M4ShaleGas
Measuring, Monitoring, Mitigating, Managing the Environmental Impact of Shale Gas

Proper management of waste during exploitation and exploration of unconventional hydrocarbons deposits in Europe

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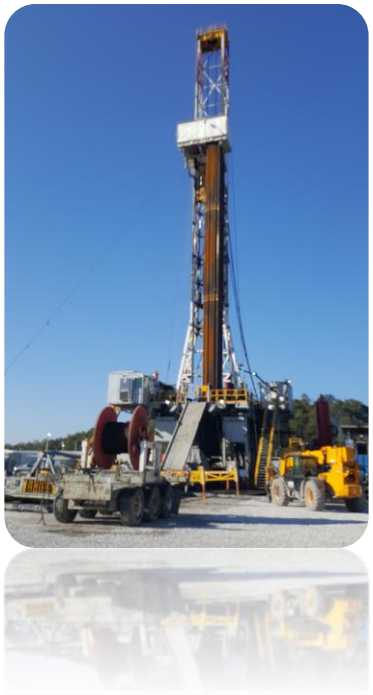


1. Legal requirements

- At **European Union level** the extractive waste management is regulated by **Directive 2006/21/EC** of the European Parliament and of the Council of 15 March 2006 on the management of waste from extractive industries and amending Directive 2004/35/EC

- Directive covers the management of waste resulting from the **prospecting, extraction, treatment** and **storage** of mineral resources and the working of quarries

- Directive 2006/21/EC is supplemented by **five** published **decisions**

1. Legal requirements

- In Europe, waste generated during exploration and exploitation of gas from **unconventional** hydrocarbon deposits are bounded by **the same** legal regulations as waste generated during exploration and extraction of **conventional** hydrocarbon deposits

- For the waste from exploration and exploitation of gas from shale formations there are **no uniform requirements** regarding the **scope of research on quality** of this type of waste, **guidelines** for their **treatment**, **transportation**, **disposal** and **storage**

- **Supplementation** of the **existing legislation** is necessary

2. Composition of waste from shale gas operations

- **Little information** about the qualitative composition of waste generated during exploration of unconventional hydrocarbon deposits **is publicly available**
- Characterization of waste has been reported in the **literature** in various degrees of detail

The content of individual organic and inorganic components in the drilling wastes and the values of the measured parameters can **vary in a wide range**

Drilling wastes are characterized by a fairly **high pH**, high content of **chloride ions**, **metals** (Al, Mg, K, Na, Ca and Fe), **total dissolved solids** (TDS), **total** and **dissolved organic carbon** (TOC and DOC) and **hydrocarbons**

2. Composition of waste from shale gas operations - flowback water

The chemical composition of flowback water is characterised by a **high variability** in qualitative terms

Flowback water:

- has **pH** in the range of **5.7** and **7.4**
- contains significant amounts of **total dissolved solids** (TDS)
- among the inorganic components there are mainly **metals** (such as Ba, Ca, Mg, K and N) and **anions** (bromides, chlorides, fluorides, sulphates and hydrogencarbonates)
- the organic components determined in the samples of flowback water are **hydrocarbons** and **anionic surfactants**

In addition, as shown by the research carried out as part of this project, samples of flowback water may also contain **alcohols**, **sulphur compounds** and a **broader spectrum of metals** than those already determined

3. Flowback and produced water classification

- There are currently **no uniform guidelines for classifying** this type of waste
- In **Poland**, flowback and produced water has so far been classified under code 01 05 99, i.e. ***as wastes not otherwise specified***, and in the **UK** as waste under code 01 01 02, i.e. **as *wastes from mineral non-metalliferous excavation***
- If flowback or produced water contains hazardous substances or components, then it should be classified **as hazardous waste**
- It is important **not to classify flowback water as a wastewater**, since it cannot be reused in this form in accordance with current legislation for hydraulic fracturing
- There is a real need to **supplement the *List of Waste*** with a new type of waste (i.e. flowback and produced water) with a code that is suitable for both hazardous and non-hazardous waste

4. Flowback water quality tests

Parameter:
General parameters:
pH, electrical conductivity, total dissolved solids (TDS),total suspended solids (TSS), dry residue, biochemical oxygen demand (BOD), chemical oxygen demand (COD), total organic carbon (TOC)
Alkali or alkaline-earth metals and others:
sodium (Na), potassium (K), calcium (Ca), magnesium (Mg), strontium (Sr), aluminium (Al), iron (Fe)
Heavy metals:
barium (Ba), cadmium (Cd), lead (Pb), molybdenum (Mo), antimony (Sb), total chromium (Cr), zinc (Zn), copper (Cu), nickel (Ni), vanadium (V), arsenic (As), cobalt (Co), selenium (Se), mercury (Hg), tin (Sn)
Anions:
chlorides (Cl^-), bromides (Br^-), fluorides (F^-), sulphates (SO_4^{2-}), hydrogencarbonates (HCO_3^-)
Aliphatic hydrocarbons:
hydrocarbons C_6-C_{12} and hydrocarbons C_{12}-C_{35}
Aromatic hydrocarbons:
monocyclic aromatic hydrocarbons (BTEX), polycyclic aromatic hydrocarbons (PAHs)
Other organic and inorganic parameters:
ammonia nitrogen (or total nitrogen), phenol index, anionic surfactants, alcohols (depending on the composition of the fracturing fluid), petroleum ether extract (or chloroform extract)

4. Flowback water quality tests

The range of **physicochemical parameters**, which should be determined in **flowback water samples**, includes:

- typical indicators of environmental pollution
- parameters defined by law for waste in general
- and parameters, which should be additionally monitored in wastes such as flowback water due to their specific nature

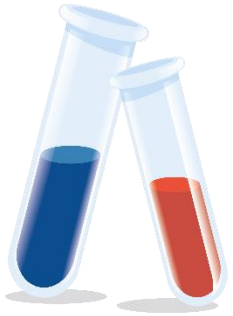
In addition, such wastes should be subjected to **toxicological** and **ecotoxicological tests**

4. Flowback water quality tests

The realized project has also shown that not less important than the proper scope of research is also:

- the method of **sampling** and **preparing the sample** for the tests

- selection of an **appropriate analytical method**, which should have an appropriately defined limit of quantification and uncertainty

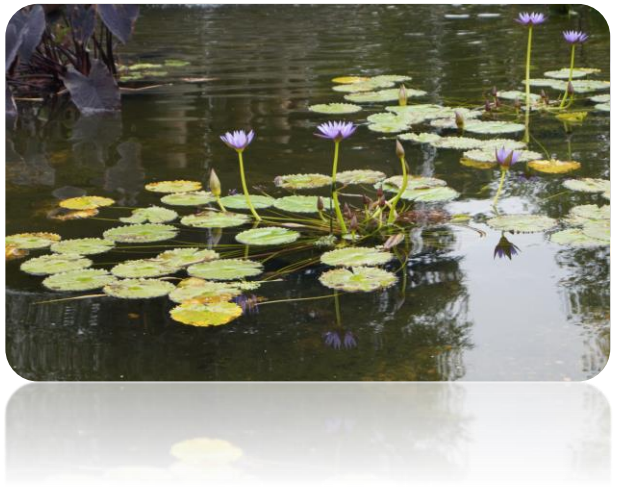


4. Flowback water quality tests – further research

Further testing is needed to develop:

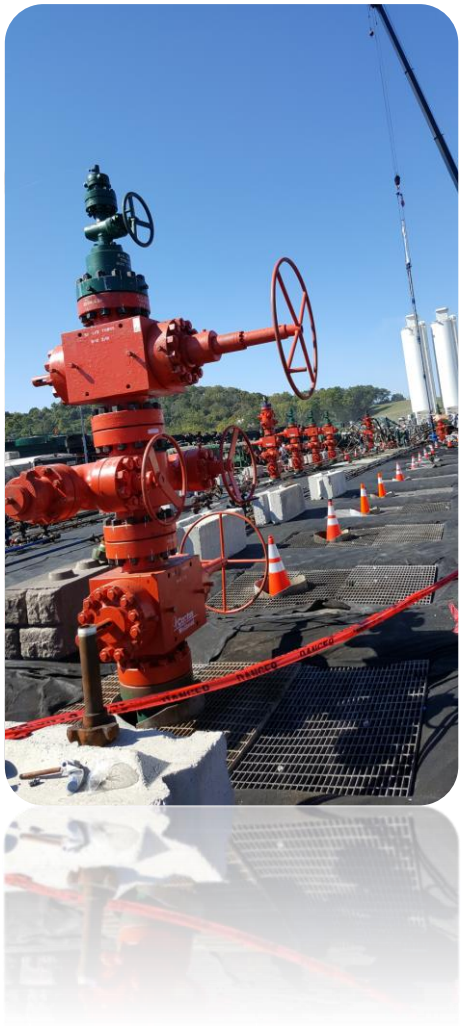
- a **flowback water sampling procedure** for laboratory testing (including the purpose and location of sampling before, after separator or from the container)
- and **guidance on analytical methods** dedicated to the determination of individual substances and components in these fluids with very complex matrix

Testing of such samples should not involve methods routinely used for testing water quality



5. Waste handling - possibilities

- **Flowback water** can be:
  - reused on-site in the next hydraulic fracturing process after pre-treatment (preferable)
  - transferred (treated or not treated on-site) to wastewater treatment facilities or other waste recovery or disposal facilities
  - transferred to a mining waste disposal facility (as a last resort)



Disposal of flowback water by **deep well injection** is not used, although such a method of disposal is **permitted** (under certain conditions) in accordance with European law

6. Summary and conclusions

- Waste connected with shale gas operations is **usually not inert** waste and often indicates (**depending on concentrations of individual substances and chemicals** contained in it) toxic or very toxic properties to aquatic organisms and may cause long-term adverse effects in the aquatic environment

- Waste should **not enter in an untreated form** into the environment, even unintentionally

- The amount of publicly available detailed **information** on the scope and results of shale gas operations waste in Europe is **low** and **selective**, as is the amount of data on substances and chemical compounds used in the preparation of process fluids

6. Summary and conclusions

- There is also **no information** available on the **amount of waste** resulting from exploration and exploitation of unconventional hydrocarbon deposits

- Data on the **composition** of the **process fluids** used in the drilling operations and information on the **composition** and **properties** of the **waste** generated, as well as information on how to further manage the waste, should be made **public**

- Storage of this type of information will allow us to make a clear statement **whether possible environmental pollution** occurring even after time **is related to shale gas operations**

Disclaimer

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