HELCOM Recommendation 42-43/8

Amends HELCOM Recommendation 17/6

Adopted 28 March 2025
having regard to Article 20, Paragraph 1b)
of the Helsinki Convention

SUSTAINABLE MANAGEMENT, UTILIZATION AND SAFE DISPOSAL OF PHOSPHOGYPSUM

THE COMMISSION,

RECALLING Article 6 of the Convention on the Protection of the Marine Environment of the Baltic Sea Area, 1992 (Helsinki Convention), in which the Contracting Parties undertake to prevent and eliminate pollution of the Baltic Sea Area from land-based sources;

HAVING REGARD also to Article 3(1) of the Helsinki Convention, in which the Contracting Parties shall individually or jointly take all appropriate legislative, administrative or other relevant measures to prevent and abate pollution in order to promote the ecological restoration of the Baltic Sea Area;

RECOGNIZING that in order to prevent and eliminate pollution of the Baltic Sea Area the Contracting Parties shall promote the use of Best Environmental Practice (BEP) and Best Available Technology (BAT) as laid down in Article 3(3) and the criteria for which are specified in Annex II of the Helsinki Convention;

RECALLING that HELCOM Copenhagen Ministerial Meeting in 2013 addressed in its Minutes i.a. the needed efforts to reduce inputs from phosphogypsum waste piles;

RECALLING ALSO the agreement to revise Recommendation 17/6 on "Reduction of Pollution from Discharges into Water, Emissions into the Atmosphere and Phosphogypsum out of the Production of Fertilizers" by introducing best practices for reducing and monitoring discharges from phosphogypsum waste sites, for the implementation of the updated Baltic Sea Action Plan (BSAP) adopted at the HELCOM Ministerial Meeting 2021;

RECALLING FURTHER the vision of the Baltic Sea Regional Nutrient Recycling Strategy that nutrients should be managed sustainably in all HELCOM countries, securing the productivity of agriculture and minimizing nutrient loss to the Baltic Sea environment through efficient use of nutrients and cost-effective nutrient recycling;

RECOGNIZING ALSO that without proper management, monitoring and precautions, phosphogypsum waste sites storing the residues from phosphorus fertilizer production can be sources of significant discharges of phosphorus and other contaminant (heavy metals, radioactivity etc.) to the Baltic Sea;

RECOGNIZING FURTHER in this respect that, to minimize environmental impacts from phosphogypsum, the BAT and BEP should be applied to production process, safe stacking during production as well as decommissioning of old stacks;

ACKNOWLEDGING existing national and international legislation and competences and, for those Contracting Parties being EU Member States, also other relevant EU legislation, including IED and respective BREF on LVIC-BREF, aiming at preventing further degradation of the marine and freshwater environments and at achieving a healthy sea in good environmental/ ecological/chemical status;

RECOMMENDS to the Governments of the Contacting Parties to the Helsinki Convention to apply the BAT and BEP for sustainable management and safe disposal of phosphogypsum as contained in Annex 1,

RECOMMENDS FURTHER that the actions taken by the Contracting Parties should be reported to the Commission in 2027 utilizing the reporting format in Annex 2 and thereafter every four years.

Annex 1. BAT and BEP for sustainable management and safe disposal of phosphogypsum

Introduction

Phosphogypsum (PG), the main production residue of phosphate fertilizer industry, primarily consists of calcium sulfate dihydrate. Depending on the origin of the phosphate rock, it contains various impurities, which can restrict the reuse of PG as a secondary primary resource. Consequently, large quantities of PG are accumulated in surface stockpiles that occupy extensive land areas and may pose significant environmental risks of contamination. Such contaminants include nutrients (phosphorus), heavy metals (e.g. lead, cadmium, mercury, arsenic) and radioactive substances (isotopes of uranium, thorium, radium, lead, polonium) that can be discharged into aquatic environment (surface and groundwaters) or dispersed/emitted into atmosphere in a form of dust. PG can be classified as a by-product in EU in case respective conditions[1] are met.

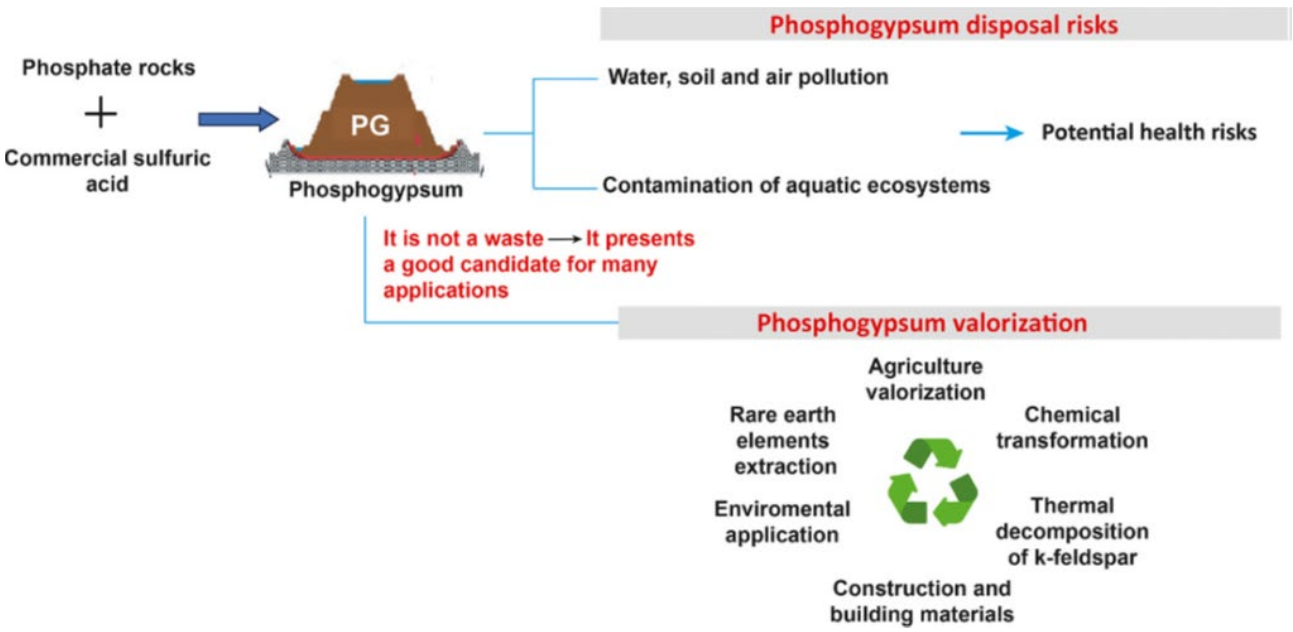

Figure 1. From ”Exploring the potential reuse of phosphogypsum: A waste or a resource?”, Science of The Total Environment, Volume 908, 2024 (https://doi.org/10.1016/j.scitotenv.2023.168196).

Best Available Techniques (BAT) and Best Environmental Practices (BEP)

This document outlines the following BAT and BEP aiming to reduce environmental risks of phosphogypsum.

1. **Production process**
    - Attention should be paid to the choice of phosphate rock. Choosing phosphate rock with low levels of impurities will reduce the amount of hazardous substances ending up in phosphogypsum. This will reduce the risk of release of hazardous substances from the phosphogypsum stack and improve the possibility of utilizing phosphogypsum for other purposes.

2. **Utilization/valorization of phosphogypsum**
    - There are several potential uses for phosphogypsum such as usage in agriculture or construction but possible restrictions by national legislation should be checked before use.

- It should be ensured that the re-use of phosphogypsum does not result in the release of radioactive or other hazardous substances.
- To reduce impurities in phosphogypsum, pre-treatment methods can be used to improve the utilization of phosphogypsum-based products.

3. Safe stacking during production

- Phosphogypsum should only be stacked on land and phosphogypsum and acidic stack effluent should be kept within a closed system.
- There should be an impermeable bottom layer for the phosphogypsum pile as well as circulation water ponds.
- Water should be collected and utilized in the production plant or treated by a wastewater treatment plant.
- To avoid pollution of the subsoil and groundwater by acidic and contaminated phosphogypsum leachate and run-off (process water and rainwater), stringent preventive measures, such as seepage collection ditches, intercept wells, natural barriers and lining systems, should be established.
- To prevent or minimize pollution of the surrounding area and water systems provisions should be made for any effluent overflow.
- The effluent should be treated with an appropriate method, such as immobilization of soluble P2O5 and trace elements by neutralization, before it can be released from the system.

4. Decommissioning and remediation of old stacks

A. Phosphogypsum stacks on land

- The aim for decommissioning is to prevent further environmental contamination, including leaching of harmful substances (heavy metals, radionuclides) into groundwater and surface waters. Decommissioning may take place either successively and partially, for large stacks that continue to receive waste in some sections while other sections are decommissioned, or all at once after the stack is no longer receiving any waste or when the environmental risks necessitate immediate closure.
- The following parameters should be considered when planning decommissioning of a phosphogypsum stack:
  - *Size and shape of the stack*: The geometry of the stack affects its stability. Larger stacks with steep slopes are more prone to slope failures and require careful design and reinforcement.
  - *Water content in the phosphogypsum*: The amount and state of water in the stack (e.g., free, bound in crystals) affects both stability and potential for leaching. Dehydration during decommissioning might reduce the stack's water content and improve stability.
  - *Stability and slope construction*: Engineering solutions include flattening slopes to improve stability and reducing the risk of slope failure. Structures like berms or retaining walls may be needed for additional support.
  - *Dewatering of the surface*: Dewatering helps reduce surface runoff, leachate generation, and slope instability. Consideration of future climate change (e.g., more intense rainfall) is essential in the design of surface water management systems.
  - *Hydrological properties*: The stack’s hydrological properties and those of the cover system must work together to prevent water infiltration, enhance runoff, and reduce seepage. Covers with low permeability (e.g., clay or synthetic liners) are essential to minimize water entering the stack.

- Ecological restoration may be necessary if the surrounding environment has been significantly degraded by the stack's presence. Restoration aims to return the site to a more natural state, improve biodiversity, and create new habitats for wildlife. The following aspects should be considered for ecological restoration of the site:
  - *Use of vegetation - natural or artificial*: Vegetation can be used to stabilize the cover system, prevent erosion, and assist in the natural restoration of the ecosystem. Native plants are preferable for long-term sustainability, but artificial (engineered) ecosystems may also be considered to support specific restoration goals.
  - *Benefits of ecological restoration*: Restoration can improve water quality, increase carbon sequestration, and create recreational spaces for communities. It also enhances the long-term success of the decommissioning by promoting natural water filtration and slope stabilization through root systems.
  - *Risks from vegetation*: Some vegetation, particularly deep-rooted trees, could damage the integrity of the cover system by penetrating through barriers, increasing the risk of water infiltration. Careful selection of plant species is crucial to avoid such damage.

B. Offshore banks containing discharged phosphogypsum

- Remediation of underwater and offshore phosphogypsum legacy sites requires a combination of the following technologies and careful environmental planning based on evaluation of location and depths, extent of contamination and ecological restoration/values. The following strategies represent current approaches to mitigating the damage caused by past dumping practices.

Seabed Capping:

- **Natural Material Caps**: Clean sediment or clay can be used to create a natural barrier that mimics the surrounding seabed environment, reducing the disturbance to marine life.
- **Geosynthetic Caps**: Similar to on-land capping techniques, geosynthetic materials can be used to provide a more impermeable barrier, particularly in areas with significant contaminant release. These synthetic barriers are typically designed to resist degradation in aquatic environments.

In Situ Containment:

- **Underwater Containment Structures**: Walls or berms can be constructed around the contaminated area to prevent the lateral spread of phosphogypsum sediments. These structures may also incorporate filtration systems to reduce contaminant release into surrounding waters.
- **Chemical Stabilization**: In situ chemical stabilization involves injecting chemicals into the seabed that bind with the contaminants, rendering them less mobile or toxic.

Sediment Dredging and Removal:

- **Hydraulic Dredging**: Uses specialized equipment to suction up the phosphogypsum and associated contaminated sediments from the seabed. The dredged material is then transported to land-based treatment or disposal facilities.
- **Mechanical Dredging**: Involves physically digging up the phosphogypsum with excavators or grab buckets, typically employed in shallower waters.

Natural Recovery and Enhanced Monitoring:

- **Enhanced Monitoring**: Sites undergoing natural recovery require rigorous monitoring programs to track changes in contaminant levels, benthic health, and water quality. This allows for early detection of any issues and the ability to adapt the remediation strategy if necessary.
- **Designated restricted areas**: Designating affected areas as areas of restricted access can help limit human activity and further disturbance, giving the ecosystem a better chance to recover naturally over time.

5. Monitoring (during the previously mentioned phases) and risk management

A. Monitoring before stack establishment and during the production phase

Sampling sites and frequency:

- *Initial intensive sampling*: An initial intensive sampling period should be conducted if previous monitoring data is unavailable. This will help identify annual variations, particularly during rain events, to establish a baseline for annual loading assessments.
- *Selection of sampling sites*: Sampling sites should be identified and established in nearby waterways, including rivers and seashore locations, to monitor environmental impacts. Groundwater sampling should be considered if water can reach the nearby waterways.
- *Sampling frequency*: Sampling should be performed monthly being sensitive to high river flow periods.

Sampling methodology:

- *Total annual load calculation*: A clear methodology should be established for calculating the total annual load of pollutants.
- *River flow analysis*: If loading may affect a river, river flow data should be collected to accurately assess the influence of flow rates on pollutant dispersion and concentration.
- *Internal loading*: Internal loading from old deposits at the bottom of waterways should be considered as part of the overall assessment.
- *Hydrological events*: Assessment of the risk and impact of typical hydrological events, such as floods or other sudden increase in flow (due to natural or human triggered processes) that may cause water level rise or release of sediments should be conducted.

Sampling variables:

- *Measured parameters*: The following variables to monitor water quality should be regularly measured and analyzed:
  - pH
  - Electrolytic conductivity [mS/cm]
  - Concentrations of total phosphorus (P-tot), phosphate ($P\text{-}PO_4$), sulfate (SO_4), chloride (Cl^-), fluoride (F^-)
  - Concentrations of metals: calcium (Ca), cadmium (Cd), nickel (Ni), copper (Cu), zinc (Zn) [mg/l], other elements as appropriate and case specific

Additional considerations:

- *Usage of the retention pond waters*: Transportation and reuse of the water, such as in fertilizer use, should be tracked and the amount transported away from the site quantified.
- *Permits and regulations*: It should be ensured that all sampling and monitoring activities comply with relevant permits and regulatory requirements. The responsible entity should be clearly identified to make recommendations and enforce compliance.

B. Monitoring pre-, during and after decommissioning above surface:

A structured monitoring plan must be in place, with specific responsibilities assigned to operators and environmental authorities.

Sampling sites and frequency:

- Pre-decommissioning data is essential to serve as a baseline reference for post-decommissioning comparisons.
- *Selection of sampling sites*: Surface water monitoring is crucial to detect any runoff or leaching of contaminants from the stack, especially during and after decommissioning. Sampling locations should be at outflows, nearby water bodies, and points of potential discharge. Groundwater monitoring involves analyzing wells located both within and around the stack for contaminants. Monitoring the groundwater flow beneath the stack is critical to assess potential leachate migration and to establish contaminant plumes.
- *Sampling frequency*: Monitoring frequency may be higher during active decommissioning (e.g., monthly or quarterly) and taper off after successful closure (e.g., semi-annual or annual).

Sampling methodology:

- *Total annual load calculation*: A clear methodology should be established for calculating the total annual load of pollutants.
- *River flow analysis*: If loading may affect a river, river flow data should be collected to accurately assess the influence of flow rates on pollutant dispersion and concentration.
- *Internal loading*: Internal loading from old deposits at the bottom of waterways should be considered as part of the overall assessment.
- *Hydrological events*: Assessment of the risk and impact of typical hydrological events, such as floods or other sudden increase in flow (due to natural or human triggered processes) that may cause water level rise or release of sediments should be conducted.

Sampling variables:

- Measured parameters:
  - Concentrations of metals: calcium (Ca), cadmium (Cd), nickel (Ni), copper (Cu), zinc (Zn) [mg/l], other elements as appropriate and case specific
  - phosphates
  - pH
  - Eh (redox potential)
  - oxygen levels
  - radioactivity

Additional considerations:

- Monitoring can be gradually reduced if contaminant levels stabilize and meet regulatory criteria over a defined period. Successive decommissioning of monitoring programs should be based on demonstrated environmental recovery and stakeholder agreements.
- Safeguarding against long-term impacts involves continued risk assessment and predictive modeling of factors like metals, eutrophication (nutrient overloads), changes in groundwater quality, and potential for further radioactive release. The monitoring plan must consider possible climate change effects, such as increased precipitation, which could affect stack stability and leaching rates.

C: *Monitoring of legacy underwater marine banks*

A structured monitoring plan must be in place, with specific responsibilities assigned to operators and environmental authorities

Sampling sites and frequency:

- Pre-decommissioning data is essential to serve as a baseline reference for post-decommissioning comparisons.

- *Selection of sampling sites*: Monitoring shall show the chemical content of the bank, and if feasible, estimates of dissolution rates, in order to calculate the load on the environment. It should also ensure human and environmental safety, through monitoring levels of hazardous substances (and radioactivity, where relevant) in biota in the vicinity of the bank. This allows authorities to take appropriate action, such as information campaigns, local restrictions of activities, etc., where needed.

If decommissioning involves remediation measures, such as removing phosphogypsum waste from the seafloor, downstream monitoring should be in place to show measures are not spreading debris or contamination over a larger area.

- *Sampling frequency*: Monitoring frequency would be expected to increase during active decommissioning in order to show changes in loads caused by the mitigation work. After remediation, longer term monitoring should continue in order to show that mitigation work has been successful.

Sampling methodology:

- *Total annual load calculation*: A clear methodology should be established for calculating the total annual load of pollutants.
- *Methods for monitoring in biota:* Standard methods for measuring heavy metals and radioactivity (where relevant) in biota should be applied, e.g. as recommended by EFSA and HELCOM monitoring guidelines.
- *Methods for monitoring in downstream sediments:* HELCOM monitoring guidelines.

Sampling variables:

- Measured parameters:

- Concentrations of metals: calcium (Ca), cadmium (Cd), nickel (Ni), copper (Cu), zinc (Zn) [mg/kg DS], As, Si, Ba, Pb, P, Co, Cr, Hg, S, V, F-, other elements as appropriate and case specific
- Phosphates, PO_4-P
- pH
- Eh (redox potential)
- oxygen levels
- radioactivity, and radioactive metals (e.g. Po, Pb, Ra, U) as apropriate

[1] DIRECTIVE 2008/98/EC: “a substance or object resulting from a production process the primary aim of which is not the production of that substance or object is considered not to be waste, but to be a by-product if the following conditions are met:
(a) further use of the substance or object is certain;
(b) the substance or object can be used directly without any further processing other than normal industrial practice;
(c) the substance or object is produced as an integral part of a production process; and
(d) further use is lawful, i.e. the substance or object fulfils all relevant product, environmental and health protection requirements for the specific use and will not lead to overall adverse environmental or human health impacts.”

REFERENCES

- Draft HELCOM report on Phosphogypsum stacks as sources of nutrient input to the Baltic Sea (2021)
- Exploring the potential reuse of phosphogypsum: A waste or a resource? Science of the Total Environment 908 (2024) 168196 November 2023, DOI: 10.1016/j.scitotenv.2023.168196
- Effluent and Dose Control from European Union NORM Industries. Assessment of Current Situation and Proposal for a Harmonised Community Approach, Volume 1: Main Report by Q Chen, J-P Degrange, M Y Gerchikov, Z K Hillis, S Lepicard, E I M Meijne, K R Smith, A van Weers. European Communities, 2003 https://energy.ec.europa.eu/system/files/2014-11/135_0.pdf
- Properties, Purification, and Applications of Phosphogypsum: A Comprehensive Review Towards Circular Economy, February 2024, Materials Circular Economy 6(1) DOI: 10.1007/s42824-024-00100-5
- Hydrochemistry and ecology of aquatic ecosystems in influence zones of mineral fertilizers production September 2023, Gornyi Zhurnal, DOI: 10.17580/gzh.2023.09.12
- Phosphogypsum circular economy considerations: A critical review from more than 65 storage sites worldwide May 2023, Journal of Cleaner Production 414(5):137561, DOI: 10.1016/j.jclepro.2023.137561
- Phosphogypsum Disposal - The Pros & Cons of Wet Versus Dry Stacking December 2012, Procedia Engineering 46:195–205, DOI: 10.1016/j.proeng.2012.09.465
- Radiation protection and management of norm residues in the phosphate industry. — Vienna : International Atomic Energy Agency, 2013. https://www.iaea.org/publications/8947/radiation-protection-and-management-of-norm-residues-in-the-phosphate-industry
- The radiochemical contamination (Po-210 and U-238) of zone around phosphogypsum waste heap in Wislinka (northern Poland) April 2012, Journal of Environmental Science and Health Part A Toxic/Hazardous Substances & Environmental Engineering 47(5):675-87, DOI: 10.1080/10934529.2012.660052
- Bioaccumulation of polonium (210Po), uranium (234U, 238U) isotopes and trace metals in mosses from Sobieszewo Island, northern Poland, E3S Web of Conferences, DOI: 10.1051/ e3sconf/20130129003

Annex 2. Reporting format

<table>
<tr><td colspan="2">Phosphogypsum waste stack site</td></tr>
<tr><td>Country:</td><td>Year:</td></tr>
<tr><td colspan="2">Site name:</td></tr>
<tr><td colspan="2">Status of the site
☐ Active production ☐ Decommissioning</td></tr>
<tr><td colspan="2">Site location
☐ On land ☐ Offshore</td></tr>
<tr><td>Amount of phosphogypsum waste, tonnes</td><td></td></tr>
<tr><td>Phosphorus content of the stack, tonnes</td><td></td></tr>
<tr><td>Estimated phosphorus load, tonnes*</td><td></td></tr>
<tr><td>Estimated amount of hazardous and radioactive substances</td><td></td></tr>
<tr><td>Estimated amount of radioactive substances</td><td></td></tr>
<tr><td>Validity period and limit values in the environmental permit</td><td></td></tr>
<tr><td>Origin of phosphorus rock used in production</td><td></td></tr>
<tr><td colspan="2">Please describe the BAT/BEP applied on the site.
(Please tick relevant boxes or add description)</td></tr>
<tr><td>Safe stacking during production</td><td>☐ Acidic stack effluent is kept within a closed system
☐ Impermeable bottom layer
☐ Circulation water ponds
☐ Water is collected and utilized in the production plant
☐ Water is treated by a wastewater treatment plant
☐ Seepage collection ditches
☐ Intercept wells
☐ Natural barriers and lining systems
☐ Water systems provisions for effluent overflow
☐ The effluent is treated with an appropriate method, such as immobilization of soluble P_2O_5 and trace elements by neutralization, before it is released from the system
…
Other, please describe.</td></tr>
<tr><td>Monitoring</td><td>☐ Surface water monitoring in place
Please include a map of surface water sampling sites
Sampling frequency:
Measured parameters:

☐ Groundwater monitoring in place
Please include a map of groundwater sampling sites
Sampling frequency:
Measured parameters:

☐ Assessment of the risk and impact of typical hydrological events, such as floods or other sudden increase in flow</td></tr>
</table>

	(due to natural or human triggered processes) that may cause water level rise or release of sediments has been conducted
Decommissioning and restoration of site	*Please describe the measures taken.*

*Technical note on calculation on phosphorus load [to be added]