

## Increasing awareness for soil biodiversity and protection The international touring exhibition ‘The Thin Skin of the Earth’

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### Abstract

The Senckenberg Museum of Natural History Görlitz developed an international touring exhibition with the title ‘The Thin Skin of the Earth – Our Soils’ as the national contribution to the International Year of the Soil 2015. Since the opening of the exhibition in October 2015 it had been shown at six localities and seen by more than 120,000 visitors. It will tour at least for another four years. The exhibition deals with soil biodiversity, the heterogeneity of soils as well as soil protection. It meets the challenge to present objects, processes, topics and formats completely unknown to most of the public by using recent most specifically developed digital and analogue formats and a sophisticated scenography. To address its main messages to the visitors, emotionalizing and immersive forms of information transfer are crucial and, therefore, central elements of the educational concept. The general concept behind the exhibition, its contents, the educational approaches applied and the major results of an external evaluation are described. Conclusions are drawn on the suitability of touring exhibitions and the approaches chosen to inform and sensitize a broad public for soil protection.

**Keywords** soil protection | soil biodiversity | touring exhibition | scenography | public awareness

### 1. Introduction

Major reasons for deficiencies regarding public awareness of the necessity to protect soil ecosystems are the inaccessibility of the soil, the loss of appreciation of soils, especially in urban populations, but also the lack of information on the relevance of soil organisms for decomposition and nutrient recycling in terrestrial ecosystems (Xylander et al. 2015) as indicated by scarce consideration in school and academic education (e. g. Müller 2012). Without soil organisms, fertility of soils would decrease fast with significant impact on e. g. agriculture and forestry. Therefore, the global economic value of soil organisms for ecosystem services is considered to be higher than  $1.5 \times 10^{12}$  US\$ yr<sup>-1</sup> (Louise

Jackson, [http://www.fao.org/fileadmin/user\\_upload/foodclimate/presentations/biodiv/Soil\\_Jackson.pdf](http://www.fao.org/fileadmin/user_upload/foodclimate/presentations/biodiv/Soil_Jackson.pdf), modified after Pimentel et al. 1997, Brussaard et al. 2007). Obviously, public awareness for soil protection stands in significant contrast to its relevance (see also Müller 2012, Xylander et al. 2015). This lack in awareness is also reflected by the national and EU legislation for soil protection, the focus of which is on the abiotic aspects of soil. Soil biota are considered only in the context of habitat functions what underestimates its importance.

The Senckenberg Museum of Natural History Görlitz (SMNG) is an international research institute with a special focus on soil animals and more than 20 scientists working on soil animals; the collection holds about 4.5 Mio specimens from various groups of soil

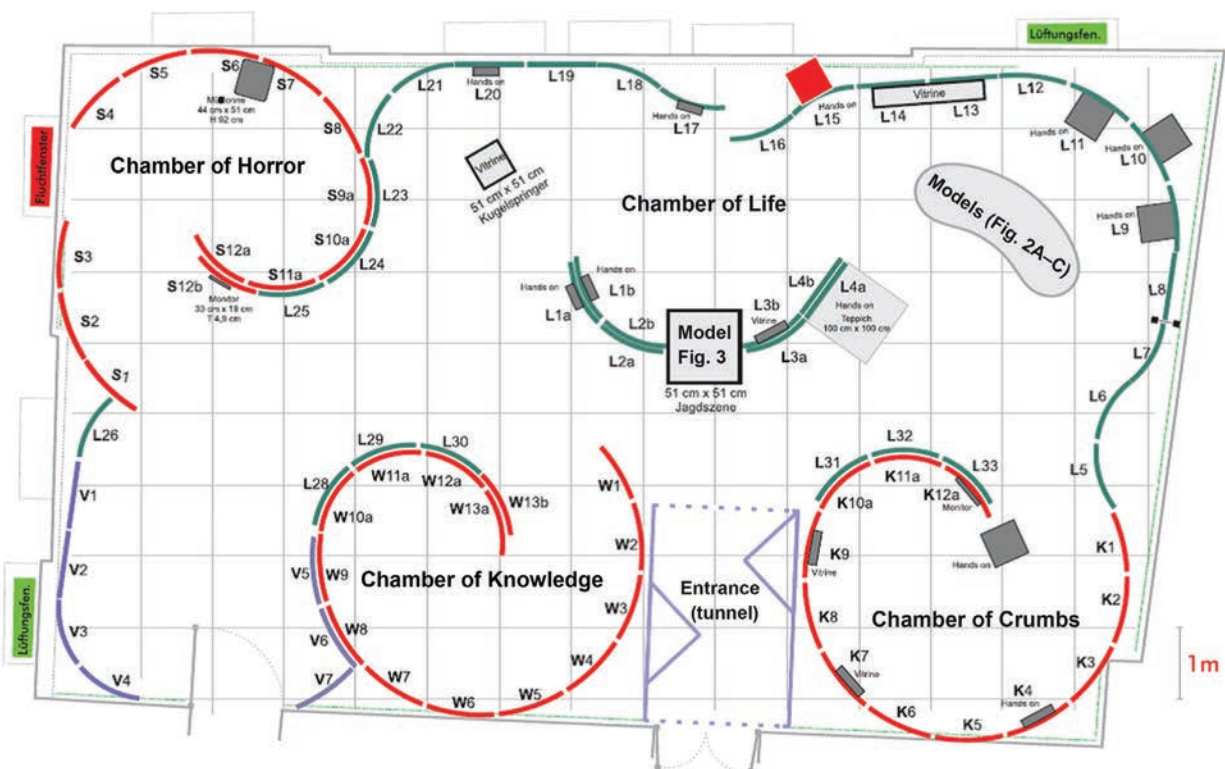
animals (Xylander 2018). To increase the awareness and to draw the attention of the public on soil biodiversity and ecosystem services as well as on the major drivers of soil destruction, the SMNG developed three touring exhibitions, which dealt with these topics: ‘Tiere im Boden’, presented 1995 – 2002 (curated by Wolfram Dunger and Karin Voigtländer, Voigtländer & Dunger 1998) and ‘Unter unseren Füßen – Lebensraum Boden’/ ‘Beneath our feet – Life in soil’, 2004 – 2012 (curated by Karin Hohberg and Willi Xylander, see Hohberg & Xylander 2004). These two exhibitions were successful vehicles to raise the awareness of the public for soil biodiversity. The new touring exhibition by Helga Zumkowski-Xylander, Willi Xylander and colleagues (‘Die dünne Haut der Erde’ / ‘The Thin Skin of the Earth’, 2015, ongoing) deals – besides the obligatory unit on soil biodiversity – also with the heterogeneity of soils and their formation, with soil research as well as with soil protection. The exhibition was financially supported by the Federal Ministry for Science and Education (BMBF) as part of the Edaphobase-project (see Burkhardt et al. 2015, www.edaphobase.org) within the National Biodiversity Initiative as the German contribution for the International Year to the Soil 2015.

## 2. Content of the exhibition

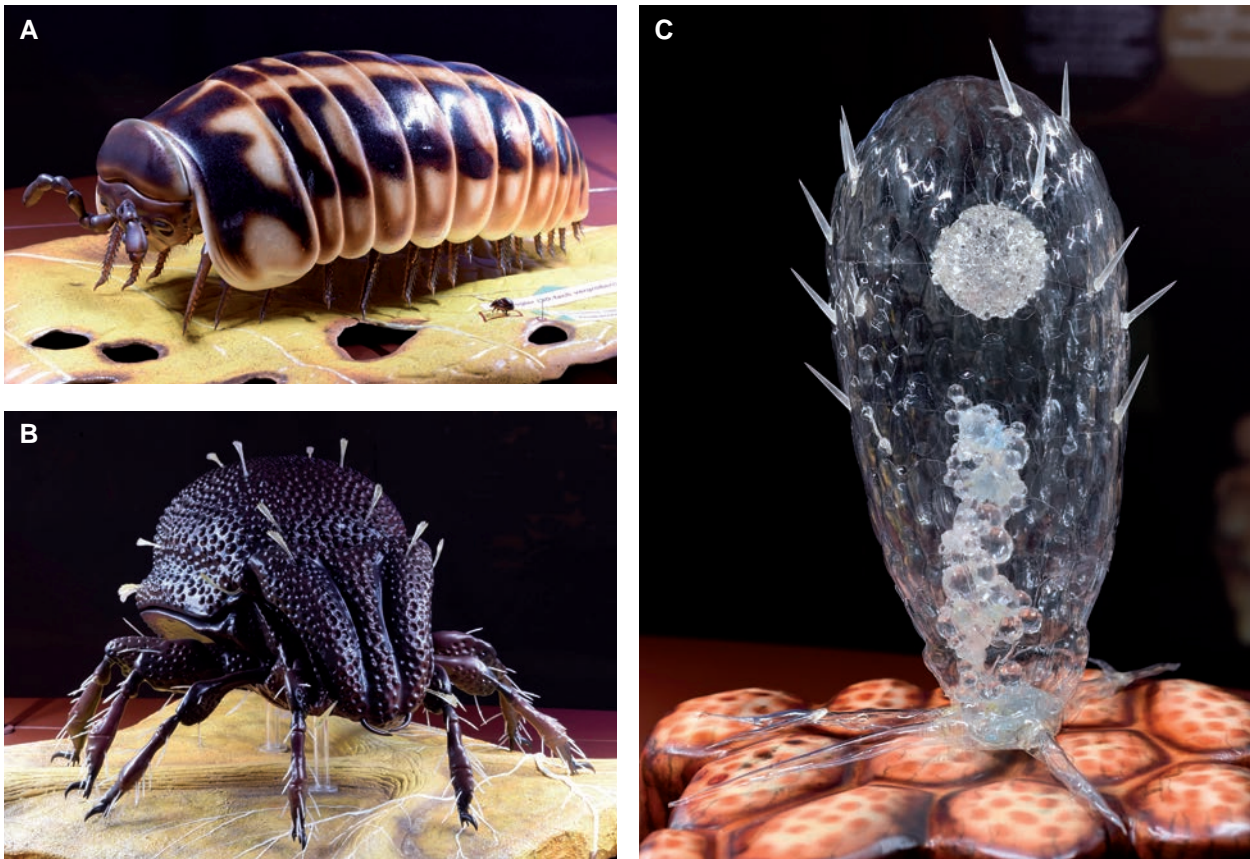
The exhibition comprises four major topics indicated by separated spaces and their specific scenography. These topics are: a) soil biodiversity (presented in the ‘Chamber of Life’), b) soil heterogeneity and pedogenesis (‘Chamber of Crumbs’), c) soil science (‘Chamber of Knowledge’) and d) soil destruction and protection (‘Chamber of Horror’).

The module ‘Chamber of Life’ is the central part of the exhibition (Fig. 1) giving access to all other chambers. It presents the biodiversity, biology and relevance of all major groups of soil organisms with a special focus on soil animals, but also including fungi, protozoans, bacteria and algae. Ecosystem services, especially decomposition and recycling are visualized e. g. by a simplified chain of ‘decomposers’ (pill millipede, oribatid mite, testate amoeba) (Fig. 2). The morphology of representatives of the decomposition guilds and also the interaction between them are visualized by high quality models.

The eye catcher of the exhibition (a predatory mite just killing a springtail, Fig. 3) stands for the second major topic of the ‘Chamber of Life’: predator-prey-interrelationships and the trophic levels in the soil.



**Figure 1.** Floor plan of the exhibition during its presentation in the Senckenberg Museum of Natural History Görlitz (July 2016 to January 2017) showing the four ‘chambers’, the tunnel entrance and their spatial interrelationship.



**Figure 2.** Three representatives of a chain of sequential decomposers representing different size classes: (A) macrofauna (*Glomeris hexasticha*, Glomeridae, Diplopoda), (B) mesofauna (*Carabodes ornatus*, Oribatida, Acari) and (C) microfauna (testate amoeba). All three models are 3D-prints by Klaus Leitl. Photos: Sven Tränker, Senckenberg.



**Figure 3.** Predatory mite (*Veigaia cerva*, Gamasina, Acari) overwhelms a springtail (*Orchesella cincta*, Collembola). Model by Esben Horn. Photo: Andrzej Paczos, Senckenberg.

Close to this model, information is provided on foraging strategies of predatory soil animals as well as on defense mechanisms of prey organisms. Further items are reproduction, brood care and the adaptation of soil organisms to environmental constraints, e. g. paralleling climate changes. Scanning electron micrographs of various soil organisms convey the outer morphology and the fascinating heterogeneity of the subsoil world.

In the exhibition section ‘Chamber of Crumbs’ the peculiarities and variability of soil types is presented reflecting pedogenesis in relation to geology as well as physical, chemical and biological processes of decomposition and climate. A single soil profile (Podsol) was selected that visualizes soil horizons and explains their development. In this section also the importance of soil fertility for the cultural development of man is considered.

The module ‘Chamber of Knowledge’ explains how scientists develop and address their research questions and how new insights contribute to the development of new research questions (addressing the idea of ‘public understanding of research’) as well as strategies for soil protection. Different research projects are presented, e. g. on the interaction of soil organisms and climate change (Römbke et al. 2011), the impact of man on extremely sensible ecosystems (here: Antarctica, Russell et al. 2014) or flood control; also molecular approaches and applications for determination of soil biota are presented in a video installation (e. g. Decker et al. 2017, Lehmitz & Decker 2017, Schenk et al. 2017, Wesener et al. 2015, 2016). Last not least applications from the online open-access data warehouse on soil animals ‘Edaphobase’ are demonstrating its potentials as research tool, reference and data repository ([www.edaphobase.org](http://www.edaphobase.org), Burkhardt et al. 2014).

The exhibition part ‘Chamber of Horror’ deals with the destruction and protection of soils. It aims at raising awareness on destructive impacts such as erosions, eutrophication, desiccation, pesticide application, soil compaction and sealing, but also on our consumer behavior and its consequences for soil devastation. It furthermore shows how these impacts influence the soil as resource and ecosystem leading to a reduction of biodiversity and decline of ecosystem services.

The chambers can easily be differentiated by their arrangement in the exhibition as well as by their scenography. This facilitates orientation in the thematically complex and content-rich exhibition (Fig. 1).

### 3. Concept of the exhibition and realization

#### 3.1 Development of the presentation

From the very beginning (start of the project in April 2015) the exhibition project was planned to start with a presentation of first exhibition parts and a subsequent further development and enlargement successively throughout the project period, which ended in July 2018. Hence, a first version was presented already six month after the start of the project at the EU Parliament in Brussels (on about 150 m<sup>2</sup>).

Subsequently, it was shown slightly modified at the Natural History Museum in Chemnitz. For the third location in Görlitz, the exhibition was enlarged to about 180 m<sup>2</sup>. Here the scenography was realized for the first time as initially intended with all four ‘chambers’ presented. For the Senckenberg Naturmuseum Frankfurt, the exhibition was extended to 230 m<sup>2</sup>. Its final size of more than 300 m<sup>2</sup> was reached when presented at the Museum Koenig in Bonn (Tab. 1).

The size of the exhibition increased due to adding new topics as complete units, models and new panels to the ‘chambers’ from location to location. The panels of the exhibition consist of alu-dibond; they are bent in various curvatures with a special technique. This and its modular conception allow the exhibition to tour through Europe, where it is presented in museums with rooms varying in size and cubature. This flexibility helps to optimize the arrangement of the exhibition.

Since the presentation in Görlitz, the exhibition is covered with a ‘canopy’ of unflammable Contra-H-tissue (inflammation class DIN 4102 B1). This intensifies the visitors’ impression to move through a system of soil clefts and cavities meeting the soil organisms (Fig. 4). The canopy is fixed to a fan of steel, which itself is fixed to the top edges of the panels and to specific pillars. In the ‘Chamber of Life’ (the most variable part of the exhibition), these fans allow a specific adaptation, so this central and largest exhibition unit may vary in size and can be easily adapted to various locations. The canopy of the ‘Chamber of Life’ is black, while all other ‘chambers’ are covered by a white tissue, according to the scenography visualizing the impression of a sterile laboratory or concrete (standing for mostly sealed urban habitats).

For the presentation in Görlitz an entrance (‘tunnel’) was produced consisting of three moveable segments, which can be extended to the length of six meters. Half way through this tunnel, a movie showing soil mesofauna is projected onto a curtain of threads (see 3.4). The exit of the exhibition is tunnel-shaped again (see 3.4).

First presented in Bonn, a children's playing ground (soil pore) was installed, where material is presented produced for education (see below). Furthermore, a 'Soil Cinema' with 30 seats (the size of school class) was included. Here, visitors can take a rest and watch the movies from the exhibition in full length without interference with other visitors passing by.

Since November 2017, here the exhibition presents the worldwide first virtual reality animation on soil organisms. It enables the visitors to virtually meet and interact with representatives of the soil animals (Collembola, Oribatida, Gamasina, Enchytraeidae, Chilopoda) in their natural habitat, the soil pore system, through which the visitor virtually walks. The implemented size relation of about 1:200 gives the impression that the visitor has the size of a woodlouse. Future amendments will show the soil animals of the litter layer and of the tiny water films around soil particles; these parts will be introduced into the exhibition in 2018 (Xylander et al. 2018). The evaluation (see below) certified that the VR animation became a valuable addition to the exhibition.

The development of the exhibition was accompanied by a group of peers from various disciplines, e. g. museum directors and museologists, soil biologists and soil scientist as well as an expert for museum education. The curatorium gave a heterogeneous and valuable input regarding various aspects of presentation, techniques

and transfer; the members encouraged the exhibition team not to focus too eager on scientific correctness but on most suitable forms of transfer to the broadest public. So the contribution of the curatorium to the target-group specific development of the exhibition and its inclusiveness cannot be overestimated.

### 3.2 Target groups

'The Thin Skin of the Earth' addresses to all those who are or should be interested in the ecological well-being of soils: politicians and disseminators in order to provoke the big changes necessary in our legislation and in our thinking, but just as well to the average consumer, gardener, farmer and citizens.

The exhibition was developed for a variety of target groups, but has a special focus on families and school classes (especially from the age of 8 to 10, see e. g. Noschka-Roos 2012); these two groups comprise the majority of visitors in natural history museums; on the other hand we considered them to be the most important groups to address our most urgent messages, because it is one of the exhibition's targets to change the visitor's attitude towards environmental issues following the concept of 'from idea to action'. But 'only information' is insufficient to reach this objective. Therefore, various



Figure 4. Canopy roofing over the 'Chamber of Life' thereby creating the impression of moving through soil pores.

emotional forms of implementation were considered and realized (see 3.4).

To meet the demands of younger visitors, a children's level was introduced (Fig. 5) and about 20 hands-on-elements were included, many of which are installed in a height especially adapted to the size of smaller children. Due to this parallel level for children, parents may find time for orientation and reading while the children are busy using the hand-on-elements or playing in the soil pore. Still, they are not separated from the adults since the children zone walks along throughout the exhibition so that communication and exchange of information is possible in both directions between children and adults.

Educational material and hand-outs have been developed for school classes (see 4.3). Furthermore, the soil cinema not only allows pupils to follow the videos, but teachers often gather their classes here for summarizing the visit or explain special topics.

Although best agers were not among the primary target groups, they became a group of extremely eager visitors of the exhibition. Many of them addressed their comments, impressions, thanks and sometimes critique to the curators via the guest book, email or orally (during the opening ceremonies at the various locations).

### 3.3 International presentation

An international presentation of an exhibition is only reasonable, if the topics, taxa, processes and phenomena are similar (or equivalent *pars pro toto*) across borders, landscapes and regions. The ecological phenomena presented here, such as decomposition, ecological guilds and predator-prey-interrelationships, the major taxa of soil organisms and the destructive impacts of man are similar or even equivalent nearly worldwide. Hence, an international presentation (with moderate modifications) is possible with relatively little efforts of adaptations as it was already documented by an earlier soil exhibition of SMNG (Beneath our Feet), which was presented in 7 European countries (Xylander 2012).

As a consequence, the exhibition was from the beginning planned to be also presented in other countries if possible (e. g. Xylander 2006, 2012) in order to reach a much larger group of visitors and to raise awareness for soil biodiversity, ecosystem services and soil protection.

A general challenge for international touring exhibitions is the easy and non-destructive exchange of languages. For 'The Thin Skin of the Earth' an innovative technique was developed to make the exhibition 'optionally multilingual': On all panels the localization, size and shape of text fields are clearly defined. Into these fields, the translated texts can be inserted. Therefore,

texts are printed on specific foils with micro suckers (Yuko Tako ® XAD 1082) and cut out in the appropriate size. These foils adhere to smooth surfaces without glue. They can easily be removed without leaving traces. The foils are reusable and the whole presentation can be transferred into e. g. an English version within a single day by covering the originally German text fields with the foils (and vice versa). On demand, versions in any other language can be produced; the costs for the transfer into other languages must be covered by the partner museum.

Other forms of presentations (e. g. touch screen animations, movies) can be switched to other languages by replacing the SD-Card.

In 2017, a colored 80 pages exhibition catalogue was published in German and English (Zumkowski et al. 2017a, b). It comprehensively summarizes the content of the exhibition (see 4.4.).

### 3.4 Scenography

'Scenography' describes the use of color, shape, light, arrangement and other effects to stage an idea, topic, object, or element within an exhibition in order to increase the emotional perception of the visitors of the idea behind an exhibition and the representativeness of important objects. So an exhibition's scenography is of great importance to raise awareness for its idea and key message (see e. g. Hilger 2012). In any case, regarding the scenography content/idea, visitors (recipients) and products (the exhibition or any of its parts) have to be considered synergistically (Oswalt 2008).

In 'The Thin Skin of the Earth' four different colors are used to separate the four main modules, the 'chambers'. These colors stand for humus and decomposition (dark brown with included litter, 'Chamber of Life'), soil research and the laboratory atmosphere (light blue, 'Chamber of Knowledge', Fig. 6), soil as structure and the processes of its formation (biscuit brown, 'Chamber of Crumbs') and soil destruction, e. g. by sealing, erosion, pesticides, or compaction (concrete grey, 'Chamber of Horror', Fig. 7). Additionally, in the three latter chambers the panels are arranged in spirals. The decentralized lighting is dimmed in the 'Chamber of Life', but shines in complete brightness in all other chambers.

In the 'Chamber of Life', a black canopy covering this part of the exhibition creates the impression of a tunnel system simulating the slits and clefts, which can be found in the soil as well as tubular structures standing for earthworm tubes. So visitors strolling through the exhibition become a 'part of soil life' themselves. The other three chambers are covered by a whitish canopy.



**Figure 5.** Hands-on-station at the children’s level. Here children can ‘decompose’ wood using a file that symbolizes e. g. the radula of a terrestrial snail. Photo: Jacqueline Gitschmann, Senckenberg.



**Figure 6.** Insight into the ‘Chamber of Knowledge’. The blue coloration of the panels represents the tilings of a laboratory.



**Figure 7.** Impression from the ‘Chamber of Horror’. The grey background coloration of panels stands for concrete and thereby for sealing of soil by urban development. The trash cans contain flat panel displays with short videos on soil erosion and pesticide contamination.

The majority of panels are not straight or standing in right angles to each other, but they are bent forming curved walls implying the ‘organic structure’ of the soil.

The entrance of the exhibition is also an important element. Here, the visitor passes a curtain (of silk threads) onto which a movie is projected showing mesofauna in an endless loop; the springtails and mites in the projection have the size of about 15 cm. By passing the curtain the visitor emotionally ‘enters the soil’. During this passage the visitor ‘shrinks virtually’ and changes his size ratio (1:20). Together with the ‘movement through the soil pores’ this ‘change of size scale’ is the major scenographic trick to realize the inclusion into the unknown world of the soil and thus emotionalize the visitors.

Behind the entrance curtain, many models and organisms are presented in the scale that refers to their respective size ratio (e. g. many springtails, some oribatid mites, the glomerid, the earthworm tip, the mouse head). By this change in size the exhibition meets the challenge that the visitors have to deal with magnified models and must adjust to large and thus often scary creatures they are not familiar with – as they are presented in a size ratio outside their daily experience. The direct response from visitors shows that the majority instinctively understands this scenographic artifice.

Not only the entrance, also to the exit of the exhibition such a scenographic presentation is applied: Again a curtain of silk threads is installed and the projection shows the passage of a camera through the exit of a mouse hole to the litter-covered surface of a deciduous forest. Here, the visit of the exhibition ends and the visitors is ‘transformed again’ to his normal size.

In the ‘Chamber of Horror’ two trash cans are used to present erosion and pesticide intoxication as two ‘elements of destruction’: Flat panel displays are affixed underneath the lids of the trash cans. When raising the lids, the visitor starts a video showing effects of destruction by short video sequences from TV broadcasts.

### 3.5 Adaptation for touring

To develop an exhibition, which subsequently tours for nearly a decade – to reach as many citizens and to spread the idea behind the exhibition as far as possible – is a real challenge: The exhibition is shown at numerous museums with various conditions (regarding e. g. size, shape and height of exhibition rooms, access, and room climate). The curator and her team had to consider from the conceptional phase e. g. the choice of loadable



materials (allowing a fast assembly and disassembly and surviving that about 15 to 20 times), flexibility of element arrangement and modular structure (so that modules may be left out in case of too little space), various illumination in the different museums (natural as well as artificial), security devices installed or the electricity supply for electronic devices of the exhibition.

As the alubond panels may be arranged in various constellations, the flexibility of the exhibition is high. As a speciality, the panels of the 'Chamber of Life' may be built up in a convex as well as in a concave shape, which allows to increase or reduce the space needed for this central part of the exhibition. The panels with the SEM micrographs may be omitted without a significant loss of information. Furthermore, the children's 'soil pore' and the cinema can be arranged in separate rooms close by or they can even be left out.

In any case, the exhibition has to be specifically fit into the condition of every partner museum – a job, which usually takes a week. The partner museums, therefore, have to provide a floor plan to scale of the room. However, the experience shows that the construction team always has to improvise for an optimal fitting into the conditions on site.

### 3.6 Models of soil animals

To show the morphology of soil animals, high quality models turned out to be an important requisite. They present the details of the organism, which normally are too small to be seen without a good microscope. However, installations of microscopes in exhibitions are a technical, economic and security challenge – especially in touring exhibitions. Hence, strongly magnified models are the favorable format to show minute animals, to make them perceptible for the visitors and to popularize the soil inhabitants.

The models of soil animals were exclusively developed for this exhibition by well-known artists and model builders in close cooperation with taxon experts and the exhibition team. Various techniques and materials such as 3D-printing, carving and molding were applied. These models serve as eye-catchers in the exhibition and stand for the different topics (e. g. decomposition, predator-prey-relationship etc.). Some of these models are built from resistible materials and presented unsheltered; they may be touched by the visitors thus realizing the 'hands-on-minds-on' approach (Fig. 8).

The most significant eye-catchers of the exhibition are models illustrating two major topics of the 'Chamber



**Figure 8.** Woodlouse model as hands-on-element. Some models are robust and touching is allowed.



**Figure 9.** Standard arrangement of the panels showing a) a striking headline, b) the subtitle explaining the specific topic, c) major text passage with illustrations as well as digital formats and d) children's level. Photo: Sven Tränkler, Senckenberg.



**Figure 10.** Children's level, here with an integrated hands-on element. The comic shows the way of a soil sample to the museum for extraction of soil animals and investigation procedure. Photo: Sven Tränkler, Senckenberg.

of Life': a) a scene, where a Gamasid mite just catches a springtail with its chelicera (soil predator-prey-interactions; the mold models were made by Esben Horn/Denmark, Fig. 3) and b) a group of decomposers with a pill millipede, an oribatid mite and a testate amoeba (standing for various size groups of decomposers and the phenomenon of sequential sequestration; these models are D-prints by Klaus Leitl/Austria, Figs 2A–C). All these models were newly produced for the exhibition and open a view into the heterogeneity of soil life, which is completely new for the visitors.

Beside these 'artificial models', in the presentations on soil mammals also dermo-plastics are shown.

## 4. Educational techniques, standards and approaches

Regarding the educational formats, priority was laid on diversity and suitability for the topics presented: The exhibitions includes three touch screen monitors, four listening stations, a smell station, a move-sensor animation of biodiversity and a number of soil organisms, an interactive 'diffusion mill', a selfie station with take-home-messages, twelve monitors and nine further hand-on-stations.

In November 2017, the VR animation was added (which is not considered here in detail, but see Xylander et al. 2018). Due to the diversified wealth the visitor remains concentrated and receptive - in spite of the rather high information density the visitor faces in the exhibition.

### 4.1 Panel structure

All text information given on the panels follows a standardized structure:

1. striking headlines attracting the visitor inspire reading
2. subtitles explaining the major theme of the panel
3. the main text presenting and explaining the phenomenon displayed on the panel, whereby the texts are mostly combined with appropriate pictures (Fig. 9 shows 1-3)
4. on many panels, the lowest part is attributed to children (children's level) using comic figures and text passages in 'easy language' but also hands-on-stations (Fig. 10) to address the major information to young visitors

Pictures and graphs of the panels may stand alone and visualize the content, but clearly correspond to the headline and the subtitle. Visualization contributes significantly to

the understanding of the phenomena described. Many of the text passages are written in simple language.

On the 'children's level', a springtail called 'Klara Kugelspringer' and drawings of other soil animals address the take-home-messages for children. Klara Kugelspringer is also the main figure in a booklet for children, which was created for the exhibition (Zumkowski-Xylander 2017).

Specific panels with colored scanning electron micrographs present details of the morphology of soil animals. These panels constitute optional parts of the exhibition and may help to adapt it to the different sites of presentation.

### 4.2 Hands-on-elements

A large number of digital and analogue hands-on-elements allow a visual, acoustic, haptic and even olfactory approach to soil biodiversity, ecosystem services and soil protection (Figs 11 and 12). So children as well as adults may interfere with all their senses (as proposed e. g. by Pankop & Hawig 2017) to allow reflections of all day experiences on biological phenomena and deepen the take-home messages of the exhibition:

- To decompose wood using a file as an analogue of the radula of a snail or the pars molaris of an arthropod jaw.
- To smell defensive secretions of e. g. ants, beetles and millipedes at a smell station.
- To compare the body plan of selected soil organisms with technical solutions (bionic) used in Play mobile toys, e. g. a rotifer moves with its ciliary fields like an underwater scooter with its propellers or the front legs of a mole work like an excavator shovel.

By such interaction, children understand the phenomena and correlate them with their personal experiences. This helps to better understand these phenomena and to allow children to find out by themselves - without additional explanations by their parents.

### 4.3 Material and special educational offers to support the staff at the presenting museums

Comprehensive material for education has been provided for the touring exhibition to support the staff of the partner museums to prepare and teach lessons on soil biology within the exhibition (Fig. 13). This material comprises work sheets for different grade levels (digitally and printed), memory games, puzzles of different complexity as well as a craps where the players accompany a scientist during sampling



**Figure 11.** Hands-on element: A listening post. Photo: Jacqueline Gitschmann.



**Figure 12.** Hands-on element: A smelling post with olfactory samples of various defense secretions of soil organisms.



**Figure 13.** Educational material produced for the exhibition. Photo: Maria Pilz.

and extraction of soil animals. Helga Zumkowski-Xylander developed the game ‘soil builder’ where children have to collect seven ingredients of an intact soil (springtails, mites, minerals, water and air, fungi, bacteria and earthworms) but become disturbed by anthropogenic impacts (e. g. erosion, pesticides, soil compaction or sealing); this game is available electronically within the exhibition and as card game in the museum shops.

An illustrated book for children under 8 years (‘Klaras springtail and her journey’, Zumkowski-Xylander 2017) presents the differences in biodiversity in agricultural landscapes and natural forest ecosystems as well as the consequences of erosion and anthropogenic biodiversity loss.

During the presentations in partner museums, different events were organized for various target groups as a prerequisite for participation of visitors, optimal transfer and inclusion (see also Graf et al. 2012). Guided tours in German, English and Polish were provided as well as offers for visitors with migration background (German as second language). The international schools in Frankfurt and Bonn and the German/Polish- classes in Görlitz already used these offers. For multipliers, e. g. teachers, special workshops were organized to train them how to integrate soil biodiversity into lessons at school and to use the material provided. Especially school classes used the educational program organized by soil biologists of SMNG (in Görlitz, Frankfurt and Bonn) and investigated soil life under the microscope. Furthermore, parts of the exhibition (panels and banners) were provided for NGOs and youth organizations (e. g. ‘Jugend forscht’ and the ‘Youth Parliament of the Alpine Convention’). We are in contact with further partners for such cooperation.

Such special or ‘out-house’ presentations enlarge the audience that shall become sensitized to the soil topics and help the NGOs to work with professional material at low budget level.

#### 4.4 Exhibition guide

An exhibition guide book reflects the exhibition contents and serves as educational material, for advertisement of the exhibition, as general reader on the major exhibition topics and as a document of soil biology, soil science, research and protection that may survive the exhibition itself.

The German version of the 80-page booklet was printed in spring 2017, the English version in October 2017, just in time for the World Climate Conference COP23 in Bonn. It reflects the majority of panels although it does not copy them 1:1. The copyrights for pictures used in the exhibition had mainly been extended to the printed guide. Some photos were, however, not reproducible and instead new pictures and figures were included.

The President of the EU Commission, Dr Jean Claude Juncker (who also intended the opening ceremony at the EU-Parliament in Brussels in October 2015) as well as the Federal Ministers of Science and Education, Prof. Dr Johanna Wanka, and of Environment, Dr Barbara Hendricks, wrote welcome addresses for the guide indicating their acknowledgement of the topics reflected by the exhibition (especially of soil protection, see Zumkowski et al. 2017a, b).

#### 5. Presentations in other museums, advertisement and evaluation

The exhibition has been touring since October 13<sup>th</sup>, 2015 and was shown at six locations in Belgium and Germany (Tab. 1). Until now, more than 120,000 visitors saw the exhibition. Three museums from Germany and other European countries have ordered it for future presentation; so it is completely booked until summer

**Table 1.** Exhibition sites of ‘The Thin Skin of the Earth’

City	Institution	Period of presentation
Brussels	EU Parliament	13.10.2015 – 20.10.2015
Chemnitz	Naturkundemuseum ‘Tietz’	24.10.2015 – 08.05.2016
Görlitz	Senckenberg Museum für Naturkunde	11.06.2016 – 08.01.2017
Frankfurt	Senckenberg Naturmuseum	19.01.2017 – 23.07.2017
Bonn	Museum Alexander Koenig	06.09.2017 – 28.01.2018
Dessau	Umweltbundesamt	19.03.2018 – 04.06.2018
Osnabrück	Museum am Schoelerberg	13.09.2018 – 22.03.2019
Dresden	Senckenberg Naturhistorische Sammlungen	March 2019 – Oct.2019
Graz	Universalmuseum Joanneum	Oct. 2019 – July 2020

2020. Interests from further institutions are indicated. Presentation of the exhibition is intended until 2023.

The ordinary loan period is five to six months per location. In between, periods for dismantling and construction as well as adaptations for the next locations are necessary. The museums pay a loan fee which covers all costs and compensates for wear and tear. A commercial benefit is not intended.

For advertisement of the exhibition, print media such as posters (by Bernd Pöppelmann, Fig. 14), flyers and postcards have been developed, which may be adapted according to the demands of the presenting museums.

Special events for the regional media and target groups (press conferences, introductory events, previews) had a good resonance. Especially after the openings, but also during the presentation the exhibition received a very good response by the media. Various journals with focus on the museal scene reported on the opening activities, on content and scenography of the exhibition as well as on the VR installation.

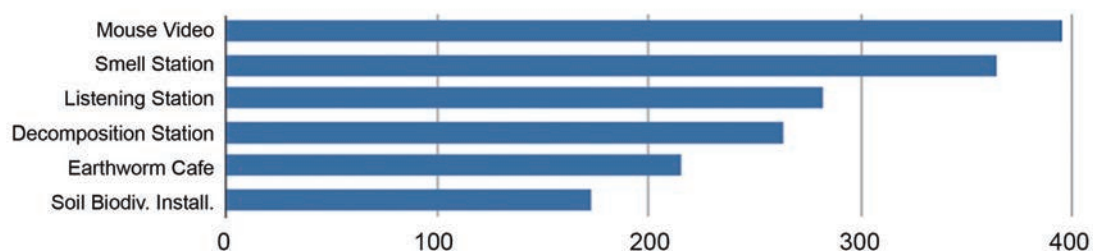
During the presentation in Bonn 'The Thin Skin of the Earth' was part of the official program of the world climate conference (UNFCCC Calender COP23).

## 5.1 Evaluation

During its presentation in Bonn, the exhibition was evaluated (Nagy 2018, unpubl.) using questionnaires and interviews to interrogate the visitors' response ( $n = 124$ ) and measuring the time of residence of visitors inside the exhibition ( $n = 34$ ). Due to organizational reasons school classes could not be included into this evaluation. The results presented in spring 2018 on 52 pages confirmed the assessment by the curatorium - based on the view of visitors.

The evaluation showed that:

1. Families were the dominant group (comprising 68% of the visitors).
2. On average, children were more attracted by the exhibition as they were staying longer than adults in the exhibition.



**Figure 15.** Ranking of the six media from the 'Chamber of Life' most often recalled in the interview. More than 80% are hands-on elements. For methods applied see Nagy (2018).



**Figure 14.** Painting by Bernd Pöppelmann for the exhibition used for advertisement and print material. Original Bernd Pöppelmann, Graphic adaptation Ekkehard Mättig, Senckenberg.

3. The hands-on-elements were intensively used and recalled. Of all the exhibition units, hands-on-elements were most often recalled in the interviews (with 75% to 83%, depending on the chambers, Fig. 15).
4. The magnified models of soil animals promoted the interest for the unknown and the invisible in general, but the individual models recalled differed depending on the age of the visitors interviewed.
5. The highest impact (memory effect) had a short movie showing a couple of gravedigger beetles burying a mouse.

In total, the evaluation shows that the exhibition meets the interests and demands of the target groups considered. Hands-on-elements are extremely suitable to increase consideration, internalisation and remembrance of the soil subject. Especially crucial topics such as soil protection, conservation and destruction were transferred to the visitors appropriately by the media applied.

The virtual reality installations (VR) supplemented the exhibition as it generates emotional experiences with animated soil animals and a fascinating journey through the visualized soil pore system. The exhibition causes interest and sensitizes for the problems of soil protection, misuse and destruction. The evaluation protocol ended with the statement: 'The majority of visitors was excited and would like to see the exhibition a second time.'

## 6. Conclusions

1. A touring exhibition is an appropriate format to address the items of soil biodiversity, ecosystem services and soil protection to a broad audience. For successful long-term touring various prerequisites have to be realized.
2. Various forms of educational approaches are necessary to maintain the visitors' concentration and reach a maximum awareness, e. g. high quality models of soil organisms, digital and analogue hands-on-media, movies, and VR.
3. Scenography increases the immersive impact. By the size-scale-transfer at the entrance, by arrangement of the largest part of the exhibition as a walk-in 'soil pore', by use of colors, illumination, arrangement of models and media visitors feel like being a part of the soil themselves, thereby increasing the deepness of emotional inclusion. All this raises the awareness for the soil subject.
4. Educational material for different purposes and target groups (e. g. work sheets, games, exhibition guide books) is needed to support the educational staff of the partner museums. Especially the printed guide constitutes a format that may serve as material to reflect the content of the exhibition and its take-home messages.
5. External interdisciplinary expertise is helpful (if not indispensable) to focus not only on scientific correctness but also on a maximum success in transferring the message to a broad audience. An external evaluation finally measures the success of the approaches; it may be used to adapt the exhibition to optimally meet the visitors' demands and the transfer of the key messages.

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