Discussion Paper: Man-Made Radon Pollution? Unexpected Radon Measurements in Northwest Germany: Presentation and Attempts at Explanation

Iris M. Reuther

Abstract**—**Radon is known as a geogenic and radioactive noble gas, formed primarily from the decay of uranium. Its presence in the soil varies greatly between regions and it is typically considered to occur as a result of geological processes. Many countries, including Germany, map the concentration of radon activity in the soil. According to such mapping, northwest Lower Saxony has very low levels of radon. This paper looks at the radon levels measured inside buildings that are in contact with the ground in Wilhelmshaven, a town in the aforementioned region. While these findings are not particularly high compared to some other regions, they are still somewhat surprising. A geological peculiarity became apparent when investigating the cause of these levels: the partly huge caverns below this region have been used by the Federal Republic of Germany to store oil for decades. The author believes it possible that radon may have risen from these caverns through the layers near the surface, from which it can penetrate residential buildings and negatively impact the health of residents as a result. The higher concentrations of radon inside these homes in contact with the ground in Wilhelmshaven are thus caused by human activity.

This paper outlines the geological conditions of the region in question based on the corresponding literature along with the occurrence of oil-filled caverns. It rounds off with a description and findings of the indoor measurements taken, followed by assumptions for the plausibility of this hypothesis. Should this be confirmed, this would have major consequences for both the aforementioned region as well as the use of residential buildings above man-made oil storage facilities.

Extensive research will be required to scientifically prove the causality between oil storage in caverns and radon exposure indoors. Nevertheless, with this paper the author invites the scientific community to discuss this matter further in the meantime.

Keywords**—**North-West Germany, Lower Saxony, oil caverns, radon, pollution, Wilhelmshaven.

I. Introduction

The radioactive, geogenic noble gas radon is a decay product of uranium. Its occurrence is considered to be caused by geological processes. In this article, an unexpected anomaly in indoor radon measurements in individual buildings in the northwest of Germany will be presented, investigated and a theory developed.

The general geological situation in the region will first be methodically explained. This is done using publicly available sources. The same applies to the expected radon levels in the soil in this area. Thirdly, in addition to the expected radon concentrations, the results of the measurements will also be shown, which are the reason for this discussion paper. Finally, chapter xx sets out the thesis and explains why these levels could be caused by human activity.

It should also be mentioned in advance that this paper only provides a basic geological overview. The author writes as a specialist in radon, not as a geologist. Accordingly, the focus is on the radioactive inert gas.

II. Background

A. Localisation and geological background

The region in question forms part of Wilhelmshaven. This town is located in the northwest of the Federal Republic of Germany in the federal state of Lower Saxony. It is highlighted in Fig. 1 (Lower Saxony) and Fig. 6 (Germany). Geologically, large parts of the coastal region are characterised by so-called “coastal deposition”. These areas, also called “marshes”, are a postglacial landscape formed by flat deposits [1]. They are semi-terrestrial soils of class M, abbreviated as “MC”. Worldwide, they are rather rare as the largest contiguous area on the North Sea coast of the countries Denmark, Germany, the Netherlands and Great Britain. That is why they are briefly explained here. Geologically, they are very young areas and thus assigned to the Holocene. They were initially naturally formed by gradual silting of salt marshes by sedimentation on pioneer plants. Around 1,000 years ago, this process was started by levelling. The land thus obtained (“raw marshes”) was desalinated by precipitation and within decades became very fertile arable land (“old marshes”). This process was not yet fully complete in the so-called “young marshes”, which are up to 600 years old. Fig. *2* shows a schematic cut-through of such a coastline. The so-called lime marsh in Wilhelmshaven was first created by dykes after 1,700 AD.

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Wilhelmshaven is located in such an area. This can be seen more precisely in Fig. *3*. See [2] for the following information:

Soil type: MC5
Soil type plain text: Very deep lime marsh
Geotype: gr=muddy sands
Miscellaneous: Groundwater has been lowered
Mean max. groundwater level: 6 dm below the surface
Mean min. groundwater level: 13 dm below the surface

The abbreviation "MC" covers "groundwater soil from loosely layered, carbonate-containing tidal sediments (upper limit of the carbonate layer < 4 dm below the surface)." Overall, the town is about 3 metres above sea level. Even if the groundwater is permanently lowered to 60 – 130 cm below the surface, it is still present near the surface.

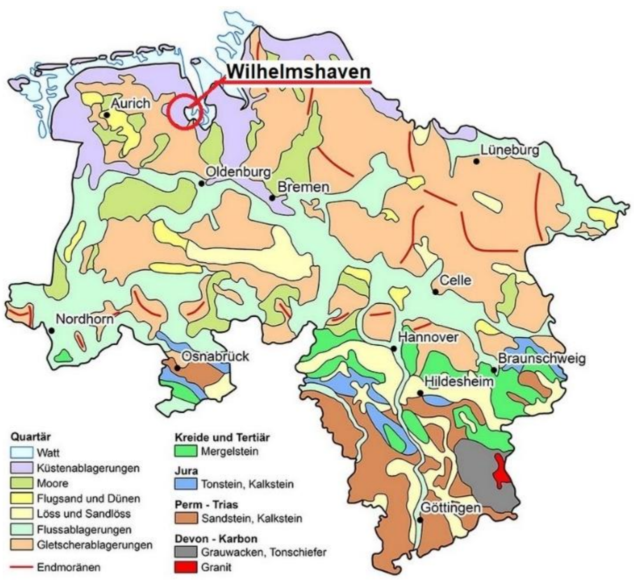

Fig. 1 Geological overview of Lower Saxony and Bremen with the town and region of Wilhelmshaven highlighted by the author according to [3]. Purple areas indicate coastal deposition.

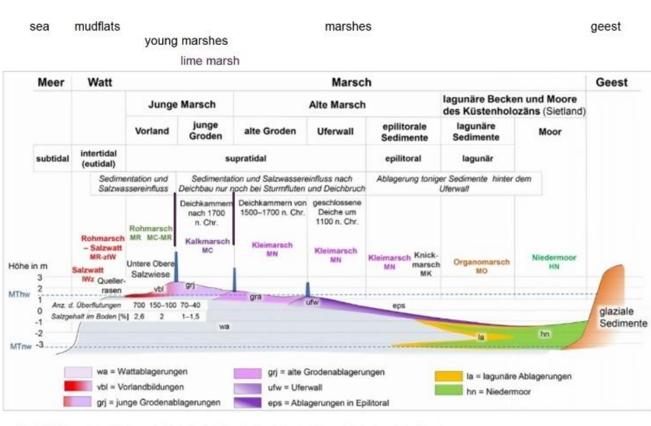

Fig. 2 Schematic cross section of soil landscapes, sedimentation areas and soil types in the marsh from [1] modified and supplemented by using translated terms by the author.

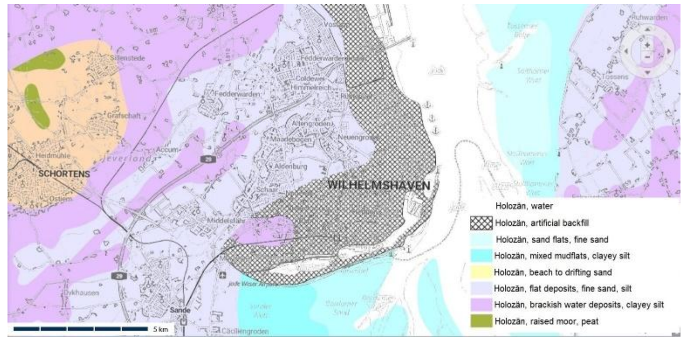

Fig. 3 Soil map of Lower Saxony for the area around the town of Wilhelmshaven, excerpt from [2], modified by the author.

Furthermore, it is known that layers carrying salty groundwater are often found below the surface groundwater [4].

Far below these layers there is a mushroom-shaped salt dome in the region. A large number of caverns were introduced into these from 1973 onwards [5]. These are cavities created by rinsing with water. The nearby North Sea provided and ensures the necessary amounts of water. This region has also been selected for the storage of strategic oil reserves, which is now mandatory for all EU countries, due to the oil port on the Jade River, which imports around 20 % of German oil. In 1979, there were already 33 caverns for 10 million tonnes of crude oil. The cavities are each designed for approximately 100 years of use [6]. In 2008, 20 crude oil reservoirs were allocated to the Etzel site alone at a depth of 800 – 1,600 m. Etzel is located near Wilhelmshaven, where the headquarters of the caverns are located and after which this storage facility is named. There, 9 of these cavities were also used for natural gas at depths of 900 – 1,100 m. These were filled with 841 million m³ of natural gas as part of the national reserves [5]. A recent source currently mentions 75 caverns with a volume of 46 million m³ at a depth of 1,000 – 1,500 m with a diameter of 60 m over a height of 300 – 500 m spread over a field of 15 km² [7]. Until March 2016, 99 such storage facilities were approved, and 144 caverns are planned as the final stage. It is already one of the largest plants of this kind in Europe [6]. The volumes of the individual caverns also increase in part without brine flushing, and targeted re-flushing is to be carried out [6]. Fig. 5 shows a current overview of the caverns in the region and the caverns in Etzel. Fig. 4 provides a three-dimensional impression of the underground storage facilities.

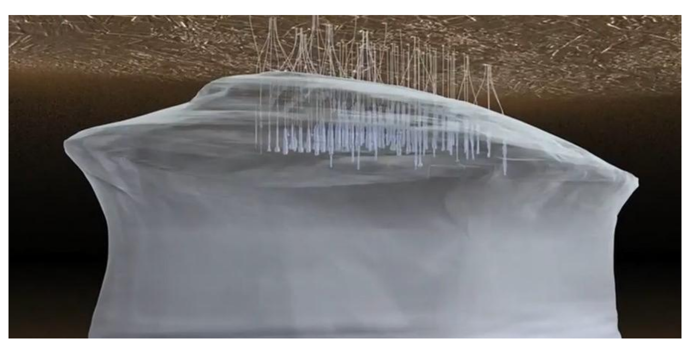

Fig. 4 Animation of the caverns in the salt dome, extract from [8]

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Simply put, there is a wet, geologically young topsoil on a mighty, 250-million-year-old salt dome. A large number of caverns were flushed out of this to store natural gas and oil.

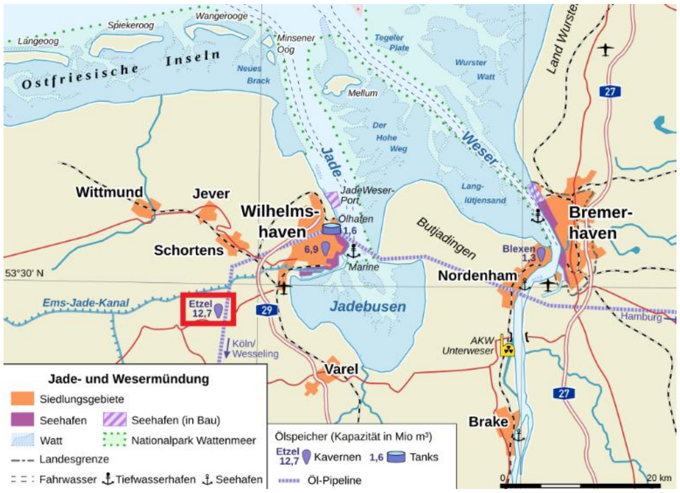

Fig. 5 Overview of the Etzel cavern system from [9], extract, modified by the author.

B. Background regarding radon levels

As in the previous chapter for geology, the situation regarding the radon levels in Wilhelmshaven will also be described based on generally available sources. Most of the so-called radon prevention areas in Germany are far away from the coast [10]. These areas are defined by the statistically increased, higher indoor exposure. However, increased levels can typically only be expected inside buildings if a corresponding occurrence is found in the building ground (exceptions are old buildings in which radon-contaminated materials have been installed). This is not the case in the region around Wilhelmshaven. This is illustrated by Fig. *6*.

Fig. 6 Radon in the ground, map of Germany from [11], modified by the author, marked the town of Wilhelmshaven.

A glance at the Geoportal of the German Federal Office for Radiation Protection also shows for Wilhelmshaven values of less than 20 kBq/m³ of soil air at a depth of 1 metre (which is not shown), otherwise about 25 – 32 kBq/m³ of soil air at a depth of 1 metre. This can be clearly seen in Fig. *7*.

Fig. 7 Radon in the ground, excerpt from [12], modified by the author, marked the location of Jade University.

For comparison: in radon prevention areas, 200 to 1,000 or more kBq/m³ of soil air is easily measured. The reference values exceeding 100 Bq/m³ of indoor air based on recommendations by the WHO or 300 Bq/m³ of indoor air according to the German Radiation Protection Act, are then regularly measured so that action can be taken there (cf. [13]).

III. Radon

A. Radon as a health risk

The health risks of exposure to radon are little known to the general public, but well known among experts [14]. Therefore, it should be briefly pointed out only for other readers of that text that this radioactive noble gas, a decay product of uranium, is considered harmful to the lungs in particular. Approximately half of the natural radioactive radiation (about 1.1 millisievert) and 10 % of lung cancer deaths are attributed to radon [15]. It is now assumed that other diseases are also associated with this type of radioactive exposure, and research is being carried out at various locations around the world [14].

As a result of this threat, EU-wide measures to protect the population have been enforced over the past decade. In Germany, this included, among other things, the designation of so-called radon prevention areas, within which obligations to measure levels were introduced at many workplaces from 2021 onwards, on the basis of which then also structural measures may become necessary [13]. Since there is no dose of radioactive radiation below which harm to humans can be excluded, radon protection works exclusively with reference values, not with limit values. For more information, see 0.

B. Special radon exposure

Prior to protecting the general population, people in particularly radon-exposed situations must be prioritised. This primarily includes former mining regions, in particular uranium mining [16]. The same applies to sites of oil or natural gas extraction and geothermal energy. The latter has so far had even less experience than oil. It is known there that radioactive waste, which is abbreviated as NORM (naturally occurring radioactive material), can cause significant radiation levels [17].

Water production, treatment and distribution plants must also be regularly tested for radon. This is why regular measurements are required, especially for water works.

Radon is highly soluble in fat and, above all, water and can be transported to the surface from great depths with groundwater. In particular, ancient magmatic rocks, such as granite or rhyolite, as well as minerals such as apatite, zircon and monazite, have often deposited uranium as a source element for radon. High permeability, cracks or fractures in the Earth's crust can also cause the inert gas to reach the surface in relevant quantities.

Radon has a half-life of around 3.8 days, meaning parts of the element may decompose before they have a harmful effect on humans. The derivatives of radon, polonium, bismuth and lead are also radioactive and partly of low half-life. However, lead, for example, does not occur in gaseous form.

C. *Measurements and findings*

Since Wilhelmshaven is far away from the nearest radon prevention area, there is no formal reason to carry out radon measurements. Due to the background described in the adjacent section, significant radon exposure is not to be expected anyway.

The author, however, works as a researcher with such measurements. The Federal Office for Radiation Protection is also interested in radon exposure to workplaces outside the precautionary areas in the context of a study [18]. Before the author took part in this study, she had carried out measurements as part of an internal research project starting in the end of 2022. Long-term measurements (13.12.2022 – 14.12.2023) were carried out at various locations in 4 rooms in contact with the ground at Jade University. Only those at the Wilhelmshaven site are listed here in Table .

TABLE I
LONG-TERM RADON MEASUREMENTS IN SELECTED ROOMS AT JADE UNIVERSITY WILHELMSHAVEN (12/22 - 12/23).

No.	Room	Radon concentration [Bq/m³]
1	V-K 14	55
2	H-K 09b	112
3	S-K 12	136
4	S-K 09	175

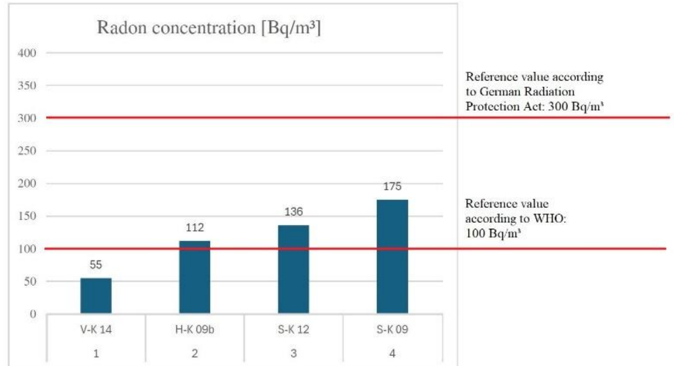

Fig. 8 Graphical representation of the measured values from Table with highlighted reference values according to WHO and the German Radiation Protection Act (own representation).

IV. EVALUATION, DISCUSSION AND THESIS

A. *Assessment of the findings*

These findings in Table are largely in line with expectations for the interiors of buildings built after the Second World War, especially after around 1970 – but not in that region. Especially the measurement value of no. 4 is remarkably high. They are all below the German reference value of 300 Bq/m³ of indoor air, although workspaces are not formally an opportunity to take measures, cf. [13]. However, these values of 112 - 175 Bq/m³ of indoor air are above the WHO recommended reference value of 100 Bq/m³ of indoor air.

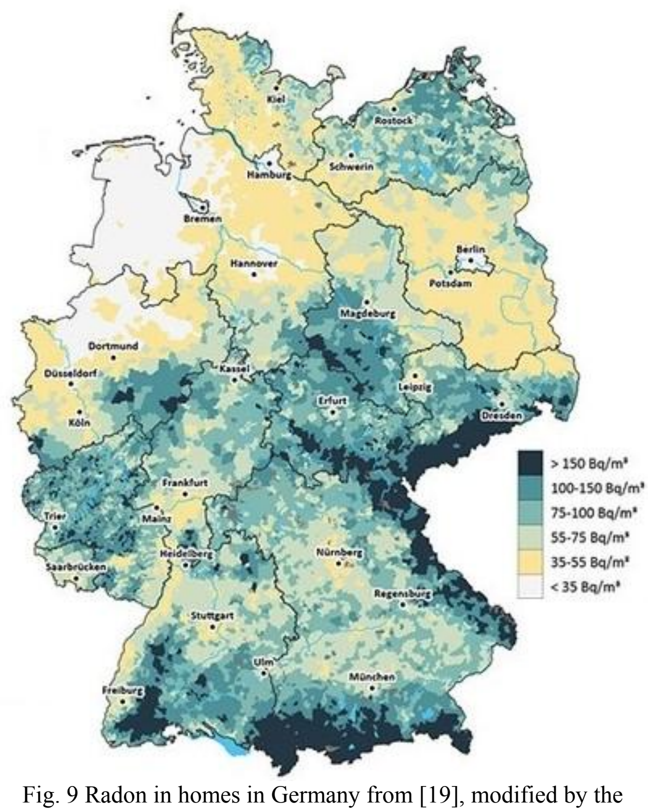

Fig. 9 Radon in homes in Germany from [19], modified by the author.

The reasons why these values, although formally of little concern below the German reference value, are noticeable to the author, are illustrated by Fig. *9*. The estimation of the average radon activity concentration in homes in Germany is shown here.

Even though the premises at Jade University are not residential, a comparison is made Fig. *9*. At present, the corresponding value for workspaces is only determined via the aforementioned study [18] and will hopefully be published in the foreseeable future. It is clear from the above-mentioned figure that values exceeding 100 Bq/m³ of indoor air in homes in the region around Wilhelmshaven, indeed along this part of the coast at all, are not expected. Rather, these are results that can be expected in mountain regions such as inland or along the borders with the Czech Republic, Austria or Switzerland.

A look at the latest, high-resolution map for radon in homes also confirms that in the Wilhelmshaven region, less than 35 Bq/m³ can be expected. This map extract is shown here as Fig. *10* (25 Bq/m³ are mentioned in the interactive version). In fact, this map shows ‘nothing’, so to speak.

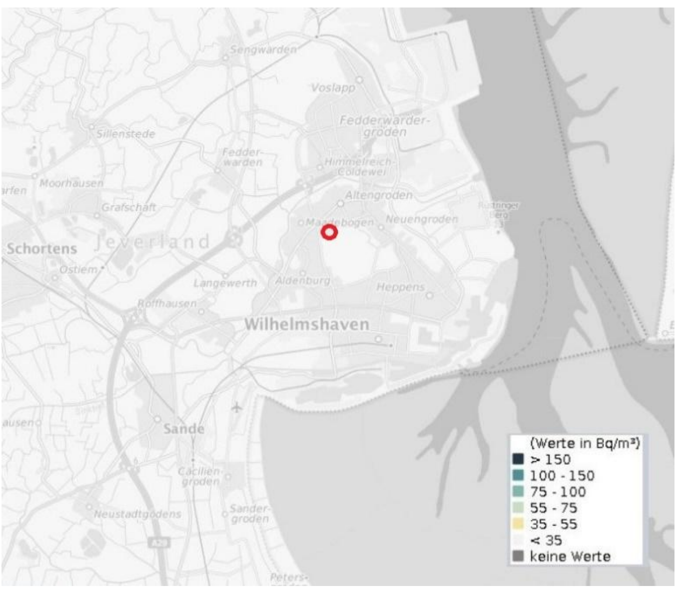

Fig. 10 Radon in homes, excerpt from [12], modified by the author, marked the location of Jade University.

B. Discussion

This discrepancy between expected and actual long-term radon exposure values is the reason for this publication. What could be the cause of this difference, albeit measured only selectively, yet still significant?

The naturally present geology with its mighty salt dome and the marshes above which were formed by (natural or artificial) sedimentation (cf. Fig. *2*, Fig. *4*) are not magmatic, uranium-containing layers from which radon could rise. If oil or gas were to be extracted in this region, radioactive contamination would be obvious. This risk has been known for decades, although not very popular [17]. However, Germany's only offshore oil production is much further north. Fracking [20] or geothermal energy [21] are also considered to be the cause of increased radioactive substances, in particular uranium (uranium-238), radium (radium-226) and radon (radon-222), reaching the Earth's surface. In particular, radium is considered to be of particular concern due to the half-life of 1,600 years. Even in regions where nuclear bombs have been detonated above ground for testing, the radioactive contamination caused by oil and gas extraction is considered to be significant [17]. Nevertheless, the region around Wilhelmshaven is not known for this either.

A plausible explanation for the measured values is also coincidental; after all, geological conclusions on radon exposure indoors is not considered reliable [22]. Nor can it be completely ruled out that correspondingly exposed material was used during the construction of the buildings due to not very probable, but theoretically conceivable situations.

C. Thesis

However, the author does not believe that chance or radioactive material is a probable cause for the measured values. On the contrary, due to the introduction and storage of crude oil and natural gas, it is considered possible that uranium, and consequently the decay product radon, may have entered the subsoil of Wilhelmshaven and its surroundings. In view of the approximately 50 years during which these caverns have been used as storage, the large quantities of oil and the many underground pipelines (for oil, brine, gas, etc.) etc. in the subsoil, such a cause of the increased measured values cannot be ruled out in the opinion of the author.

Between the surface of the earth and the upper edge of the salt dome in which the caverns are located lies soil formed by sedimentation, cf. Fig. 2 and Fig. 4. It can be assumed that permeable layers are present there (cf. Table). In addition, disturbances caused by the creation of caverns such as cracks, fissures, crevasses etc. must be presumed there [6]. Finally, these layers of earth may contain water, which could serve as a “means of transport” for (not only) radon.

TABLE II
GAS PERMEABILITY OF DIFFERENT SOIL TPYES

Soil type	Gas permeability [m²]
gravel	$> 10^{-10}$
sand	$10^{-10} – 5 * 10^{-12}$
silt	$5 * 10^{-12} – 10^{-15}$
clay	$< 10^{-15}$

One of the documents used for the last approval of the extension of the cavern plant will be considered below. It not only describes the relevance of the plant for the regional economy, but also deals with environmental compatibility for people and animals [23]. There are two aspects to human health: noise and vibration (page 19). In the case of groundwater, a reference to “substance inputs or contaminated sites” (page 24), which are not further named, appears. A radioactive hazard is not identified.

Another expert opinion in connection with the extension of the plant was issued at the end of 2016. It explicitly deals with the expected soil subsidence and horizontal soil movements [6]. There, depressions observed already in situ (page 13) and lateral displacements (page 25) are described. The depressions have now been compared with the forecasts and the actual reduction between 1975 and 2015. Both values match up and amount to 0.30 – 0.40 m in about 40 years (for the old caverns, which represent only a fraction of the total target number). Approximately 1.13 m is forecast for 2040, approximately 2.06 m for 2080 and a reduction of approximately 2.36 m for 2100. The reader is able to assess for themselves whether the calculations contained in this document for the year 2317 are still useful and relevant.

For the thesis presented here, however, the already occurring subsidence by several decimetres is relevant. They clearly demonstrate the existence and extent of the above-mentioned fissures and crevices, which facilitate radon and other NORMs to ascend to the Earth's surface.

Admittedly, it is irritating that the assessment on the environmental compatibility [23] of 2013 does not mention ionising radiation (the German Radiation Protection Commission had already referred to the dangers of radon in a report in 2005). On the basis of this environmental impact assessment, the Lower Saxony government has also decided to significantly expand the plant. It is irritating to note that subsidence of the Earth's surface of more than 2 metres is almost tacitly accepted in a region for which at the same time a 30 cm rise in sea level is being warned [24]. It is irritating that the decision to phase out nuclear energy was taken in 2011 due to radioactive radiation and highly toxic waste in Germany [25], but the state of Lower Saxony in 2013, by deciding to expand the cavern facility, promoted the further development of such radiation and waste.

The irritations and inconsistencies mentioned in the previous paragraph lead to the following question.

V. Question and Task

The author hereby asks this question to the technically equipped colleagues, in particular from the field of geotechnical engineering: Is there any reason to assume that the thesis listed in chapter IV.C is correct? Or is the connection assumed by the author so absurd that from a technical point of view there is no reason to further examine this thesis?

There is no doubt that further research is an indispensable prerequisite for further statements on the subject. It is indisputable that this is only a presumption, a well-founded, conceivable, but by no means proven connection.

From this, the question arises as to the task of the participants of this conference as well as of the scientific community as a whole. It is the assessment of the thesis raised and, consequently, the challenge to substantiate this thesis by the results of further research or to reject it in this way.

VI. Summary

The geology of the Wilhelmshaven region in the north-west of Germany has been impinged. For more than 50 years, caverns for the storage of oil and gas have been produced and used in a salt dome. Recently, radon measurements were carried out in individual rooms of the Jade University at the Wilhelmshaven site. Results were obtained in individual rooms, which are not particularly worrying, but are unusually high for this region of Germany. This paper raises the question of a possible connection between caverns and radon exposure. It is recognised that further research on this issue is essential.

Acknowledgment and Remarks

The author of this publication thanks the Jade University of applied sciences for the financial support. Thanks as well to my colleague from the occupational security department and my student assistant.

This publication is published in black and white. If you are interested in a colour version, please do not hesitate to contact me. Most of the sources in this work, as well as a small part of the labelling, are written in German. The author will also be happy to help in this regard if you are interested in the subject.

References

[1] Landesamt für Bergbau, Energie und Geologie, „GeoBerichte 40," 03 11 2021. [Online]. Available: https://nibis.lbeg.de/DOI/dateien/GB_40_Text_13_web_neu.pdf. [Acessed 10 10 2024].

[2] Landesamt für Bergbau, Energie und Geologie, "NIBIS Kartenserver," 2024. [Online]. Available: https://nibis.lbeg.de/cardomap3/#. [Accessed 04 10 2024].

[3] Niedersächsisches Ministerium für Umwelt, Energie und Klimaschutz, "Hydrogeologische Räume in Niedersachsen," [Online]. Available: https://nibis.lbeg.de/cardomap3/. [Accessed 04 10 2024].

[4] Klinikum Wilhelmshaven, "Neubau Bautagebuch," 09 2024. [Online]. Available: https://www.klinikum-whv.de/unternehmen/neubau/aktuelles_neubau.php. [Accessed 05 10 2024].

[5] R. Sedlacek, "Untertage-Gasspeicherung in Deutschland," 2008. [Online]. Available: https://www.yumpu.com/de/document/view/12293160/ugs-201250979396bb9fc. [Accessed 05 10 2024].

[6] Bundesanstalt für Geowissenschaften und Rohstoffe, "Prognose der Oberflächenverformung für die Kavernenanlage Etzel," 31 10 2016. [Online]. Available: https://www.lbeg.niedersachsen.de/download/144438/anhang_1_senkungsprognose_bgr_2016.pdf. [Accessed 10 10 2024].

[7] STORAG ETZEL, "FAQ," 2024. [Online]. Available: https://www.storag-etzel.de/info-service/faq. [Accessed 05 10 2024].

[8] STORAG ETZEL, "Wieso in Etzel," 2024. [Online]. Available: https://www.storag-etzel.de/info-service/faq/warum-in-etzel. [Accessed 10 10 2024].

[9] Wikipedia, "Kavernenanlage Etzel," 07 02 2024. [Online]. Available: https://de.wikipedia.org/wiki/Kavernenanlage_Etzel. [Accessed 14 10 2024].

[10] Bundesamt für Strahlenschutz, "Radon-Vorsorgegebiete in Deutschland," 15 06. 2021. [Online]. Available: https://www.bfs.de/DE/themen/ion/umwelt/radon/karten/vorsorgegebiete.html. [Accessed 03 11. 2023].

[11] Bundesamt für Strahlenschutz, "Radon in der Boden-Luft in Deutschland," 10 04 2024. [Online]. Available: https://www.bfs.de/DE/themen/ion/umwelt/radon/karten/boden.html. [Accessed 10 10 2024].

[12] Bundesamt für Strahlenschutz, "Geoportal," 2017. [Online]. Available: https://www.imis.bfs.de/geoportal/. [Accessed 08 07. 2023].

[13] I. M. Reuther and R. W. Uhlig, "Radonschutz im Baubestand – Stand des WTA-Merkblatts," in Proceedings Bauphysiktage in Weimar 2024: Bauphysik in Forschung und Praxis, Weimar, 2024.

[14] I. M. Reuther, "Working from Home as a risk. How remote work as a new habit, gaps in both infor-mation and legal regulations on radon in

Germany may increase a health risk," in International Conference 2023 on Architecture, Building and Construction, 23rd – 24th November 2023; Conference Proceedings, London, publication process ongoing.

[15] Bundesamt für Strahlenschutz, "Radon-Handbuch Deutschland," Salzgitter, 2019.

[16] Bundesamt für Strahlenschutz, "Bergbauliche Hinterlassenschaften mit erhöhter natürlicher Radioaktivität," 28 06 2023. [Online]. Available: https://www.bfs.de/DE/themen/ion/umwelt/altlasten/hinterlassenschaften/bergbau.html. [Accessed 10 10 2024].

[17] J. Döschner, "Industrie verschweigt Gefahren durch radioaktive Rückstände," 07 12 2009. [Online]. Available: https://www1.wdr.de/archiv/energiekonzerne/oelquellen-industrie100.html. [Accessed 10 10 2024].

[18] Bundesamt für Strahlenschutz, "Radon@work - Studie: Radon am Arbeitsplatz," 31 05 2023. [Online]. Available: https://www.bfs.de/DE/bfs/wissenschaft-forschung/natuerlich-ion/laufend/radon-arbeitsplatz.html. [Accessed 10 10 2024].

[19] Bundesamt für Strahlenschutz, "Radon in Wohnungen in Deutschland," 12 12 2023. [Online]. Available: Radon in Wohnungen in Deutschland. [Accessed 10 10 2024].

[20] R. Klatt, "Fracking verursacht radioaktive Belastung der Luft," 29 10 2020. [Online]. Available: https://www.forschung-und-wissen.de/nachrichten/umwelt/fracking-verursacht-radioaktive-belastung-der-luft-13374271. [Accessed 10 10 2024].

[21] Bundesamt für Strahlenschutz, "Rückstände aus der tiefen Geothermie," 23 06 2023. [Online]. Available: https://www.bfs.de/DE/themen/ion/umwelt/rueckstaende/tiefengeothermie/tiefengeothermie_node.html. [Accessed 19 10 2024].

[22] K. Leicht, "Irrwege im Radonschutz," in Proceedings Bauphysiktage in Weimar 2024: Bauphysik in Forschung und Praxis, Weimar, 2024.

[23] Grontmij GmbH im Auftrag des Niedersächsischen Ministeriums für Ernährung, Landwirtschaft und Verbraucherschutz, "Endausbau Energiespeicher Etze," 13 03 2013. [Online]. Available: https://www.arl-we.niedersachsen.de/download/88131/Unterlage_zur_Antragskonferenz.pdf. [Accessed 10 10 2024].

[24] J. Kube and D. Müller-Dum, "Die Nordsee im Klimawandel: Hier steigt das Wasser," Helmholtz Klima Initiative, 18 01 2023. [Online]. Available: https://www.helmholtz-klima.de/aktuelles/die-nordsee-im-klimawandel-hier-steigt-das-wasser. [Accessed 10 10 2024].

[25] Bundesamt für die Sicherheit der nuklearen Entsorgung, "Der Atomausstieg in Deutschland," Bundesministerin für Umwelt, Naturschutz, nukleare Sicherheit und Verbraucherschutz, 21 01 2024. [Online]. Available: https://www.base.bund.de/DE/themen/kt/ausstieg-atomkraft/ausstieg_node.html. [Accessed 10 10 2024].

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