Review of environmental radiological monitoring programmes and development of an environmental radiological monitoring guide

Bonetto Juan Pablo[1], Czerniczyniec Mariela, Canoba Analía

Autoridad Regulatoria Nuclear, Gerencia de Apoyo Científico técnico, Av. Del Libertador 8250, C1429BNP, Buenos Aires, Argentina.

[1]Corresponding author e-mail: jbonetto@arn.gob.ar

The environmental radiological monitoring programme is a highly valuable complement for ensuring radiation protection of both the environment and the public. Since its beginnings, the Nuclear Regulatory Authority of Argentina (ARN) has been carrying out full environmental monitoring programs routinely at nuclear fuel cycle facilities within the country. This monitoring is carried out independently of the facilities´ own environmental monitoring. Over the last years the ARN has been reviewing both, the facilities' and its own monitoring programs, so that the operators' environmental performance is most efficiently controlled through the regulator's auditing and verification monitoring. As a result of this, the objectives of the environmental monitoring have been reformulated, new sampling criteria have been established, and both, operator and regulator responsibilities, have been reinforced, in terms of environmental monitoring. As a corollary of all this work, the need for an environmental monitoring guide has been recognized. Therefore, an ARN environmental monitoring regulatory guide is currently under development, in line with the latest ICRP recommendations, which will unify technical criteria for the design of environmental sampling programmes.

The objective of this paper is to summarize the activities previously to the development of an environmental regulatory guide, and to present what we consider is necesary to be included in such a guide.

Environmental monitoring – regulatory guide - sampling

1. Introduction

During normal operation of nuclear facilities, different radioactive substances are produced or handled, that will be discharged in a controlled manner to the environment. These facilities are designed so that discharges are small enough to avoid affecting significantly the environment. Furthermore, there are limits set to the amount of radionuclides that can be discharged, so that environmental impact and public exposure is minimized. These "authorized discharge limits" (Ki) are calculated out of modeling exposure pathways for the different radionuclides as well as their transfer factors within the different pathways compartments. Discharge (source) monitoring is the activity which enables the operator to demonstrate compliance with these limits. Environmental monitoring is complementary to discharge monitoring in order to demonstrate that public exposure has been minimized.

In 1974, as Argentina´s first nuclear power plant (NPP) started its operation, an initial routine environmental monitoring programme was presented and carried out by the Radiation Protection and Safety division [1, 2], a separated Management from that operating the NPP, though both belonging to the National Atomic Energy Comission of Argentina (CNEA). In that programme, environmental monitoring was described as a tool for radiological protection, with the objective of verifying safety norms and ICRP recommendations compliance concerning public exposure, and which would not be properly fulfilled without an accompanying discharge monitoring. Experience with environmental monitoring already dated back to early 60´s measuring of fallout radionuclides [3]. In this same spirit, Radiological environmental monitoring in the surroundings of uranium mining and milling facilities were also being carried out since the early 70´s. Later on, during the 80´s, as private operators were granted the exploitation of some of the uranium mines, environmental monitoring programmes were required from operators, while CNEA continued with their routine monitorings. NPPs, still operated by CNEA, were also required to perform their own environmental monitoring, while the Radiation Protection and Nuclear Safety Division carried on with most of their original monitoring.

By 1994, that former Radiation Protection and Safety Management was used as the basis for a new regulatory entity, independent from CNEA and from the NPPs operators (also separated from CNEA), and by 1997, out of that entity, the Nuclear Regulatory Authority of Argentina (ARN) was created. In the present, a management within ARN is in charge of carrying out an independent radiological environmental monitoring on selected nuclear facilities, analyzing the samples, and evaluating the results. The nuclear facilities carry out their own environmental monitoring, as required by their operational licenses.

Since the first monitoring programmes in the seventies, not only technical aspects such as sampling points and frequencies, analytical techniques, etc., have been modified, but also the operator-regulator relationship, and therefore the scope and even objectives of the monitoring have changed. This was particularly true after the creation of the ARN. However, some of these changes seem not to have been in agreement with the objectives of this type of monitoring, as it is now conceived.

By 2007 a thorough revision of existing monitoring programmes was started. Objectives were reformulated and uniformed sampling criteria were established in order to cater for those objectives, prior to a review of operators' and ARN programmes. As of now, this updating process is quite advanced for some facilities, particularly NPPs, while it is still in its early stages for other facilities. While the process is still ongoing, we have acknowledged the need for ARN to come up with an environmental monitoring guide (normal operation). This guide would not only provide operators with a basis for their planning, but, together with routine documentation, will help to maintain coherent monitoring planning through the following years.

This paper intends to summarize and reflect the lessons learned during this process, and present what we consider should be included in such a guide.

2. Establishing objectives and monitoring criteria

As ARN environmental laboratories are undergoing ISO 17025 accreditation for some techniques, while for others it has already been reached, sampling techniques and procedures are updated to conform accreditation. But a previous step, sampling point and sampling frequency selection also needs to be accounted for. Yearly reports informing environmental monitoring results have been available to the public since ARN creation. Before that, internal reports were also periodically available since monitorings started. However, the criteria used for sampling points and frequency selection were not as easily available. Clearly, such selection of points and frequency should be totally dependent on the objectives of the monitoring. So the objectives needed to be outlined again as a starting point for the whole monitoring program.

The first NPP monitoring plan [1] offered a sensible explanation of its objectives, applicable to any facility. ICRP publication 43 [4] is a fundamental reference to any monitoring design. Very timely came IAEA´s safety guide RS-G-1.8 [5] providing a set of general and specific objectives, and further specifying on the subject.

Out of that reference and other countries experience [6, 7] it was decided that for ARN the objectives of a radiological environmental monitoring program should be:

To check for consistency with discharge monitoring data, thus verifying compliance with dose restrictions

- To check for consistency between environmental and dosimetric models data, thus verifying dose limits of the representative person are not exceeded.
- To determine presence and evolution of radionuclides in the environment in order to evaluate the impact of the facility. Also use data as reference levels in case of accidental emission of radionuclides.
- To detect unadverted radionuclide emissions.
- To provide information for stakeholders.

Any radiological environmental monitoring program should provide the following information: The radionuclides to be monitored, the environmental media to be sampled, the appropriate sampling points, and the frequency of sampling. As mentioned before, criteria needed to be reestablished to provide that information.

All radionuclide listed with an authorized discharge limit (K_i) should be monitored, provided their half-lives allows them to reach the environment. Depending on the fraction of the K_i routinely discharged and on their relevance regarding doses to the representative person, either screening or more specific techniques can be used. Specific techniques will be employed for those radionuclides which are considered indicators. In those facilities which do not have releases, or are no longer in operation, different radionuclide dispersion scenarios were studied so as to define target radionuclide.

The environmental media to be sampled should be that related to direct exposure pathways, such as environmental dose rate, particulate material, aerosols, air tritium (condensed), in atmospheric pathway; and surface and underground water in aquatic path. Also integrating matrices like soil and sediments are essential to follow radionuclide evolution. Finally, several foodstuff samples (milk, vegetables) are needed for representative person dose calculation.

Ideally, the sampling points for an operational monitoring would be the same used in the pre-operational monitoring. However, those pre-operational monitoring or environmental impact assessments required of older facilities were not designed to appropriately meet the objectives and criteria currently set. At least three sampling points should be otherwise included in the monitoring plan: *i)* An upwind or upstream point which is not influenced by the facility discharges, but where environmental matrices of interest are similar to those of the monitored site, called *background point*; *ii)* A sampling point placed were the highest concentration of the target radionuclide is expected, which is called *maximum point*; and *iii)* A point placed were the representative person, whether hypothetic or real, is located. While the representative person sampling point results should allow dose calculations verification, the use of the maximum point results would be used for trends calculation and also for comparison against background points in impact evaluation.

It is important to stress that more sampling points can be added according to stakeholders information needs, for example, schools, water pumps, etc.

The PC-Cream program is currently being used to adjust sampling points associated to atmospheric discharges [8], while a generic IAEA model is used to determine complete mixing in rivers [9].

Regarding sampling frequencies, higher ones are expected to be applied for environmental media directly related to the effluents: surface water and air. Ideally, continuous water sampling devices are to be deployed in the receiving water courses or lakes. Also permanent sampling stations, located according to the above–mentioned criteria for sampling point location, should be deployed for continuous air sampling. Low sampling frequencies, on the other hand, are adequate for integrating matrices such as sediments and soils. Frequency of analysis should depend on the relevance of the radionuclide, and of course, on its half-life. The use of temporal composite samples can be very appropriate for less relevant radionuclides in terms of dose, and for media sampled for dose calculation purposes (foodstuff).

Analytical methodology should be focused on screening methods, as available, for easy and quick obtention of results for comparison against dose, restrictions or any derived limits. Detection limits (DL) of at least one order of magnitude below reference limits are acceptable.

However, for radionuclides of specific importance due to their dose contribution or their use as indicators (for example, Tritium, Uranium), it is preferable to use specific techniques with as low DLs as possible. This will allow for better statistical evaluation of results.

These criteria for the monitoring design are in good agreement with current recommendations [10]

Once the criteria were thus established, monitoring plans were outlined for all facilities, and means were provided to update ARN monitoring. At the same time, the facilities´ own currently approved monitoring plans were measured up to these objectives and criteria, and the conclusions were discussed with those responsible for the monitoring plan design.

3. Need for a radiological environmental monitoring guide

As described before, prior to the revision of monitoring plans, both operators and regulators carried out separate monitoring plans on their own. During meetings with the operators, not only the criteria for sampling were discussed, but a new approach to the roles of operator and regulator in relation to environmental monitoring came out, following IAEA guidelines [5]

Basically, the operator has the responsibility for designing and carrying out an environmental radiological monitoring plan for each period of a facility´s life (pre-operational, operational, and closure), appropriate to the objectives of such a plan. The operator will report the results to the regulator and also report any significant variation that may suggest an unpredicted negative impact due to the operation. It should also perform periodical population surveys and keep updated information on population location, feeding habits, etc.

On the other hand, ARN is responsible for reviewing and eventually authorizing the monitoring plans, and for the verification of the results provided by the operator. This verification is considered now as a process including not only the review of the reports with the data received form the operators, but also the review and approval of the sampling and analytical methodology proposed, with intercomparison exercises where applicable. Of course an independent monitoring capability should be maintained, but oriented towards the verification of the operators sampling, with less emphasis on sampling frequency.

At this point, for a better organization and transmission of these concepts to the operators, it was concluded that the ARN needed to produce an environmental radiological monitoring guide. This guide would also help harmonize the different ideas that what is now the ARN has had since the beginning, regarding environmental monitoring.

This guide would contain not only the objectives, criteria for monitoring plan design and responsibilities previously described, but would also include guidance on how to present the data: Include uncertainties where positive values (above DLs) are obtained, include DL values when nondetects (below DLs) are obtained, include supporting information such as sampling and analysis date, type of sample (grab or composite), etc.

A correct evaluation of the data is vital for an adequate monitoring, therefore the guide should provide information on this issue: Results should be compared first to local and international reference values, where available. Comparisons with derived environmental limits should also be made. To assess the impact of the facility´s operation, the data should be checked against preoperational values. Where not available, at least a comparison against background values should be made. Trend tests are also required to analyze the evolution of radionuclides in environmental media.

It is worth mentioning that data evaluation will be required from operators, but will also be performed by the ARN out of the results obtained from operators monitoring after regulators verification.

4. Conclusions

Based on a vast experience in radiological environmental monitoring in Argentina, it was recognized that a review of monitoring plans objectives and design criteria was needed.

For a more effective implementation of changes in monitoring plans derived from this review, a radiological environmental monitoring guide was called for.

This guide should define the objectives of the monitoring, the operator and regulator roles (in relation to environmental monitoring), the criteria for monitoring design, comunication of results and data evaluation, among the most relevant items.

5. References

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