

Learning Card 2: Mapping of Chemicals and Chemical Flows

Orientation

What can this unit help you with?

You may use this unit if you

- Have to understand the purpose and concept of process flow mapping;
- Have to familiarize with practical mapping tools like: eco-mapping and flow diagrams.

Intended results of the unit

- Students can prepare eco-maps by visiting a factory;
- Students can prepare process flow diagrams for a factory.

The analysis and documentation of the chemical process flows lays the ground work for inventorying of chemicals and establishing chemical management system framework for promoting responsible usage and prevention of adverse impacts on environment, health and safety as well as losses in a factory. This also makes it easier for us to later identify and document hazard/risks related to entire range of production processes, products, Non-product Outputs (NPOs) activities under the purview of a company as well as plan and monitor the improvement measures.

1. Eco-mapping
2. Process flow diagrams.



An eco-map is a simple, practical tool for visualisation of process flows. It is good to use in resource efficiency, OSH and/or chemical management for identifying and documenting the prevalent situation and issues, identifying and analysing common issues and priority, selecting and planning areas for improvement, monitoring progress of implementation, auditing and reporting.

2. Then we need to consider using different maps to create a useful multi-layer set of graphical information (e.g., for chemicals, water, energy, air, wastes).
3. We need to prepare or verify during an initial factory/site walk-through.
4. We also need to collect and fill in additional information, using guiding questions and observations on site. It is better to involve staff and workers on-site in different processes or production areas.

We also need to take into consideration of the general location of our factory in the area. We can ask the following questions for that purpose:

- Any water bodies around the compound?
- Housing areas? Schools?
- Neighbouring industries?
- Roads used by the company?
- Other...



Figure 3: Example of symbols used in eco-mapping. Source: Resource Efficient Management of Chemicals in Textile and Leather Sector Companies by GIZ

We also need to decide and agree on our own standard symbols beforehand and use them consistently in all maps. For example: to indicate gravity of observed “hotspots” we can follow these conventions:

- Hatched lines: small problem (area to be monitored, problem to be studied)
- Circle: large problem (stop, corrective action)
- The more serious the problem: the thicker or larger the circle or symbol will be.

What Is Process Flow Diagram?

The process flow diagram represents a schematic of the production/process steps, different inputs, intermediary products, final product, and non-product outputs (defined as materials that

do not end up in the final product). It allows us to prepare mass balance and/or cost analysis and identify where we can encounter opportunities for cost savings.

How to Prepare a Process Flow Diagram

To make a process flow diagram, we need to follow these steps:

- (1) We need to draw a general outline of our production process first. We can always prepare separate and more detailed diagrams for each production steps and process.
- (2) We have to include inputs, outputs and non-product outputs. In the second step, we can start differentiating and detailing these.
- (3) Then, we have to indicate quantities and/or value of inputs, outputs, non-product outputs as far as already known to us. In batch processes, in which the input and quantities may vary from product to product, this may not be feasible.

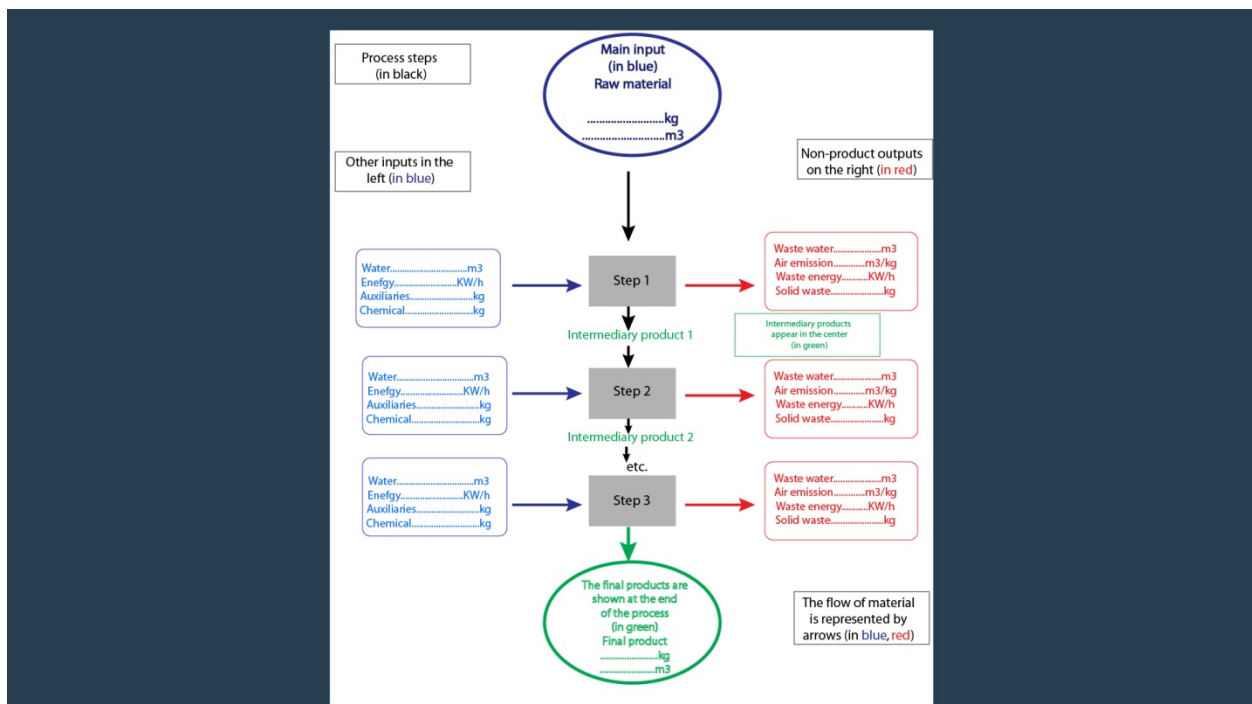


Figure 4: Preparing a process flow diagram. Adapted from: Resource Efficient Management of Chemicals in Textile and Leather Sector Companies by GIZ

Some Practical Tips

Processes/process steps in a process flow diagram are represented by squares and flows are represented by arrows. Inputs (raw materials, water, energy, chemicals) are put on one side. But main input comes from above. In a process flow diagram, the intermediary products are located

below each process. The NPOs are kept as output to the right side of the diagram. Lastly, the final product comes from the process.

Checking Whether the Process Flow Diagram Contains All Relevant Information

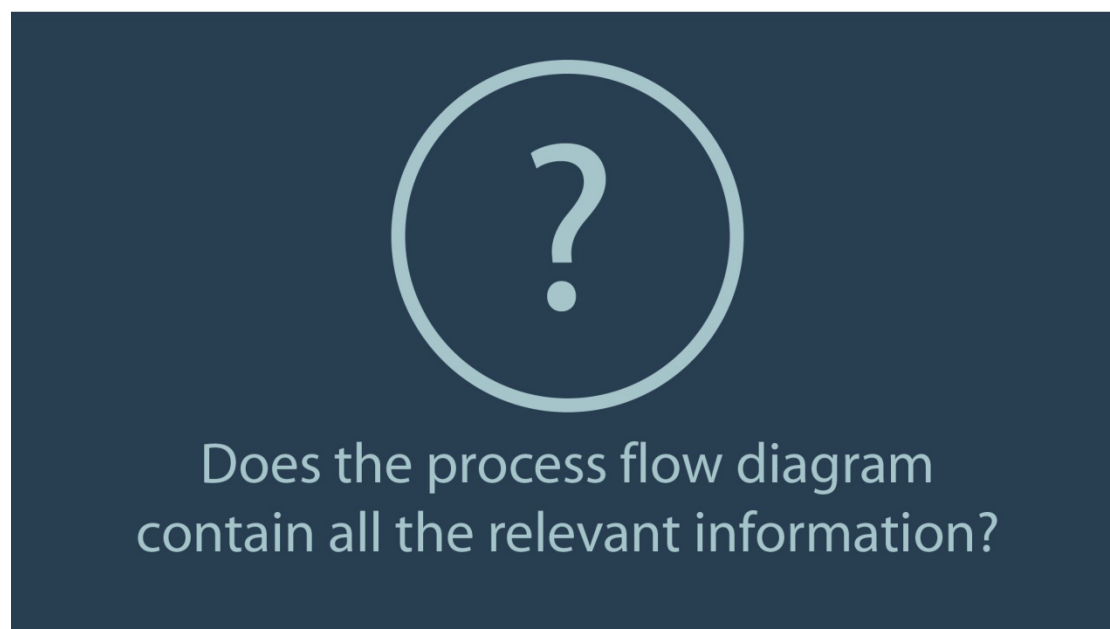


Figure 5: Does the process flow diagram contain all the relevant information? Courtesy: Kazi Farhan Hossain Purba.

To check whether the chemical flow diagram contains all the relevant information, we need to ask ourselves the following questions:

- Have all important inputs in each production process been considered?
- Can we recognize the sources of the non-product outputs?
- Have we been able to quantify inputs, outputs and non-product outputs?
- Can we assign monetary values to the inputs, outputs and non-product outputs?
- Are there any information gaps for which we need to collect further information?

Conclusion

To lay the groundwork for inventorying of chemicals and establishing a chemical management system framework for promoting responsible usage and preventing adverse impacts on the environment, health and safety, and losses, we need to map chemicals and chemical flows. We also need this to support identification and documentation of hazard/risks related to an entire range of production processes, products, non-product outputs (NPO) activities under the

purview of a factory. The information collected by making eco-maps and process flow diagram will work as a foundation for our next learning units.

Didactical Elements

Quizzes and Self-Tests:

True-False

1	For preparing eco-maps, we are always bound to make new ground and floor plans to facilitate identification and visualization of environmental problems every time within a company.	
	<ul style="list-style-type: none">▪ Correct▪ False	False
2	Non-product outputs are defined as materials which do not end up in the final product.	
	<ul style="list-style-type: none">▪ Correct▪ False	Correct
3	Eco-map is used in monitoring progress of implementation, auditing and reporting.	
	<ul style="list-style-type: none">▪ Correct▪ False	Correct
4	To make a chemical process flow diagram, we need to draw a general outline of our production process first.	
	<ul style="list-style-type: none">▪ Correct▪ False	Correct
5	We can't decide our own standard symbols and use them in our eco-maps because the symbols are already set by the authority.	
	<ul style="list-style-type: none">▪ Correct▪ False	False

Choose Multiple

1	The process flow diagram represents: (Choose multiple)	
	<ul style="list-style-type: none"> ▪ A schematic of the production/ process steps ▪ Fire-fighting devices ▪ Different inputs ▪ Intermediary products ▪ Final product ▪ Non-product outputs ▪ Appropriate PPE 	<p>Answer:</p> <ul style="list-style-type: none"> ▪ A schematic of the production/ process steps ▪ Different inputs ▪ Intermediary products ▪ Final product ▪ Non-product outputs

Sorting Tasks

Sort the words to the correct sentences:

respiratory	practical	resource	priority	documenting	flows
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1. An eco-map is a simple, __ tool for visualization of process __.
2. Eco-map is good to use in __ efficiency, OSH and/or chemical management for identifying and __ the prevalent situation and issues, identifying and analysing common issues and __, selecting and planning areas for improvement, monitoring the progress of implementation, auditing and reporting.

Answers:

1. practical, flows
2. resource, documenting, priority.

Exercise

Read the situation below and complete the tasks:

Welcome to 'Beautiful Colours', a small textile company that specializes in dyeing and printing fabrics. The top management of "Beautiful Colors", has engaged you for helping them in chemical management. To better understand the situation at hand, you organize a meeting with the company management and visit the factory. During the first walk-through of the factory, you have observed and noticed the following:

1. There is a general storage area where the raw material and chemicals are received. When the suppliers deliver chemicals, the company workers straight-away places these in-store without any further quality control. One of the workers points out the red symbol with the black exclamation mark on a chemical bag, wondering its meaning, but the store supervisor does not know. The storage area is quite full. In the front yard, the workers have stored two containers with Aniline and Acetone.
2. All the dyes and chemicals are stored in bags and containers next to the fabric material, directly on the floor. Since the last rainy season, the roof of the storage area has been leaking. A few bags got wet and were put aside in a corner. New materials have already been ordered. John, the most skilled worker, is the only one who can identify different chemicals even though labels or markings on many chemical containers are damaged, missing or in a foreign language.
3. Because of his long experience, John hands out the chemicals needed in the dyeing or printing process to each worker individually. In case of any questions regarding the chemicals, everybody checks with him. When inquiring about material safety data sheets, he indicates that there seems to be a folder somewhere in the manager's office, but he does not know exactly. You see some chemical containers with acetic acid and dyestuff such as reactive black and basic yellow.
4. Once the workers have received the chemicals, they carry these in open and unmarked buckets to the respective production areas. In the dye kitchen, the colour baths are prepared by mixing water with dyes and auxiliary chemicals. Johan is responsible for preparing the chemicals used in these operations –a task that demands most of his time and is done according to recipes based on long years of working experience. After all these years, Johan is not very enthusiastic about his job. He sometimes does not pay attention to mixing the exact quantities of chemicals, adding more or less than "usual". Sometimes he lets one of the helpers do the mixing. The staff keeps a few open bags and containers of powdery dyestuffs and other chemicals in the mixing place. Sometimes, bags get spoilt when they have been lying on the wet floor for too long. To clean the dye kitchen from dust and spilt materials, the floor is swept by the cleaning personnel every week. When you leave the dye preparation area, you notice that your white shirt is covered with black dye particles.
5. Abebe, responsible for dyeing the fabric, wears boots, saying it makes him feel better and safer, unlike his colleagues, who wear open sandals. Abebe adds other auxiliary chemicals (salt)

for colour fixation during the dyeing process and regulates the temperature of the heated dye bath in the machine. Dyeing is done in old, open machines, which use large amounts of water. Every now and then, the machines start leaking. When the leakage in the machines gets too big, it just gets fixed in an improvised way by Beca, who is in charge of general maintenance. Occasionally, when the colouring vessels are filled too much, liquids spill out of the vessels onto the floor. Lots of water and spillages end up on the floor, making it slippery and keeping the cleaning staff very busy all day. Once the process is complete, the waste dye liquor is drained into the drainage going to the treatment plant. It is estimated that up to 40% of the dyes and 80% of the auxiliaries end up in the wastewater.

6. The cleaners also hose the floor, with the wash water flowing out into the sandy factory yard. The cleaning effluent goes directly into the nearby drainage. The drainage is often blocked by some old packaging, and the cleaning effluent flows into the yard.

7. After dyeing, the next step is drying the fabric, which is done outside in the open air, before going to printing. While you walk from the dyeing to the printing area, you slip several times on the wet floor.

8. In the printing area, you meet Caleb, who is the production supervisor. There is a small “colourful” area at the entrance of the printing areas where a helper is mixing the printing paste as per instructions from Jeff. Apart from a container with 2-Naphthol and Sodium hydroxide, there is one more chemical container without a label but some handwritten sign. You observe how several female workers carry out manual screen printing. You immediately notice the solvent smell in the air. An exhaust fan is mounted on the rear wall, which blows the air to the outside toward the neighbouring building. You also see some containers with dry printing paste lined up on the rear side of the room. When inquiring about the containers with the workers, they indicate that they often prepare too much printing paste. The left-over paste is collected and thrown out with the waste into the yard every now and then. Since you start feeling dizzy in the printing area, you proceed to the backyard.

9. On the way to the backyard, you pass the product storage area, the entrance to the product storage area, and the walkways are rather narrow, so workers carry heavy bundles of materials in and out. Apart from the final products and spare parts, you also see one container with Citric acid and one container without any label.

10. The factory has a simple wastewater treatment plant (ETP) built ten years ago located in the backyard. Beca, who is in charge of general maintenance, also seems responsible for running the effluent treatment plant. During the treatment process, the ETP staff adds some chemicals to adjust the pH and some other chemical to help the settling of solids. You note that the electrical control panel is quite corroded and hangs on one hinge. It seems that it will fall off anytime. Also, the railings of the walkways over the treatment tanks are quite corroded and partly missing. The treatment sludge from the wastewater treatment process is dried and stored in the factory yard and taken away for land-filling. Some solid wastes, including the packages of some hazardous chemicals, collected every week by the local garbage collector.

11. According to the manager, the company gets its process water from a ground well in its compound. Electricity is provided through the company's own diesel generators. When the chemical containers in the storage area are empty, some workers take them home to use them as storage for drinking water. Before doing so, they do some basic cleaning of the empty containers by washing off the remainder chemicals with tap water in the factory yard. Empty chemical bags are thrown out into the factory yard and burned in the corner of the yard from time to time, and other types of waste (e.g. plastic wrappings, office papers) collected from the different parts in the factory.

12. On your way home, you stop at the tea stall next to the factory and get in conversation with some local people from the neighbourhood who share their concerns about the daily colour changes of the river water and the chemical smell from the factory.

Your tasks

As a first step, you assist the company in understanding the situation by documenting the process flow and systematically identifying and documenting chemicals stored and used and chemical waste as in the organization/company.

For this purpose:

1. Review the information provided to you,
2. Identify the location and flows of chemicals and chemical (containing) waste,
3. Document the process flow,
4. Recognize and point out possible NPOs and chemical hotspots (defined as areas that pose an immediate risk to the environment and health),
5. Identify the internal key stakeholders and decide who should be involved in the company's chemical management change team,
6. Present your finding to the management (plenum).

Hotspots

Which one allows us to prepare mass balance and/or cost analysis as well as identify where we can encounter opportunities for cost savings?

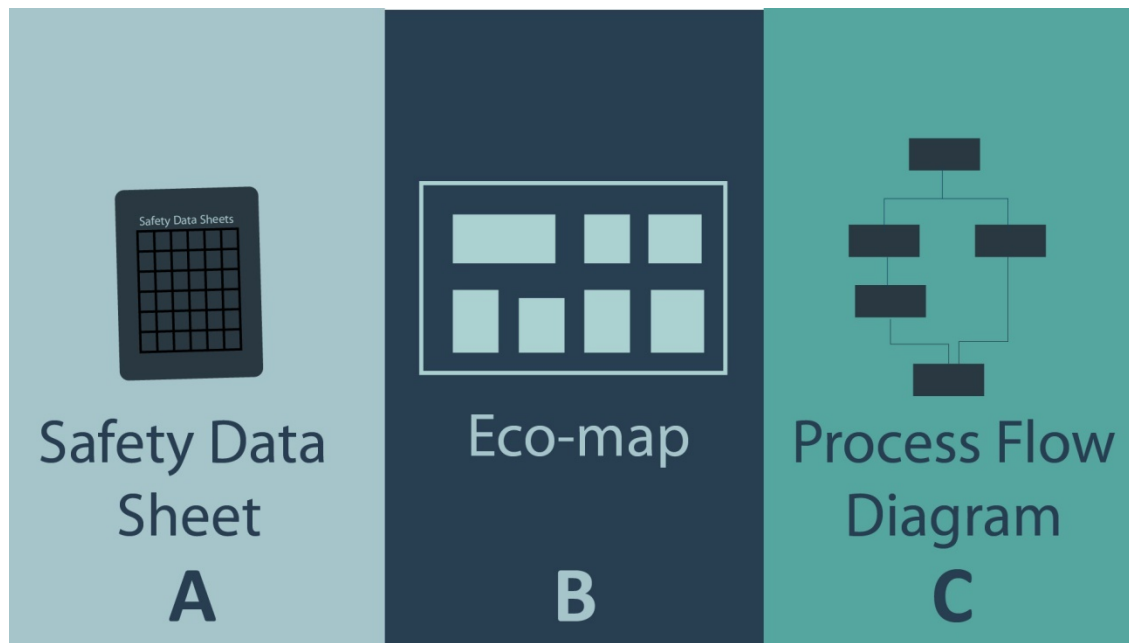


Figure 6: Hotspot. Courtesy: Kazi Farhan Hossain Purba.

Answer: C.

References/Additional Literature/Links

1. More information on eco-map, chemical flow process and hotspots can be found from this link: <https://www.sia-toolbox.net/solution/resource-efficient-management-chemicals-textile-and-leather-sector-companies>. By downloading the REMC Company Handbook from the 'Further information section', you can read section: 2.1 for that purpose.
2. To know more about eco-mapping, you can visit this link: <https://www.sia-toolbox.net/solution/eco-mapping> and from 'Further information' section you can download Eco-Mapping Guideline (2002).
3. To know more about chemical flows, you can go to this link: https://www.sia-toolbox.net/sites/default/files/04_chemical_flows_en.pdf

Unit Feedback

If you wish you can give us feedback on the learning unit here. This is of course, optional.

Technical Elements

How did the technical elements of the unit work for you? Did you have any difficulties?

Didactical Elements

How did the didactical structure of the learning unit work for you? Do you have any comments or suggestions to make it better?

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