;
- Limits of detection in test methods; and
- How we use the data from the testing programme.

The UK Soil and Groundwater Technology Association (SAGTA) produced a report in 2003 (Ref 1) which addressed the statistical issues around assessing site test data. It concluded that to be practically certain of detecting a spill of at least 5 metres in diameter, one sample would need to be taken every 50 m^2 across the site. For a one hectare site, this would entail drilling 200 boreholes, at a typical cost at 2008 prices of 250,000 euros. Just by way of example, the same site could be biologically treated to remove hydrocarbon contamination to a metre depth for slightly less than this cost.

The example site A appended was divided into eleven zones of similar activity, and each zone averaged about a hectare in area. For this site, applying the same principle, 2,200 boreholes would be needed every seven years to deliver the requirements of the draft Directive.

Clearly, this level of investigation is entirely impractical and the costs (circa 2.6 M euros) are untenable. Constraints at the site in question meant that only a fraction of this number of boreholes (22 in total across the whole permitted site area of 11 hectares) was installed, and even then many practical problems of preservation occurred at the closure stage. Specific issues which constrain how much investigation is practical include:

- For existing sites, access for drilling rigs is limited by height and width, and many parts of the IPPC permit area are entirely inaccessible due to tanks, buildings and pipe work;
- Unless a plant is shut down for a period of time, there are areas where it would be unsafe to take drilling equipment due to presence of hazardous, potentially explosive, gases etc;
- The presence of buried services (water, power, sewers etc) excludes drilling holes in many areas; and
- It is not sensible to drill in some locations where there are sealed floors or bunds, as this would compromise the long-term integrity of the containment.

In practice the typical PPC permitted site will have a baseline survey which can only feasibly be based on a small number of boreholes (single figures) per hectare. The use of statistics to characterise such data will be very limited and uncertain. Only where an IPPC site is simple in terms of the breadth of activities and the ground relatively homogeneous will it be possible to characterise the site statistically.

Returning to repeat the exercise every seven years then presents further comparison difficulties for soils. New boreholes will by necessity need to be located a metre or more away from previous holes to avoid drilling in disturbed soils, and this will lead to sampling of different material at given depths as strata slope and vary locally. It will not be possible to definitively decide whether different contaminant concentrations are a function of incremental pollution, previously unidentified pollution or just the fact that the sampling location is in a slightly different location.

In terms of water sampling, experience at Site A was that at least half the groundwater wells used to provide baseline data were dry when the closure survey was undertaken 2 years later. Hence no comparison was possible. Other wells had been destroyed in prior demolition works due to heavy plant inevitably tracking across their covers, and replacement wells did not provide consistent water levels or quality data when installed at the closure stage.

For Greenfield sites where a new plant is built, baseline characterisation is relatively straightforward, although care has to be taken to identify naturally occurring contaminants that are common with the future IPPC activities. At Site B (case study appended), the site was built on Greenfield land some years earlier, and when the IPPC permit was issued, it was agreed with the regulator to use typical concentrations of three metals (the only Contaminants of Concern at the site) in natural soils for the region as baseline. However, it transpired that for mercury, for example, background concentration was typically 0.05 mg/kg. The normal test method which met regulatory requirements in the UK for mercury, had a limit of detection of 1.5 mg/kg, so when the closure survey was undertaken, all that could be said about soils is that mercury was less than 1.5 mg/kg, but this was more than an order of magnitude higher than the baseline. There is clearly a practical danger here in linking baseline back to natural soil quality on Greenfield sites.

When a plant is built in a Greenfield site, the initial survey may be straightforward, but the periodic seven year survey then encounters all the difficulties that older sites have of trying to emulate soil sampling at similar locations and depths. It is likely that many of the original locations will no longer be accessible due to new plant infrastructure, and compromises will need to be made. Such compromises are not compatible with achieving realistic information about incremental pollution.

Finally, it must be recognised that laboratory test methods change and improve over time, and that comparing, for example, a Total Petroleum Hydrocarbons (TPH) analysis undertaken by one method with results from a different form of analysis will lead to methodological differences which may be mistaken for incremental pollution. In Flanders in 2006, analytical methods were changed to use much more aggressive digestion agents, which extracted more of given substances from soils than previous methods achieved. So the same soil sample tested at different times would have shown substantially different results without any actual incremental pollution. Consider this for a 25 year period (typical operational life for an IPPC permit), and the test methods may have varied several times, leading to a number of external factors affecting test data without there being any actual incremental pollution.

So with all these practical difficulties, why do many sites have soil and groundwater investigations conducted, either as part of due diligence or as a precursor to remediation? Such investigations are typically focused on identifying the presence of contamination to determine the risks posed to human health and the environment. As such, they typically focus in on major areas of impact and require a number of phases of investigation and risk assessment to characterise the nature and extent of the pollution and, if necessary, to develop a remedial action plan. Appropriately used, these investigations can provide effective assessment of such gross contamination events but few, if any, of their most enthusiastic proponents would suggest they would provide the basis to determine incremental pollution.

Conclusion

In conclusion, undertaking *groundwater* sampling at IPPC permitted sites is a valid tool for assessing on-going water quality at a site, but is not necessarily a good indicator of incremental pollution, and results should be treated with great care.

By contrast, *soil* sampling is fraught with difficulty in terms of adequate characterisation of areas of ground, and repeat comparisons over long periods of time are almost always going to be technically flawed and scientifically unsound. If soil sampling is held up as a tool to measure incremental pollution across an IPPC site, it will almost certainly fail its first encounter with the law. The cost and operational difficulties will always limit the number of locations which can be sampled, and the resulting data will have high levels of uncertainty, and low levels of confidence.

Recommendations for an alternative approach

An alternative approach to avoiding incremental pollution is to pursue a policy of vigorous Environmental Management Systems, where activities on site are managed carefully, and any spills or leaks are rapidly dealt with and if practical (from an access and operational standpoint), remediated, and the outcome of remediation verified, with verification reports being stored as part of the life history of the site. As well as active management of plant and equipment, automated monitoring systems may be used to check for subsurface leaks. Undertaking remediation as and when areas of site affected become accessible, rather than waiting until the end of life at the plant, and permit surrender may also avoid problems arising with establishment of protected species in abandoned site areas, the presence of which prevents the implementation of remedial works.

The UK Environment Agency has modified their position since the introduction of the IPPC regime in 2000. Their operational experience was that it is very difficult technically to gather a representative "snapshot" of soil conditions at existing installations via soil sampling. Cost is considered prohibitive when compared the environmental benefits. The Agency now encourages investment in pollution prevention measures and monitoring systems.

Case Study A – Chemical Plant subject to closure in 2006.

A substantial chemical plant which manufactured a range of substances including surfactants, sulphuric acid, amines and ethylene oxide in the UK was closed in 2006 after more than 100 years of operation. The site was laid out over an area of about 30 hectares, of which some 11 hectares was covered by the PPC permit, which was issued in 2004. Eleven different distinct areas were identified under the permit.

In the two year period, there were no significant alterations to the plant, and the site spill register indicated a limited number of incidents, all of which had been dealt with at the time.

Ground conditions were very variable across the site, and were established in the 2003 investigation used to form the baseline with the 2004-issued permit. The geology included five different types of filled ground and six different types of natural geology in the top 4 metres of ground. Groundwater was present at depths varying from 1.7m below ground level to much greater depths below the base of boreholes. Levels varied with the seasons.

In order to surrender the site PPC Permit, the facility was required to undertake a survey to compare closure soil and groundwater conditions with those established at permit issue two years previously. 22 boreholes, with 14 having wells, installed were used to form the baseline. Due to limitations on access and service clearance, the boreholes were greatly constrained as to location, and for the 11 zones, the number of holes per zone ranged from none (for example the distribution building) to four (the ethylene oxide plant). Two or three soil samples were typically taken from each borehole from different soil horizons as baseline. Water samples were taken from all wells where water was encountered. It is thought likely that water was perched in many instances, as it varied in level in a fairly unpredictable way.

The closure survey had to take place after demolition of the plant, so it could take account of any spills or leaks which occurred during that process. However, the downside to this was that the demolition process, involving heavy plant and equipment, destroyed the headworks (flush manhole covers) of ten wells, and rendered them useless for water sampling. In addition, two other borehole locations could not be re-established due to changes in the topography of the site. In order to provide data for closure, a further twelve boreholes were drilled, all with new wells.

When it came to water sampling, six old and six new wells were dry, so samples could not be obtained for comparison purposes. It was not an option to take the wells deeper, as it was water at a defined perched level which formed the baseline, and thus required comparison at closure. In the absence of water, soil samples were taken, and leaching tests carried out to look at the soluble fraction of contaminants of concern in the boreholes. However, these were not directly comparable with original water data.

Soil samples were taken at similar depths to baseline, but sometimes found to be of a different nature to baseline samples. This was attributed to the fact that the new borehole locations were surveyed in to be within 1 and 2 metres of old locations, and this lateral distance was enough for strata to change significantly.

With low sample numbers in comparable soils or zones, it was not practical or mathematically correct to apply any form of statistical analysis to the test results, and so each result was compared on a like for like basis. None of the test results showed such a radical difference from baseline that it could categorically be attributed to new pollution. By this, an order of magnitude was taken as being a trigger to consider the result more closely. Results were both higher and lower than baseline, and the variations were not consistent in any one zone. In some boreholes, some substances gave increased values, and others, lower ones, but both substances were known to be associated with the same activity. On this basis, the report concluded that no incremental pollution was evident from the test results.

However, in parallel with the closure investigation, a decommissioning audit was undertaken, and this supplemented the site based EMS which had been run for the duration of the PPC permit. The EMS had developed procedures for registration, inspection and maintenance of secondary containment features, amongst a range of other procedures to assess and prevent product and waste discharges to ground. These gave great support to the conclusions of the closure investigation report, and in practice were given much more weight by the regulator than the soil test results.

Case Study B –Manufacturing Plant subject to closure in 2007.

This site covered an area of about 1 hectare and had been built on a Greenfield site some years prior to closure in 2007. It manufactured products using mercury, zinc and manganese. Due to the relative newness of the plant, and the perceived low potential for raw material losses in this high tech modern plant, the regulator agreed to accept natural background levels of the three metals as baseline condition for the site.

These were:

Substance	**Mean concentration (mg/kg)**
Mercury	0.05
Zinc	128
Manganese	625

With the benefit of hindsight, the baseline criteria should have included:

- For manganese, 220 to 8780 mg/kg and zinc, 49 to 220 mg/kg, these being the full range of likely natural background levels;
- For mercury, a value which is not below the method detection limit for the regulator-accredited test method (in this case, 1.5 mg/kg).

Test results from four boreholes showed topsoil overlying natural glacial till, and a further two holes showed granular fill over glacial till. A total of five samples were tested from control locations away from the process activity, and nine samples were tested from areas of potential impact.

Mercury was not detected at any location, but was reported as being <1.5 mg/kg ie below detection limit, but still potentially up to 30 times the agreed baseline value.

Zinc test results ranged from 75 to 103 mg/kg in areas of potential impact, which was all below the agreed baseline value.

Manganese results ranged from 235 to 960 mg/kg in areas of potential impact, straddling the baseline value for manganese, but falling well within the natural range noted above.

It was concluded that there was no evidence of incremental pollution based on soils data. Groundwater was not present at shallow depth below the site, and was protected by the layer of glacial till, and so not assessed for the purposes of permit surrender.

Case Study C –Manufacturing Plant subject to closure in 2006.

A site in Italy was closing with permit surrender. The site did not have any baseline soils or groundwater data, and it was agreed at closure that the land would be remediated back to a risk-based standard related to its intended new use. This comprised placing a 300mm capping layer over the entire area, but this solution was not viable in one area where nesting birds had established themselves. This created a contradiction between pollution control requirements and conservation interests. This might have been avoided if the site clean up had occurred progressively rather than waiting until closure, by which time, protected species had become established.