NORM: EU Directive Implications beyond EU Borders

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Abstract. The lecture provides general overview of the management of Naturally Occurring Radioactive Materials (NORM) that is required in accordance with the Council Directive 2013/59/EURATOM of 5 December 2013.
Following a brief introduction to the issue of NORM, particular attention is drawn to the implications of the adoption of the document beyond the borders of the European Union:

- The potential problems associated with trade in commodities containing NORM, their transport and entry into the EU through the international borders; and
- The implication of the adoption of the principles and limiting values listed in the Directive in countries outside the EU.

The examples of the following instances are provided –

- Verbatim adoption of the limiting values in developing countries and associated implications for the management of the overall health of the population and the state of the environment in these countries; and
- Advice provided in the past by some EU experts to developing countries, mostly through community organisations, with limited understanding of the local culture, on the basis of incomplete (or incorrect) data and without consideration of long-term implications of the information and advice provided.

1. DEFINITIONS

Many different definitions are used to describe 'Naturally Occurring Radioactive Material', NORM. The 'natural source' is defined in both 1996 [1] and 2013 [2] EURATOM Directives, but not 'NORM'.

The Safety Glossary of the International Atomic Energy Agency (IAEA) [3] defines NORM as –
Radioactive material containing no significant amounts of radionuclides other than naturally occurring radionuclides
To which we can add:
Material designated in national law or by a regulatory body as being subject to regulatory control because of its radioactivity.

Effectively, almost everything is "NORM" and a qualifier above is definitely needed. For the material to come within the scope of regulations it has to be disturbed or altered from natural settings, or contain technologically enhanced concentrations of natural radionuclides due to human activities; which may result in an increase in relatively significant radiation exposures and risks to the public above background radiation levels [4].

2. INTRODUCTION

Article 23 of the 2013 Directive [2], on NORM, states –
Member States shall ensure the identification of classes or types of practice involving naturally–occurring radioactive material and leading to exposure of workers or members of the public, which cannot be disregarded from a radiation protection point of view. Such identification shall be carried out by appropriate means taking into account industrial sectors listed in Annex VI.

What we need to consider is that several such lists exist and, whilst they are generally similar, there are some important differences. Let us compare the lists of industries of interest from the 2013 EC Directive [2], International Atomic Energy Agency (IAEA) [5], and Australian Radiation Protection and Nuclear Safety Agency (ARPANSA) [6], in Tables 1 and 2.

Table 1: Similarities in the lists of industries

Industry	EU [2]	IAEA [5]	Australia [6]
Thorium compounds and products	X	X	X
Niobium	X	X	X
Oil and gas production	X	X	X
Titanium pigment	X	X	X
Thermal phosphorus	X	X	X
Phosphate fertilisers	X	X	X
Phosphoric acid production	X	X	X
Zircon and zirconia	X	X	X
Coal fired power plants	X	X	X
Iron and steel	X	X	X
Tin, lead, copper	X	X	X
Mining ores other than U	X	X	X

Table 2: Differences in the lists of industries

Industry	EU [2]	IAEA [5]	Australia [6]
Rare earths	From monazite only	From all minerals	From all minerals
Tantalum	X	-	X
Geothermal energy	X	-	X
Cement, clinker ovens	X	-	-
Water treatment	Only ground water	All water	All water
Aluminium	-	X	X
Zinc, lead	-	X	-
Mineral sands	-(1)	-	X
Scrap metal recycling	-	-	X
Tunnelling	-	-	X
Building industry	X(2)	-	X
Missing from all three lists			
Paper and pulp production(3)	-	-	-
Hydraulic fracturing(4)	-	-	-

Notes:
(1) Mining and processing of heavy mineral sands occurs in Norway and Ukraine.
(2) Building industry is listed separately, in Annexes 8 and 13 of the 2013 EC Directive [2].
(3) The pulp and paper industry in Europe accounts for approximately a quarter of an overall world production and is a major employer [7]; it is not known if any investigation of NORM-associated issues were carried out in the EU.
(4) It is not clear if hydraulic fracturing would be included into 'oil and gas production' listed in Table 1.

3. WHAT IS IN THE SCOPE OF REGULATIONS

Prior to 2013 there were significant differences between the levels applicable in the EU and those used internationally, and a detailed discussion was provided in the Comparative study of EC and IAEA guidance on exemption and clearance levels, in 2010 [8]. Two documents were compared – IAEA Safety Guide on the Application of the concepts of exclusion, exemption and clearance [9] and EU Guidance on the practical use of the concepts of clearance and exemption [10].

It has been shown that –
…the overall correspondence of both sets of values is poor. The ratios span a large range between 0.01 and 100, with many nuclides being two orders of magnitude less restrictive in RS-G-1.7 than in RP 122 part I, including the important nuclide Pa-231 and many other radiologically important nuclides.
The illustration is given in Table 3, reproduced from page 10 of EU RP-157 [8].

Table 3: List of radionuclides of natural origin grouped according to the ratios of values between IAEA RS-G-1.7 [9] and EU RP-122 Part I [10]

Ratio up to…	Nuclides
0.01	Th-231
0.1	Bi-210, Th-234
1	Ra-223, Ra-224, Th-227, U-234, U-235, U-238
10	K-40, Th-228, Th-230
100	Pb-210, Po-210, Ra-226, Ra-228, Ac-227, Th-232, Pa-231

It should be noted that the differences above no longer exist; the values in the 2013 Directive [2] are the same as in the IAEA Basic Safety Standards [11]. Table A Part 2 of the Annex VII of the 2013 Directive [2] and Table I.3 of the IAEA BSS [11] give the same values for exemption or clearance for naturally occurring radionuclides in secular equilibrium with their progeny:

- Each radionuclide in the uranium decay chain or the thorium decay chain – 1 Bq/g
- Potassium-40 – 10 Bq/g

Or course, it does not mean that the full scope of regulations needs to apply as soon as these concentrations are exceeded, the graded approach should be used:
IAEA BSS [11], paragraph 2.18: *The government shall ensure that a graded approach is taken to the regulatory control of radiation exposure, so that the application of regulatory requirements is commensurate with the radiation risks associated with the exposure situation.*
Article 24.1 of 2013 EU Directive [2]: *Member States shall require practices to be subject to regulatory control for the purpose of radiation protection, by way of notification, authorisation and appropriate inspections, commensurate with the magnitude and likelihood of exposures resulting from the practice, and commensurate with the impact that regulatory control may have in reducing such exposures or improving radiological safety.*

4. NORM – NOT WELL-KNOWN ISSUES AND PROBLEMS

4.1. Relatively high levels of radiation exposure

Typically, NORM is not associated with levels of radiation exposure that may result in a worker approaching even 25% of the annual exposure limit. However, this is not always the case, as illustrated by the following exposure situations – all three observed personally by the author.

4.1.1. Thorium-containing mineral monazite

A rare earth phosphate mineral, monazite, is a typical component of heavy mineral sands deposits around the world and contains around 7% of thorium. It may be present in enhanced concentrations in a deposit itself, or may be concentrated during separation of different minerals.
The gamma dose rates in order of 140 – 180 μSv/hour are not uncommon, thus a worker may reach an annual limit of 20 mSv/year in approximately two weeks, not even accounting for the exposure due to the inhalation of dust and radon/thoron progeny.

4.1.2. Abandoned 'legacy' sites

There are many so-called 'legacy' sites around the world, where the mining/processing operations were simply abandoned without any remediation. Most of them are associated with uranium mining and production, but there is also a significant number related to NORM in general.
For example, at one of the legacy sites in Ukraine (abandoned thorium and uranium production), gamma dose rates may reach 1,300 μSv/hour; therefore a worker may reach an annual limit of 20 mSv/year in only two days, only from gamma radiation. Additional information about this site has been presented at the NORM-VIII Symposium in 2016 [12].

4.1.3. Build-up of radon in enclosed environments

A significant amount of minerals and concentrates are transported around the world inside sea containers and in bulk, in hermetically sealed hulls of bulk carriers.
It is not a well-known fact that in these situations concentrations of radon emanating from the material containing only 1 – 1.5 Bq/g of uranium may reach 8,000 or more Bq/m^3, within approximately 48 hours. Therefore, the workers opening sea containers or unloading bulk mineral shipments may reach an annual limit of 20 mSv/year within 4-5 weeks.

4.2. Additional health, safety and environmental hazards

Additional, and very serious, health and safety hazards are very often observed in situations where NORM is present. As a rule, these hazards are much more severe than any presented by potential radiation exposures and must be addressed first. The examples, also personally observed by the author, include:

- Nests of feral bees in a rusted drum with NORM in Australia (approximately 20 bites are likely to result in a fatality),
- Abandoned NORM waste mixed with chemicals, asbestos and mercury in Asia (representing an immediate health hazard),
- Wall cracks in underground mines in Europe, Australia and Africa (possibly resulting in multiple fatalities),
- Significant problems with acid mine drainage in Africa, Asia and Australia (resulting in major environmental problems).

4.3. Detection of radioactivity at EU borders

Even if a material is exempt from the transport safety regulations and the associated signposting, the concentrations of radionuclides may cause elevated gamma radiation levels outside the packages (e.g. sea containers). The equipment that is used at border crossings and in ports worldwide easily detects these levels.

The complexity of regulations dealing with transport of potentially radioactive materials and very small differences that may or may not qualify NORM for exemption are typically hard to understand – even for a regulator. A full understanding of the regulations can hardly be expected from a customs official, normally dealing with many other (and very different) matters on a day-to-day basis.

Therefore, the transport documentation for NORM needs to contain detailed information about the concentrations of naturally occurring radionuclides in this material, irrespective of the applicability of transport regulations. All necessary information, such as gamma spectrum for the material, may be provided in the document that is accompanying every shipment – Material Safety Data Sheet (MSDS). Whilst not absolutely necessary, this information would assist in the process of clearing a particular NORM through the radiation detection equipment at international border crossings.

5. POTENTIAL ADOPTION OF THE 2013 DIRECTIVE INTO THE REGULATION OF A NON-EU COUNTRY

5.1. Potential issue

It is quite possible that the text of the EU 2013 Directive [2] (or some parts of it) will be adopted into the regulations in some developing countries, especially in Africa, for the following reasons:

- Regulators in the francophone countries tend to rely more on the documents from the EU, which are immediately available in French, and not on the IAEA ones;
- As a rule, only Safety Standards of the IAEA are translated into six official UN languages;
- The IAEA documents are not translated into the languages such as Portuguese.

There are two paragraphs that specify the limits of radiation exposure:

1. Article 7.2 discussing reference levels and referring the user to an annex.
2. Article 12.2 telling the user exactly what the limit should be.

It is, therefore, very likely that the Article 12.2 will be used – as it gives clear and exact instructions. The Article 7.2 is likely to be ignored, as the concept of reference levels is typically not well understood, and the Article 12.2 seems to over-write what Annex I may be suggesting, in any case.

Article 7.2: *The choices of reference levels shall take into account both radiological protection requirements and societal criteria. For public exposure the establishment of reference levels shall take into account the range of reference levels set out in Annex I.*
Annex I: *Without prejudice to reference levels set for equivalent doses, reference levels expressed in effective doses shall be set in the range of 1 to 20 mSv per year for existing exposure situations.*

However, irrelevant of what Article 7.2 and Annex I say, Article 12.2 provides clear instruction:
Member States shall set the limit on the effective dose for public exposure at 1 mSv in a year.

Even if there is a discussion in a country about planned or existing exposure situations – in each and every case (except, possibly, abandoned 'legacy' sites), the same 1 mSv/year will still apply.
Article 100.3 on existing exposure states –
Existing exposure situations which are of concern from a radiation protection point of view and for which legal responsibility can be assigned shall be subject to the relevant requirements for planned exposure situations and accordingly such exposure situations shall be required to be notified as specified in Article 25(2).
It should be noted that §3.4 of the IAEA 2014 BSS contains similar requirements.

The main problem with the adoption of 2013 Directive in non-EU countries is associated with so-called "precautionary principle", which usually interpreted in a way that in dealing with potentially hazardous technologies the benefit of the doubt must go to the public and not to technologies. The combination of this principle with the uncertainty about health effects of low level ionising radiation means that a theoretical possibility "a small dose may cause harm" is transformed into an axiom "a small dose most definitely will cause harm".

The implementation (basically, copying) of Article 12.2 of 2013 EU Directive into the regulations in developing countries could (and most likely will) lead to the diversion of limited funds from other more important health problems of the population as a whole.

It should be noted that over-regulation typically results in huge costs, despite the fact Linear-No-Threshold dose response model still being just a hypothesis, not a conclusively proven fact.
Each human life hypothetically saved by implementing the US Nuclear Regulatory Commission's regulations costs about $2.5 billion. Such costs are absurd and immoral when compared to the costs of saving lives by immunisation against measles, diphtheria and pertussis, which in developing countries range between $50 and $99 per one life saved. [13]

Of course, radiation is not the only low-level risk that is over-regulated. There appears to be an obsession with regulating low risks and an overall blindness to the diseases that are often fatal (measles, malaria and tuberculosis), and to other dangers that kill tens of thousands of people every year, such as prescription opioids and alcohol.
Developing and applying regulations intended to reduce risk from minor or hypothetical hazards (such as low-level radiation):

- Gives elected officials an opportunity to say "we are here to protect you";
- Provides support for the scientific research that may not be needed, and for the government departments that, in some cases, have much more staff that is necessary; and
- Appeases BANANA's – people of the following opinion: "Build Absolutely Nothing Anywhere Near Anything" [14].

5.2. An argument and a possible solution

J-F Lecomte from ICRP said at NORM-VIII symposium in 2016 –
NORM are existing exposure situations, because the source is not deliberately introduced, it already exists when a decision on control is taken; concentration and dissemination of radionuclides are incidental. ...some control is needed and should be provided; the level of protection should be commensurate with the risk [15].

This may not be entirely correct. If the decision is made to open a new mine, bring up the ore that is rich in uranium and thorium and process it, concentrating radionuclides significantly in the process – the source appears to be deliberately (although incidentally) introduced. Each and every new operation dealing with NORM appears to deliberately introduce the source – we could interpret this in a way that this "introduction" is associated with the regulations. The source may have existed at 0.1 Bq/g of thorium in the ground, but if after processing the concentrations of thorium reach 100 Bq/g – the regulation of the material becomes necessary.

Linking the planned exposure situation with the possible use of material for its radioactive properties appears to be a re-introduction of the concept that was present in the transport safety regulations prior to 2012, where the exemption was given or not given to the same copper concentrate depending on where it was transported – to a copper smelter or to uranium processing plant... Which was a cause of a continuous confusion, both for the industry and for the regulators.

Following a similar logic it could be argued that nuclear fuel is also NORM, as both ^{238}U and ^{235}U already existed – just the ratio has changed during enrichment… Yes, ^{235}U may have been introduced for its radioactive properties, but ^{238}U in depleted uranium – wasn't.

- So – is depleted uranium a NORM residue/waste then?

Let us consider an example where a new operation is proposing to process copper ore containing uranium and due to some objective conditions (economic, political, etc) the ore with relatively high concentrations of uranium is "put aside for the future":

- At the commencement the operation would be an existing exposure situation.
- However, when in several years uranium processing circuit is constructed and uranium concentrate is produced – the situation will become 'planned'. Or will it be "partially planned'...?
- A single worker operating half of the shift in copper flotation circuit and another half – in uranium extraction circuit will be in two exposure situations at the same time.

It is obvious that the situation will be absurd, as different radiation protection approaches and limits may need to be applied to the same worker at the same time.

Another ridiculous example would be a situation of two ^{226}Ra atoms floating in a river side by side, one being from a farmer's field (due to fertiliser use), another one – from a 'nuclear' facility. Then:

- The one from the farmer's field would be "harmless" (NORM, existing exposure situation), but –
- Another one (whilst exactly the same) acquires some magic powers and must be managed properly (nuclear, source is deliberately introduced, planned exposure situation).

A possible solution may be similar to the three "exposure bands" for workers:

- Less than 1 mSv/y
- From 1 mSv/y to a few mSv/y
- From a few mSv/y to 20 mSv/y

Or similar to the ICRP approach to the reference levels for the exposure to radon in workplaces, described by JF Lecomte at the NORM-VII Symposium in 2013 [16], that is based on the reference level of 10 mSv/year.

Could a recommendation be made on the application of the reference levels to the industries dealing with NORM?

A typical operator would always be of the opinion of "just give me the number that I should not exceed". The "practice – intervention" concept was not well understood, and the introduction of variable reference levels will, undoubtedly, result in a confusion for many regulators, who would simply use "the lowest denominator" of 1 mSv/year…

6. VERBATIM ADOPTION OF LIMITING VALUES

A verbatim adoption of the limiting values in developing countries may lead to the implications for the overall health of the population and for the state of the environment in these countries, due to potential over-regulation in a situation where resources are very limited.
The adoption of limiting values from the EU or from similar regulations in developing countries is a well-known fact and two examples can be given, without specifying the countries themselves. Both of the examples are associated with gross alpha activity concentrations in the drinking water. It should be noted that these examples are from the countries where much more serious health problems exist.

6.1. Adopting the US EPA limit after its fifteen-fold reduction

US EPA limit for gross alpha concentration in the drinking water in the document that was used in the development of "water quality regulations" was 15 pCi/L (0.555 Bq/L) [17]. In one of the African countries this limit was reduced fifteen times, to 1 pCi/L (0.037 Bq/L) and is legally applicable – despite the fact that there appears to be no laboratory in this country that could possibly measure gross alpha activity to such low levels. It seems that the values for Ra-226 and Ra-228 from the table describing minimum detection limits in the same document [17] were confused with limiting values.

6.2. Adopting the EU limit instead of WHO one

Guidelines for Drinking-water Quality of the World Health Organisation [18] state –
Screening levels for drinking-water below which no further action is required are 0.5 Bq/litre for gross alpha activity and 1 Bq/litre for gross beta activity. …The screening level for gross alpha activity is 0.5 Bq/litre (instead of the former 0.1 Bq/litre).
However, draft regulations in one of the countries in West Africa, to be adopted in 2018 say –
Le seuil de contrôle recommandé pour l'activité alpha globale est de 0,1 Bq/l. Le seuil de contrôle recommandé pour l'activité bêta globale est de 1,0 Bq/l.
The text was copied directly from Annex III of another 2013 EC Directive: 2013/51/Euratom of 22 October 2013, on radioactivity in drinking water [19].

7. ADVICE BY EU EXPERTS TO DEVELOPING COUNTRIES

Unfortunately, an advice provided by some EU experts to developing countries was, in some cases, not entirely correct. The work was often carried out with limited understanding of the local culture, on the basis of incomplete (or incorrect) data and without consideration of long-term implications of the information and advice provided. The local regulatory authorities were, in many cases, not even aware of the fact that EU experts were present in the country and it was a big disappointment for them to discover that reports about their countries have been published without their knowledge.

7.1. Namibia

The Environmental Justice Organisations, Liabilities and Trade (EJOLT) is a project that was supported by the European Commission in 2011-2015. The project was to "support the work of Environmental Justice Organisations, uniting scientists, activist organisations, think-tanks, policy-makers from the fields of environmental law, environmental health, political ecology, ecological economics, to talk about issues related to Ecological Distribution".

Two EJOLT reports were published in 2014: *Radiological Impact of Rössing Rio Tinto Uranium Mine* [20] and *Study on low-level radiation of Rio Tinto's Rössing Uranium mine workers* [21].

Unfortunately, the researchers forgot altogether to consult with the National Radiation Protection Authority of Namibia and even to tell them about the project.
The possible effects of radiation were significantly over-exaggerated; for example, one of the reports stated that –
In the case of the Rössing parking, spending 5 minutes per day during 200 working days gives an additional exposure in excess of 10 microSieverts. This is considered a "significant exposure" [20].
Of course, 10 microSieverts per year cannot possibly apply to the exposures from NORM due to the variability of natural background. Furthermore, the radiation levels at this parking spot, which the author surveyed personally, appear to be simply an elevated natural background in the area – which one would expect in the vicinity of a uranium ore body…

7.2. Zambia

Another example is the radiation protection report funded by Norwegian Church Aid [22], prepared by experts who appear to be opposed to uranium mining anywhere in the world. The copy was obtained by the author during the visit to the Council of Churches in Zambia, and neither National Institute for Scientific and Industrial Research nor Environmental Management Agency of Zambia were aware of a visit to the country and of the contents of this report. It is understood that a significant number of people lost their jobs as a direct or indirect result of the publication of this document.

7.3. Gabon

The third illustration of the problem is the EU report on the potential use of contaminated materials in the construction of residential homes in Gabon and Niger [23]. The European Parliament's Committee on Development requested this study to be undertaken.
The appropriate regulatory authority in Gabon was not contacted (and thus was not aware of the existence of the document), and the authors of the study did not even take any radiation monitoring equipment for the visit to Gabon, therefore no conclusions of the report could be verified. For Niger only a desktop study was conducted.
In addition, photographs presented in the document illustrated that there were still remnants of the old processing plant present at some location on the site.
But during the extensive audit undertaken by the author in 2011 including visits to all accessible areas of the site and during the numerous discussions with the site personnel and with the members of the public it was concluded that these photographs are likely to have been taken 7-8 years before the report was published, when the remediation of the site was still in progress…

7.4. European Committee on Radiation Risk (ECRR)

ECRR is an *informal* committee formed in 1997 following a meeting by the European Green Party at the European Parliament to review the 96/29/EURATOM Directive [1].
However –
Relatively often EU experts and local environmental organisations in Africa and Asia present ECRR documents [24, 25] as the last and definitive word of European Community on the issue of radiation protection.
This approach results in severe anxiety of local population, as both the local appropriate authorities and the companies seeking to establish a mining/processing operation are seen as providing incorrect information – despite the fact that this information is based on the latest ICRP and IAEA publications.

8. ANOTHER POTENTIAL IMPLICATION – "OUTSOURCING" THE INDUSTRY

As limiting values, both for the concentrations of radionuclides and for the radiation exposure, seem to continue to decrease – more and more companies make an effort to relocate their operations out of developed countries. The costs are, of course, a significant factor – but a regulatory burden that industries face is as significant as costs, and sometimes it is even more important.

When some industry is faced with excessive regulations – of course the preferred option is to close the plant in the country where this happens and open it in another country, where regulatory regime is not that stringent. The problem is not with the regulations themselves, as the IAEA Basic Safety Standards are accepted worldwide, – it is with their application.

Unfortunately, in a developed country it is not uncommon to hear an argument based on "an interpretation of an appendix of a guideline for a procedure that describes a regulation relevant to a section of an Act".
It would be much more practical to set performance standards for the industry in the form of radiation exposure or 'release' limits and then leave it to the industry to develop systems to meet these standards in its specific circumstances. As it was correctly pointed out about 35 years ago –
When a regulatory agency gets into writing detailed and compulsory specifications on how to meet the performance standards, there is a danger that the system of radiation protection will degenerate into a continuing effort to comply with ever more complicated regulations, procedures and guidelines – completely losing sight of the basic goal of safe operation. [26].

The long-term consequences of 'outsourcing' the industry are currently not known, but one example can be provided:
For each and every wind turbine erected in the EU about 300-400 tonnes of radioactive ore needs to be mined, crushed, leached and processed to get enough material for one neodymium magnet. Generating in the process approximately 200-250 tonnes of radioactive waste. A typical mobile phone would need about 3 kilograms of radioactive ore for the vibrating magnet, speaker, screen… Which results in serious pollution of the environment and, possibly, in some health effects for the local population – but not in the EU…
It should be noted that the issue with rare earth supply appears to be understood in the EU and different options (both recycling and mining/processing) are being discussed [27].

9. CONCLUSIONS AND QUESTIONS FOR CONSIDERATION

9.1. Health

There are areas of high natural radiation background in Africa and Asia, where annual exposure of the public may reach 7-8 mSv/year. But –

- How many African and Asian children will not have malaria or other badly needed vaccinations because the health budget would be re-directed to keep everyone under 1 mSv/year?

9.2. Environment

Having a predominantly service economy, importing everything may not be as good as some people think… As the former Australian Liberal Party Leader J. Hewson said in 2015:
With an economy that is 68 per cent services, the entire country is basically sitting around serving each other cups of coffee… [28] Thus –

- What are the world-wide and, subsequently, EU local health and environmental implications of production of nice, clean and green products for the EU elsewhere, where the controls over radiation are either at a low level or may not exist at all?

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