Optimisation in the management and disposal of NORM wastes – experiences from the EAN_{NORM} project

K. Flesch[1], R. Gellermann[2], H. Schulz[1], E. Ettenhuber[3]
[1] IAF - Radioökologie GmbH, Dresden (Germany)
[2] HGN Hydrogeologie GmbH, Braunschweig (Germany)
[3] Berlin (Germany)

Abstract

Radiation protection in the field of NORM is generally focused on the industry processing rough materials (NORM industry). However, residues arising from the NORM industry or from other industrial processes are quantitatively the major part of NORM. These waste materials are reused or have to be disposed of. Therefore, the disposal of NORM waste is an important issue considering radiation protection in the field of NORM. The basic principles of radiation protection, e.g. the ALARA principle have to be applied to both workers on a landfill or on another waste management area and persons living in the surrounding of the landfill or management area. This requires information on the radioactivity of the relevant waste to be disposed and assessments of the radiological consequences. The problems to be solved and practical experience gained in disposal of NORM waste are discussed in this paper.

1 Introduction

Until now, radiation protection in the field of NORM is generally focused on the NORM industries. The term NORM industry is commonly used for such industries where materials with enhanced contents of naturally occurring radionuclides (NORM) are handled or materials with technologically enhanced contents of naturally occurring radionuclides (TENORM) are generated. However, residues of the NORM industry or other industrial processes must also be included into the consideration of radiation protection. These residues are quantitatively the major part of NORM and they accrue frequently in huge amounts with relatively low activity concentrations (compared with radioactive substances otherwise used). They arise from several industrial processes containing significantly enhanced concentrations of naturally occurring radionuclides in raw materials (e.g. phosphates, bauxite, etc) but also from processes containing none primarily enhanced radioactivity (e.g. filter dust blast furnace processes).

The residues of NORM industries are recycled/reused or they have to be disposed of. The presence of natural radiation sources can lead to a significant increase in the exposure of workers or members of the public. Therefore these processes cannot be disregarded from the radiation protection point of view.

Some examples for NORM residues are [1]:

- Scales, residues, sludge and wastewater of mineral oil exploration, gas purification and carbon pyrolysis.
- Mining residues
- Contaminations on ferrous scraps and non-ferrous scrap.
- Materials arising from chemical and mechanical surface processing of ferrous scraps and non-ferrous scrap
- Residues, sludge and waste water of ore exploration, e.g. Al, Nb, Ta, Cu, Sn, Zn, REE, Ba …
- Scales, powders, dusts of thermal processes.
- Waste of the phosphate production in particular gypsum.

Amongst others the EAN_{NORM} project shall give a review on the current situation of radiation protection in the NORM industries in the European countries by means of questionnaires. The first results

have been reported on the workshop "European ALARA Network for NORM" held in Dresden [2]. The evaluation of the responds shows that the NORM community perceives the management of NORM waste as a discrete field of action (Fig. 1). The consequences of this fact for the radiation protection practice with special regard to optimisation will be discussed in the following.

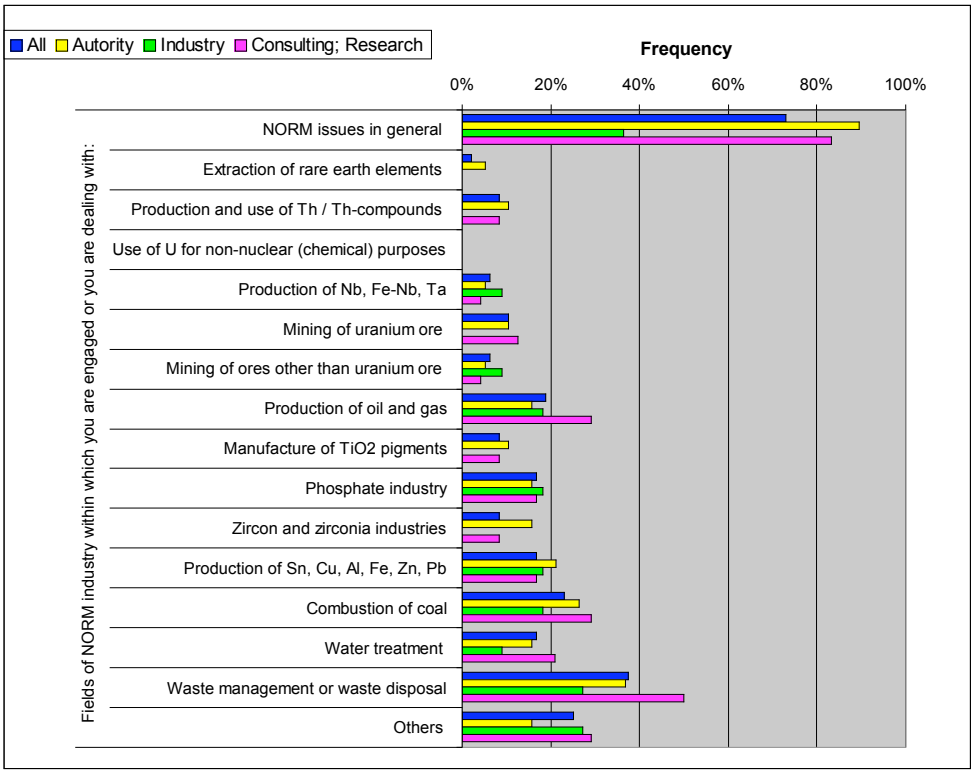


Fig. 1: Results of a questionnaire review indicating the NORM industries in which respondents are engaged [2]. Waste management or waste disposal is the most frequently named field of action (with exception of "NORM issues in general"). (from [2])

2 Classification of NORM wastes

The radiation protection control of work activities (radiation protection in the NORM industries is included) regulated in the Articles of Title VII of the EU Directive 96/29 is established in the European countries in a different manner. In several countries the materials to be included in the institutional control of radiation protection are specified in the regulations on NORM ("Positive List"). Other countries did not specify the materials of concern. They use more general approaches to decide on the inclusion of materials or processes into the control, e.g. dose assessments or exemption levels. However, the exemption levels are inconsistent in the countries applying this approach, in fact there are different national systems of classification.

The European waste regulations [3] and the national waste laws do not include the radioactive wastes. Such wastes remain under the radiation protection control until the radioactivity is decreased below the clearance levels due to the decay or they have to be disposed in a final repository for radioactive waste. The generally used dose criterion for the release of such radioactive substances from control is the de-minimis dose of 0,01 mSv per year.

Residues arising from work activities, e.g. NORM waste are radioactive substances being under radiation protection control. Therefore they cannot be categorized as commercial (non-radioactive) waste unless both the radiation protection safety and the environmental safety have been proven. A material of concern can be disposed as commercial waste if, taking into account the circumstances and modalities of the disposal, the radioactivity can be disregarded from the radiological point of view and the

waste can be released from the radiation protection control. Unlike the radioactive substances arising from practices, NORM waste can be lose its radioactive status if the radiation exposure of persons due to the chosen type of disposal is below 1 mSv per year. If this requirement is fulfilled the competent authority can release the NORM waste from the radiation protection control and the material becomes a commercial waste.

Such waste has to be classified according to the European Waste Catalogue [3]. This catalogue contains twenty main groups, most of them are industry-based but some groups are based on materials and processes. Some wastes in this Catalogue, which are related to NORM industries, are resumed in Table 1.

Table 1: Classification of wastes according to the European Waste Catalogue

01	mining: 010101, 010102
05	mineral oil exploration, gas purification and carbon pyrolysis 0501 Refining of mineral oil 0506 carbon pyrolysis 0507 gas purification and gas shipping
10	thermal processes, i.e. 1001 to 1013
11	chemical surface processing, i.e. 1101, 1102, 1105
12	mechanical surface processing, i.e. 1201, 1203
13	mineral oils and fuels,
16	other waste streams
17	demolition waste
19	waste water treatment

In some cases, NORM wastes can have significantly enhanced concentrations of radionuclides (up to more than 100 Bq/g). Nevertheless these materials should not be classified as radioactive wastes in the above-mentioned sense without a careful examination. However, if the authority decides to dispose such materials on a landfill together with other commercial waste, the recipient (the operating company of the landfill) should be informed about the special characteristics of the material, particularly with regard to the content of radionuclides. This information can be supported by a special term (e.g. "wastes with radioactivity"). If such term contributes to misunderstandings, the EAN_{NORM} platform with its "forum" could provide a suitable basis for such discussion.

3 Development of a strategy for disposal of NORM waste

In developing an optimised strategy for NORM waste handling the authorities have to carefully consider firstly the possibilities of reuse or recycling of a material, which is mostly, prescribed in the waste management laws of the European countries. Reuse or recycling should have always priority against disposal. However, in many cases a reuse or recycling cannot be considered not least because of the radioactivity of the materials or the radiation exposure arising from the use of the recycled materials, e.g. exposure of individuals to building materials produced from residues. Then an optimised strategy for the waste disposal is necessary. In deciding on the disposal of NORM residues as commercial waste several exposure scenarios have to be considered: persons working on the disposal area and living in the surrounding of the disposal area. Both groups should be considered as members of the public and the annual effective dose limit of 1 mSv should be kept for both. The problem to estimate the exposures arises from the scenarios to be considered.

If we consider the generation of NORM waste as a "source" and the deposition or the recycling or the reuse of the waste as a "sink", than we can identify some general scenarios:

Case 1: One source – no sink: complete reuse of the material in the process from which the material arises. Example: recycling/re-use of sinter dust in the hot metal production.

Case 2: One source – one sink: huge amounts of material (i.e. residues from mining, metallurgy) which are disposed on a mono-landfill or a dump. Typical examples: dumping residues of phosphate processing, red sludge from bauxite treatment, mining residues etc.

Case 3: One source – several sinks: use of NORM waste as a raw material in other industrial processes or as building material (e.g. for road construction)

Case 4: Many sources – one sink: disposal of waste from several NORM industries at landfills or in an underground waste deposit.

Case 5: Many sources –several sinks: combination of the scenario Nr. 3 + 4.

Table 2: Exposure scenarios to be considered for disposal of NORM waste

	Exposed persons	**Long-term assessments required**	**Water pathway relevant**	**Radon exposure**
Case 1	Workers	None	None	Usually not
Case 2	Workers; public	Yes	Yes	Possible
Case 3	Public, workers		Possible	In special cases possible
Case 4	Workers, public	Possible	(Yes)	In underground repositories or mines
Case 5	Workers, public	Possible	Possible	As stated in the Case 4 and/or Case 5

In the Table 2, some aspects concerning exposure scenarios are compiled. This table shows that the estimation of exposures may become a complex issue, which requires a lot of information on the waste to be disposed and on the chosen disposal site, too.

It is quite simple to evaluate the consequences of the disposal an individual case (e.g. case 2). However, a landfill or any other disposal site is usually used for the disposal of waste from several "sources" (e.g. case 4). Before an authority can decide on the release the waste for the disposal on a chosen landfill the authority needs complete information about all waste that have been released from the radiation protection control by other authorities and which have been disposed already at on the dump of concern in a time period being relevant for the exposure assessment. Information on the amount of waste already disposed and the concentrations of radionuclides in the disposed materials are indispensable since all individual cases of waste dumping in the past can be influence the exposure of a worker on the dump and also the long-term exposure of persons living in the surrounding of the site. Information on the materials released from the radiation protection control, which have been disposed on the landfill in a time period of interest, are of particular importance. All these data and information have to be taken into account in the re-assessment of the exposures before a material of concern can be released in order to dispose it on the dump. In addition to this site-specific information on the past practice of the disposal and indications about the behaviour of the exposed workers on the landfill site are needed. This contains, amongst others, e.g. explanations about the treatment procedures on the landfill site.
The dose estimations carried out in conjunction with every disposal action are more or less conservative and the real exposures are frequently overestimated. Therefore, the well-organised handling of the original data (e.g. concentrations of radionuclides in the disposed materials, masses disposed) is an important measure of optimisation. However, the data required can only be reliable and complete, if NORM wastes are disposed according to a regular procedure. Although this approach seems to be bureaucratic it is an indispensable prerequisite for an optimised solution for the disposal of NORM waste. Therefore the procedures required should be specified in the national radiation protection regulations and in the waste management regulations, too.

4 Approaches to release NORM waste from the radiation protection control and to dispose – examples of the European Countries

As an example the situation in Germany will be discussed. The approach to release of NORM waste and the information flow specified in the regulations is illustrated in the case of several waste sources disposed at one landfill (Case 4 "Many sources – one sink" according to chapter 3) in Fig. 2. Because of the competences of the radiation protection authorities in the Federal Lands in Germany for the release of waste materials and because of the regional authorities being competent for the landfill sites and because of the numerous companies producing NORM waste the composition of all needed information is very extensive. However, we cannot abstain from that in order to avoid a substantial lack of information. In the face of the complicate situation the radiation protection the authority has the urgent task to procure all information on the disposal site necessary for a sound radiological assessment of a projected waste disposal before the waste can be released form the control for the disposal on the site.

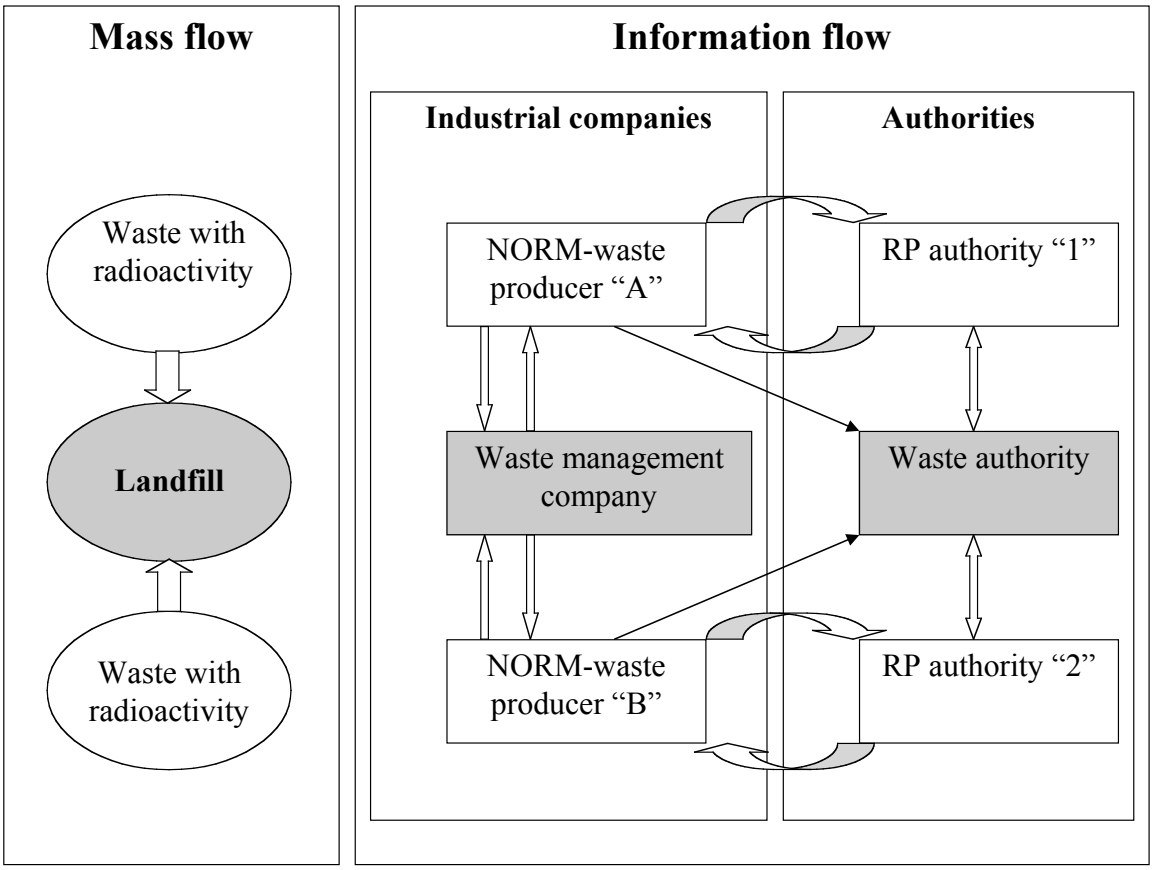


Fig. 2: Flow chart of mass flow and information flow for the release of NORM from RP control in Germany.

In several countries there are other approaches to solve the problem of NORM waste disposal and to optimise the RP control required.
In the Netherlands, the management of NORM residues is organised in different ways. Dependent of the kind of NORM, the residues are treated/recycled and are disposed either in a landfill site or in a long-term storage [4]. For example waste from the Phosphor industry (500-4000 Bq/g, Po-210, Bi210, Pb-210) is placed in an interim storage. About 500 tons per year are stored in a modular building (steel construction, containers 4 high, see Fig.3).

Fig. 3: Storage for the Phosphor industry waste in the Netherlands (from [4]).

Similar to this procedure, there is another interim storage for the solid waste from TiO_2-/pigment-industry. 5 m³ per year of the residues with about 1000 Bq/g (in filters as scale precipitates of Radium, Uranium and Thorium with daughters) are stored (Fig.4).

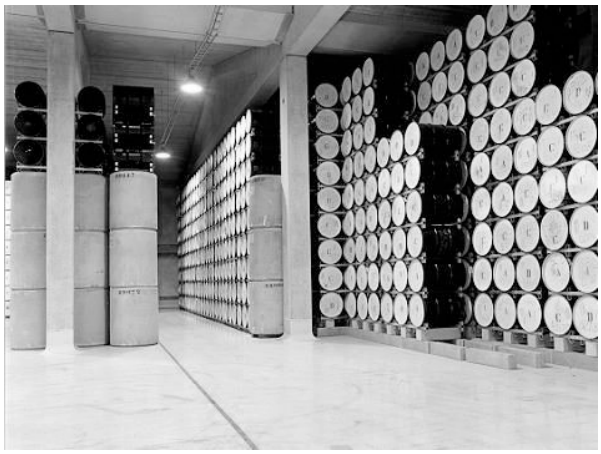


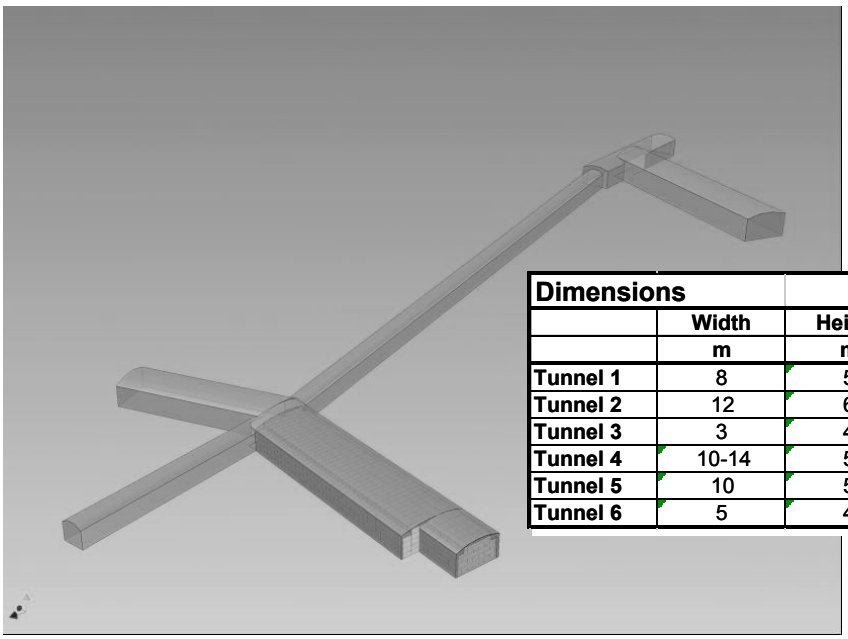
Fig. 4: Storage for solid waste from TiO_2-/pigment-industry in the Netherlands (from [4]).

Another part of residues of the TiO_2-/pigment-industry is disposed on a mono-landfill site. It is a low-level waste (< 10 Bq/g, scale Uranium and Thorium with daughters). About 25,000 tonnes per year are disposed at the site, shown in (Fig.4).

Other residues, e.g. from the oil-/gas industry, are handled according to the principles applied to all other waste in the industry with focus on highest possible degree of reuse and recycling. The contaminated objects, such as pipes, are cleaned, e.g. by high-pressure water jetting facilitating recycling of the component steel and minimisation of the NORM waste.

Fig. 5: Mono-landfill site for low-level waste from TiO_2-/pigment-industry in the Netherlands (from [4]).

In Norway, the preferential treatment of NORM is similar to the approach in the Netherlands. The principles that NORM waste has to be handled in the same way as other waste in the industry with focus on highest possible degree of reuse and recycling [5]. However not all residues are suitable for recycling. Therefore, an underground repository for NORM residues from the oil industry has been built.



Dimensions					
	Width	Height	Length	Area	Gradient
	m	m	m	m2	
Tunnel 1	8	5	45	2025	1:100
Tunnel 2	12	6	60	4800	1:100
Tunnel 3	3	4	130	4550	- 1:7
Tunnel 4	10-14	5	60	4570	1:100
Tunnel 5	10	5	34	1940	1:100
Tunnel 6	5	4	60	2100	1:100

Fig. 6: Overview of the underground repository for NORM residues from the oil industry in Norway (from [5]).

These examples get out of the way, that different NORM residues from several industrial sites are disposed at one landfill site (Case 4). For example in the Netherlands, the "Central Organisation for Radioactive Waste" (COVRA: Centrale Organisatie Voor Radioactief Afval) aims at taking permanent and on an industrial way care of all presented radioactive waste and all materials and objects.
As a central institution, all needed information, which have to be proficient in the RP control, are able to be organised, and the probability of information lacks can be neglected.

5 Conclusion

The radiation protection control of NORM residues has not only to consider workplaces in the industries itself but also workplaces on landfills or in other disposal facilities. The protection of the public in the surrounding of the landfills or facilities has to be included into the control, too. This control requires information on the radioactivity of all relevant wastes as well as clearness on the radiological consequences. If the deposition, the recycling or the re-use of NORM as a secondary raw material for other purposes is termed as a "sink", the source/sink relations can be classified into five cases. The most problematic source/sink relation from the RP point of view is the disposal of NORM from many sources into one "sink". If the NORM residue from a single source is released from control on the basis of an indicative dose of 1 mSv per year, the accumulation of several such "sources" might result in an exposure significantly above 1 mSv. Therefore, in order to control exposures and to support a radiation protection optimisation at the waste disposal the information on the radioactivity of the wastes has to collate, if possible at one authority. The strategies of NORM disposal in the Netherlands or in Norway demonstrate such approach. Due to the availability of central institutions, all needed information concerning the RP control, can be organised in a central way. Potential lacks of data can be minimised.

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Waste management, NORM, disposal, re-use, recycling