

# POTATOES

***A life cycle assessment  
for all who are interested***

**Developed within the project**



**[www.lca-meets-efs.net](http://www.lca-meets-efs.net)**



**Dear pupils, trainees, students, colleagues and all who are interested!**

With this handout we would like to introduce you to the LCA learning offer on the topic "POTATOES - regional or from the desert".

With the 2030 Agenda, sustainable development is being increasingly focused on and expanded to include new concepts and strategies. Processes in everyday life, technology and industry are to be transformed toward sustainable practice. Evaluating this, however, is not an easy task. In recent decades, however, techniques have been developed for this purpose, which, when they include all relevant impacts of a process or product in the consideration, are referred to as Life Cycle Assessment (LCA). Central to the transformation of our world today in terms of sustainable development is chemistry and the sciences and economic sectors associated with and based on it. Chemistry also needs to become more sustainable; this is being done through the concept of Green Chemistry (also Sustainable Chemistry). Since Agenda 21 already outlined how important education is for the sustainable development of our society, a change in thinking is also taking place in chemistry and a new area in chemistry-related education is increasingly being implemented in many countries: Green Chemistry Education (GCE).

GCE includes knowledge of a changed view of chemistry, for example in the field of chemical synthesis and production in research and industry. Closely related to this are also competencies in the environmentally sound, legally compliant and safety-related treatment of chemicals and chemical production processes. So far, however, assessment strategies in the context of sustainable chemistry, such as LCA, have hardly been the subject of GCE. The aim of the project is the development and implementation of a digital learning environment on assessment strategies and methods for the handling of chemicals and chemical-related processes. This concerns both the LCA and integrated methods, such as the CO<sub>2</sub> or water footprint.

A website [www.lca-meets-efs.net](http://www.lca-meets-efs.net) introduces the topic at different levels. It introduces central concepts and methods and explains these with examples.

In the following, we will *briefly* explain the student laboratory "*Life Cycle Assessment meets Education for Sustainability*" in short *LCA-meets-EfS*, the design of the student laboratory offer and safety-relevant aspects regarding behavior in the laboratory for the practical part. We would be very pleased if you would visit the student laboratory,

the project team of the student laboratory "FreiEx" at the University of *Bremen*

## **I. The student laboratory "FreiEx" in the chemistry didactics of the University of Bremen**

A student lab is a non-school learning environment that includes a pre-structured learning offering. The special feature of a student lab is that it complements school-based and non-school-based learning and is tailored to the specific learning requirements of the students. This implies a didactic design of the learning offer.

The student lab offering is designed in such a way that it can be flexibly adapted to different learning groups and also has a high degree of internal differentiation. The digital teaching and information elements, experiment instructions and supplementary materials are intended to challenge students to learn about topics in the sustainability debate and to be able to orient themselves in corresponding subject areas. The target groups for these student lab offerings are school and out-of-school learning groups, trainees, and students of scientific and technical disciplines.

## **II. The LCA material for faculty and users**

Based on current issues in the climate and sustainability debate, this handout on the LCA learning module "POTATOES - regional or from the desert" is intended to provide an introduction to the complex topic of life cycle assessment. The module can be worked on completely or only in selected subtopics. The material is suitable for learners from secondary level 9/10 of general and vocational schools and higher education.

**For teachers/trainers/lecturers/course instructors, the learning offer contains the following documents and materials:**

- Teacher information LCA learning offer "POTATOES - regional or from the desert".
- Course plans for the learning unit with suggestions for getting started, for implementation and for securing knowledge with solutions and time details
- Materials:               Work Sheets (fact check, endpoints condensed, argumentation sheet).  
                                  Print templates (world map, value chain)  
                                  DATA-SETS for calculative processing via Excel, Numbers and Sankey
- Argumentation aids and background information on the relevant endpoints
- List of data sources, media offers, further literature, order addresses

The worksheets SECTION 1-4 with the two print templates and the DATA-SET are meant to guide and support the learners in shooting the facts about their product or considered endpoint. Of course, the pupils / students are free to design their analog or digital MindMaps. Each group member can thus contribute his or her individual strengths - be it analytical, organizational, creative, linguistic - to the group work. Internal differentiation is possible in the school context.

Sustainability is important - but rarely simple. With the module "POTATOES - regional or from the desert", the LCA-relevant endpoints land consumption and virtual water for the production of these power tubers can be developed in a low-threshold and detailed manner. Due to the complexity of this module, the emissions analysis of the GHGs and the CO<sub>2</sub> footprint was deliberately omitted.

**Course Plan " POTATOES - regional or from the desert".**

PHASE	SUB TOPIC	MATERIAL	DURATION
<b>Entry</b>	Potatoes - varieties, taste, ingredients → Products from it	Survey	10 min
Tasting	Sample different potato varieties (early, late, firm floury): Determine test criteria, evaluation	Kitchen / Laboratory	20 min
Video clip	World of Wonders (2015) <a href="https://www.youtube.com/watch?v=BFbalwHu72A">https://www.youtube.com/watch?v=BFbalwHu72A</a>		10 min
Video clip	NABU planting instructions for potatoes on terrace & balcony <a href="https://www.youtube.com/watch?v=dF5esaAaWRM">https://www.youtube.com/watch?v=dF5esaAaWRM</a>		3 min
<b>Group work</b>	<b>Division of the 5 working groups with 4-6 participants</b>		
	Part 1 Virtual water & water footprint		
Fact Check	POTATOES: How are they produced and what conditions prevail in the growing countries Egypt, Israel and Germany?	AB 1	15 min
Info	The image of the potato: ingredients and nutritional values. Personal preferences and competition from pasta & rice.	Survey 2	10 min
Info	Water footprint of the growing regions in comparison	FROM 2 + DATA SET	15 min
	Part 2 Land consumption		
PRODUCTION	World map: Using the DATA SET, each group identifies the main producing countries	Research	10 min
Info:	and enters the data in the world map. Growing regions in comparison	FROM 3 + DATA SET	10 min
<b>RESULTS</b>	Fill in number tables, enter ratings in the overview	AB 4	15 min
<b>CONCLUSION</b>	<b>Group discussion / expert round / group puzzle</b>		<b>30 min</b>

In addition, the materials prepared as basic knowledge can be used to explain the endpoints "virtual water & water footprint" and "land use" considered in this module offering.

**To get started**, the learning group should/could approach the topic "POTATOES - regional or from the desert" through surveys, impulse film, planting instructions, etc. Suggestions for appropriate research questions are noted on the progress plan. Practical activities in the (school) garden or tastings arouse curiosity and are fun. With the division into groups and the handing out of the materials or delivery of links on the website, each group gets access to the work folders deposited there. **(Time requirement 1 double hour)**

**Group work** In the web folder you can find the worksheets (SECTION 1-4) of this module offer "POTATOES - regional or from the desert" for the two endpoints "Virtual water" and "Land consumption" with the DATA SET. The sub-topics in designed in such a way that both the group processing of a sub-topic itself can take place or - if it is too difficult - within a sub-topic only one producer country per group can be considered. The producer countries Egypt, Israel and Germany are available for selection. How many and which countries are worked on depends on the individual size and interest of the learning group.

- **SECTION 1 is a FACT CHECK.** A headline with research question(s) leads to the text. This contains the most important information about the product/endpoint under consideration and about ingredients, growing areas and conditions in a condensed form. Learners can/should prepare the **results of their research** for the final group discussion. A **print template "world map"** should be equipped with the identified production countries and data (as .pdf).
- A **"Value chain"** for raw material, water, energy and material flow analysis as well as the process-relevant parameters "energy demand, fresh & waste water flows, aggregates, yields, disposal, transport, emissions" are to be presented in production flow diagrams. The **print template "Value chain"** (also as .pdf) contains prepared buttons with starting material, possible work steps up to the customer. Extensible/optional is the end-of-life consideration of the packaging to add.
- **SECTION 2 & 3 are DATA SHEETS.** The information required to perform a simple LCA analysis (with area and water requirements) is presented in tabular and graphical form.
- The **DATA SETs** created for this purpose initially focus on the three production countries under consideration with the respective cultivation conditions. The required data were determined from the databases ecoinvent, SimaPro 5, umberto, ESU - Sense as well as faostat. The aim is to harmonize these suitable data in a meaningful way so that they can be successfully converted and graphically processed by learning groups in order to present a basis for the evaluation and discussion of the LCA endpoints considered here [land use, virtual water].
- A summary worksheet **SECTION 4** for the three production countries to be considered in this set is part of the documentation. **SECTION 4** forms the basis for the final presentation and group discussion. On it, facts are recorded in tabular form for the evaluation criteria "Ecological & economic, health reasons". This should be an aid for the comparative evaluation and classification of the relevant production data.
- The final **presentation of the results** (via keynote, PowerPoint, padlet or as a poster) and **discussion** (as a group puzzle / panel discussion / expert round) succeeds in communicating the results from the individual group work to the entire learning group. The argumentation aid AB 4 can provide the pros & cons of the respective production country in an expert round. (Time required: 2 double lessons).

### III. The LCA relevant terms

In this "beginner" LCA set, the endpoints area and water use are considered. Detailed emission considerations in connection with POTATO cultivation are available in the advanced module.

**Endpoint land use:** The consideration of yields or yields generated per hectare provides information about the effectiveness of a producing country. In this module offering "POTATOES - regional or from the desert", a distinction is to be made between the growing conditions in the three growing countries considered. Learners must choose which country has authoritative production figures and why. Soil quality, local climatic and geological conditions are decisive for the level of crop yields. But irrigation, fertilization and crop protection measures, as well as the use of GMOs, also have a significant impact on yield performance. These cause overfertilization and acidification of the soil used for agriculture. Food production also competes with other forms of land use such as agricultural energy production or the conservation of natural areas.

**Water footprint endpoint - virtual water (water availability):** Water, especially clean drinking water, is increasingly perceived as a scarce and valuable commodity worldwide. However, water is also used in large quantities in the manufacture of products. The Water Footprint primarily takes into account only the amount of water used, with a distinction being made between

- Surface and groundwater (blue water)
- Rainwater (green water)
- polluted water (grey water)

must be distinguished.

There are very different water requirements for potato fields in the two desert countries considered. Yields in the producing countries reflect the status of irrigation techniques. In Egypt, fields are surface irrigated with sprinklers and, depending on the time of day of irrigation, the evaporation rate is up to 70%! The water needed is pumped up from depths of up to 1,000 meters. As a result, wells are increasingly drying up, depriving the population of urgently needed drinking water. In Israel, on the other hand, the water is administered selectively and with little evaporation using drip technology. This makes it possible to grow this water-intensive fruit even in a desert climate.

Potato cultivation is limited by a large number of pests, weeds and rot fungi, which can only be countered by massive use of pesticides (especially herbicides and fungicides), which lowers soil quality and especially increases the proportion of "gray" water. Downstream water treatment in the growing regions, especially in Egypt, is often inadequate or non-existent.

### IV. Notes and literature on the technical background

- Welt der Wunder <https://www.youtube.com/watch?v=BFbalwHu72A> (2015) NABU Potato cultivation on terrace and balcony (2018) <https://www.youtube.com/watch?v=dF5esaAaWRM>
- S. Ahrens (2021) <https://de.statista.com/statistik/daten/studie/175422/umfrage/pro-kopf-verbrauch-von-kartoffeln-in-deutschland/>
- Chef - March 21 issue; Green side - early potatoes from Egypt
- Poore, J. & Nemecek, T. (2018) *Reducing environmental impacts of food by producers and consumers*. Report and dataset at <https://science.sciencemag.org/content/360/6392/987>
- <https://en.wikipedia.org/wiki/Potato>
- <https://wikifarmer.com/?s=potatoes>

