Trace substances in ascending mine waters – environmental and social effects in urban areas

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Abstract
Germany will quit from black coal mining in 2018, the last two operating mines in the federal state of Northrhine-Westphalia are going to stop production by then. Nevertheless, post-mining operations will have to be continued endlessly (in the foreseeable future). The maybe most important of these so-called “eternity tasks” is the handling of large amounts of ascending mine water: in the Ruhr mining district alone, about 120 million m^3 of mine water per year have to be pumped from depths of several 100s of metres to the surface and discharged to adjacent receiving water courses to avoid flooding of former and still active mining drifts. This water has temperatures of up to 50° C and may contribute to a future geothermal energy supply of the region. On the other hand, the mostly saline waters also partly contain unwanted trace substances of potential environmental concern. These include radionuclides (esp. ^{226}Ra and ^{228}Ra) and polychlorinated biphenyls (PCB). The former are probably geogenic contaminants while the latter are suspected to derive from anthropogenic remnants left in the galleries. These substances´ sources, mobility and distribution in surface waters and sediments are hardly understood, associated social consequences of their occurrence in this densely populated area have not yet been discussed. The proposed interdisciplinary young researchers group “Dealing with an Eternity Task in the Ruhr Area” (DETRA) aims at addressing suchlike questions from natural scientific and social scientific points of view. In summary, we will address interdependencies of geoscientific findings and social consequences around a water-related environmental problem in a densely populated urban area, and contribute to understanding the impacts of a transforming water and energy landscape in the region.

Key words: Geothermal mine water use, trace contaminants, sustainability, corporate social responsibility

Introduction
In 2018, Germany will quit from black coal mining. However, post-mining operations will probably have to be continued forever. The maybe most important of these so-called “eternity tasks” is the handling of large amounts of ascending mine water: in the Ruhr mining district alone, about 120 million m^3 of mine water per year have to be pumped from depths of several 100s of metres to the surface and discharged to adjacent receiving water courses to avoid flooding of former and still active mining drifts (Wedewardt 1995).
This water brings along temperatures of up to 50° C and may therefore contribute to a future geothermal energy supply of the region. On the other hand, the mostly saline waters also partly contain unwanted trace substances of potential environmental concern. These include radionuclides (esp. ^{226}Ra and ^{228}Ra) and polychlorinated biphenyls (PCB). The former are assumably geogenic contaminants which are also known from Polish black coal mining districts (e.g. Leopold et al. 2007) while the latter are suspected to derive from anthropogenic remnants left in the galleries. Anyway, these substances´ sources, mobility and distribution in surface waters and sediments are not well understood. Table 1 shows ambient dosage rates for different rivers receiving the former mines´ runoff. Dosage rates tend to increase from the southern (Ruhr river) to the northern (Lippe river) Ruhr Area. This is probably caused by increasing percentages of highly mineralised, Ra-rich deep waters in the northern part,

where mining was active below a thick Mesozoic overburden while the oldest mines in the southern part operated on, or close to the ground surface.

Table 1 *Ambient dose rates in former mines discharge, ordered by receiving rivers (data from Behrendt 2007).*

River	n (mines)	Ambient dose rate (nSv/h)
Ruhr	3	50-80
Emscher	6	50-600
Lippe	4	50-3000

Climate change is likely to have a significant effect on the quantity and quality of ascending mine waters due to changing amounts and distribution of precipitation. This will probably impact the occurrence and distribution/accumulation of trace substances in water and flooding sediments. Therefore, climate change scenarios and their consequences will be considered by the research group.

The consequences of handling the mentioned eternity tasks do not only have an impact on the natural conditions of an area. In densely populated areas they also affect areal social reality. The reason is that interrelations exist between natural and social conditions in a region like the German Ruhr area. This assumption is part of the discourse about (social) sustainability which occurred in the 1980s/1990s. Today the topic “sustainability” has reached the status of one of the contemporary mega trends in societies. A central concept thereby is the “triple bottom line” which identifies three dimensions of sustainability: economic, ecologic and social which are interrelated Deutscher Bundestag 1998; WCED 1987; Zimmermann 2016). It is also a complex issue that contains different perspectives on handling the different dimensions. In some views the economic (due to economic growth and sustainable management) or the ecologic dimension (in terms of protection and conservation of environmental resources) dominates the model (Zimmermann 2016). The social dimension is (usually) defined weakly. That is why there is no version in which the social dimension dominates. In other views the three dimensions are treated as equal. Anyway, although the subject has arrived in various disciplines, it is slightly becoming part of sociological research. Opielka states that there is a lack of "a sociotheoretical and time diagnostic sociology of sustainability” (Opielka 2016, 33) until now. Only since the 2000s sociological studies focus on the terms "sustainability" and "corporate social responsibility" (CSR) (Backhaus-Maul 2009; Backhaus-Maul/Kunze 2015). Thereby they are particularly referenced to sustainable organizational or economical actions (Deutscher Bundestag 1998; Backhaus-Maul/Kunze 2015; Brand & Jochum 2000; SRU 2002) – besides studies in the context of environmental sociology that concentrate on social contexts regarding relationships between nature and society as well as ecological problems.

Empirical studies on sustainability and sustainable organizational actions (in the field of organization sociology) usually can be characterized as explorative. That is because the topic still needs to be developed. Most of the works base on the sociological neo-institutionalism as one of the most popular and recent approaches concerning organization theory. The central assumption is that organizations (primarily profit-organizations) conform to environmental demands and expectations (of their stakeholders), implement e.g. CSR and sustainable strategies and thereby gain legitimacy which is important to facilitate organizational survival (e.g. Bluhm 2008; Bluhm und Geicke 2008; Brugger 2010; Hiß 2007). Today more than ever organizations act under a social legitimation pressure due to the fact that they are central actors of modern societies. Therefore they have to shoulder social responsibility and contribute significantly to the sustainable societal development (Brugger 2010; Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit 2006). Conforming activities of different actors to adapt to environmental demands also have impacts on the region in which they are located. Regions (this means social and natural conditions of an area) and actors (organizations, communities, interest groups) are interrelated with regard to a sustainable development. That contains chances as well as risks for both. On the one hand it holds chances and potentials when all relevant actors of an area are involved in planning and implementing sustainable strategies. On the other hand risks could evolve, when different interests and ideas are conflicting. The latter is an example for a perspective in which (usually) one dimension of sustainability dominates the other.

Against this background the project group „DETRA“ aims to combine a geological and an organizational perspective on sustainability in urban areas like the German Ruhr area. Due to the fact that the project still is in the planning phase the following chapter contains first ideas about the empirical work.

Methods and project goals

The proposed research group strives for the following goals:

- Implementing laboratory methods for the determination of radionuclides (γ spectroscopy) and organic contaminants (GC-qMS) concentrations in mine water, surface water and sediments,
- Describing and evaluating the current state of occurrence and distribution of the trace substances around selected mine water discharges: characterizing the problem´s extent,
- Studying behaviour and fractionation of trace elements in environmental media including the use of isotope tools (e.g., chlorine isotopes [Jin et al. 2011]): understanding the structure of sources and sinks,
- Creating suitable hydrogeochemical and climate change impact models to forecast future developments and transfer findings to other affected locations: formulating recommendations for dealing with the problem from a natural scientific point of view,
- Assessing social consequences of the problem: “good practice” in dealing with the problem, organisational sustainability and corporate social responsibility, consequences on reputation and identity, stakeholders´ self-perception and population´s social acceptance during the evaluation of an energy source with suchlike “side effects”: formulating recommendations for dealing with the problem from a social scientific point of view.

Conclusions

The proposed research group will evaluate the interdependencies of the different parts of the mentioned ascending mine water challenges: contamination with organic trace substances, inorganic trace elements (esp. radionuclide) occurrence, impact of climate change, and social consequences. It will therefore contribute to an improved understanding of the consequences of the transforming water and energy sectors in Northrhine-Westphalia.

References

Backhaus-Maul, H. (2009): Zum Stand der sozialwissenschaftlichen Diskussion über „Corporate Social Responsibility“ in Deutschland. Expertise im Auftrag des Bundesministeriums für Arbeit und Soziales. Halle.

Backhaus-Maul, H.; Kunze, M. (2015): Unternehmen in Gesellschaft. Soziologische Zugänge. In: A. Schneider; R. Schmidpeter (Hrsg.): Corporate Social Responsibility. Springer-Verlag: Berlin, Heidelberg, S. 99-112.

Behrendt, S.U. (2007): Natürliche Radioaktivität in Grubenwässern des Steinkohlenbergbaus. – *bergbau* 5/2007: 206-209.

Bluhm, K. (2008): Corporate Social Responsibility – Zur Moralisierung von Unternehmen aus soziologischer Perspektive. In: Maurer, A.; Schimank, U. (Hrsg.): Die Gesellschaft der Unternehmen – Die Unternehmen der Gesellschaft. Gesellschaftstheoretische Zugänge zum Wirtschaftsgeschehen. Wiesbaden, S. 144-162.

Bluhm, K.; Geicke, A. (2008): Gesellschaftliches Engagement im Mittelstand: altes Phänomen oder neuer Konformismus? In: Rehberg, K.-S.; Deutsche Gesellschaft für Soziologie (DGS) (Hrsg.): Die Natur der Gesellschaft: Verhandlungen des 33. Kongresses der Deutschen Gesellschaft für Soziologie in Kassel 2006. Teilbd. 1 u. 2. Frankfurt a.M..

Brand, K.-W.; Jochum, G. (2000): Der deutsche Diskurs zu nachhaltiger Entwicklung. Abschlussbericht eines DFG-Projekts zum Thema Sustainable Development/Nachhaltige Entwicklung – Zur sozialen Konstruktion globaler Handlungskonzepte im Umweltdiskurs. Münchner Projektgruppe für Sozialforschung e.V., MPS-Text 1/2000.

Brugger, F. (2010): Bedeutung der Nachhaltigkeit für die Unternehmen und die Unternehmenskommunikation. VS Verlag für Sozialwissenschaft.

Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit (BMU; Hrsg. 2006): Corporate Social Responsibility. Berlin.

Deutscher Bundestag (1998): Abschlussbericht der Enquete-Kommission (1998): „Schutz des Menschen und der Umwelt - Ziele und Rahmenbedingungen einer nachhaltig zukunftsverträglichen Entwicklung“. BT-Drs. 13/11200, 26. Juni 1998.

Hiß, S. (2007): Warum übernehmen Unternehmen gesellschaftliche Verantwortung? Ein soziologischer Erklärungsversuch. Frankfurt, New York.

Jin B.; Laskov C.; Rolle M.; Haderlein S.B.: Chlorine isotope analysis of organic contaminants using GC-qMS: method optimization and comparison of different evaluation schemes, Environmental Science & Technology 45: 5279-5286, 2011.

Leopold K.; Michalik B.; Wiegand J.: Availability of radium isotopes and heavy metals from scales and tailings of Polish hard coal mining, Journal of Environmental Radioactivity 94: 137-150, 2007.

Opielka, M. (2016): Soziale Nachhaltigkeit aus soziologischer Sicht. In: Soziologie. Forum der Deutschen Gesellschaft für Soziologie, 45. Jg., Heft 1, S. 33-46.

Sachverständigenrat für Umweltfragen (SRU) (2002): Umweltgutachten 2002. Für eine neue Vorreiterrolle, Stuttgart: Metzler-Poeschel, 2002.

Wedewardt M.: Hydrochemie und Genese der Tiefenwässer im Ruhr-Revier, DMT-Berichte aus Forschung und Entwicklung 39, 250 p, 1995.

World Commission on Environment and Development (WCED) (1987): Our Common Future (Unsere gemeinsame Zukunft) = Brundtland-Bericht. Download: http://www.un-documents.net/wced-ocf.htm. Zugegriffen: 08.03.2016.

Zimmermann, F.M. (2016): Was ist Nachhaltigkeit – eine Perspektivfrage? In: Zimmermann, F.M. (Hrsg.): Nachhaltigkeit, wofür? Springer-Verlag: Berlin, Heidelberg, S. 1-24.