OUTPUT 3:
AQUAPONICS CURRICULUM

AQU@TEACH:
Innovative educational techniques to promote learning among European students using aquaponics
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INTRODUCTION

How to use the Aquaponics Curriculum

This Aquaponics Curriculum is intended for tertiary level teachers who intend to introduce basic aquaponics to their students. Aquaponic food production is complex and requires a broad spectrum of knowledge in order to understand and manage the processes involved, including aquaculture, horticulture, chemistry, biology, food safety, and engineering. The student workload for the entire curriculum is 150 hours, corresponding to 5 ECTS, and is divided into 15 modules:

<table>
<thead>
<tr>
<th>Module</th>
<th>Topic</th>
<th>Total student workload (hours)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Aquaponic technology</td>
<td>8</td>
</tr>
<tr>
<td>2</td>
<td>Aquaculture</td>
<td>12</td>
</tr>
<tr>
<td>3</td>
<td>Fish anatomy, health and welfare</td>
<td>8</td>
</tr>
<tr>
<td>4</td>
<td>Fish feeding and growth</td>
<td>10</td>
</tr>
<tr>
<td>5</td>
<td>Nutrient water balance</td>
<td>7</td>
</tr>
<tr>
<td>6</td>
<td>Hydroponics</td>
<td>13</td>
</tr>
<tr>
<td>7</td>
<td>Plant varieties</td>
<td>10</td>
</tr>
<tr>
<td>8</td>
<td>Integrated pest management</td>
<td>8</td>
</tr>
<tr>
<td>9</td>
<td>Monitoring of parameters</td>
<td>8</td>
</tr>
<tr>
<td>10</td>
<td>Food safety</td>
<td>12</td>
</tr>
<tr>
<td>11</td>
<td>Scientific research methods</td>
<td>10</td>
</tr>
<tr>
<td>12</td>
<td>Design and build</td>
<td>13</td>
</tr>
<tr>
<td>13</td>
<td>Urban agriculture</td>
<td>10</td>
</tr>
<tr>
<td>14</td>
<td>Vertical aquaponics</td>
<td>7</td>
</tr>
<tr>
<td>15</td>
<td>Social aspects of aquaponics</td>
<td>14</td>
</tr>
</tbody>
</table>

It is recommended that the curriculum be taught according to a fixed timetable, such as one module per week or per fortnight, depending on the number of student hours required, in order to maintain student momentum. The deadlines for the completion of activities in each module will therefore need to be set in Moodle before commencing teaching. While the curriculum has been designed to be asynchronous, it may be worth considering timetabling the Moodle forum as a synchronous activity in order to allow for real time interaction between you and your students.

The curriculum has been designed as a cohort-based e-learning course. However, it can also be taught using blended learning (for more details see General Concept of Learning and Teaching Method, below). If institutions have appropriate facilities, then the curriculum can be accompanied by experimental work, either using Aqu@teach O7: Standard Operating Procedure for Student Experimental Work or an alternative SOP. In this case, the suggested order of modules is as follows:
<table>
<thead>
<tr>
<th>Stage at which the module must be completed</th>
<th>Modules</th>
</tr>
</thead>
</table>
| Obligatory before any experimental work   | 1 – Aquaponic technology  
|                                           | 4 – Fish feeding and growth  
|                                           | 5 – Nutrient water balance  
|                                           | 6 – Hydroponics  
|                                           | 9 – Monitoring of parameters  
|                                           | 11 – Scientific research methods |
| During any experimental work              | 2 – Aquaculture  
|                                           | 3 – Fish anatomy, health and welfare  
|                                           | 7 – Plant varieties  
|                                           | 8 – Integrated pest management  
|                                           | 10 – Food safety |
| At any time                               | 12 – Design and build  
|                                           | 13 – Urban agriculture  
|                                           | 14 – Vertical aquaponics  
|                                           | 15 – Social aspects of aquaponics |

Prerequisites

There are no knowledge prerequisites. However, students without any previous scientific knowledge will find that they may need to do some extracurricular background reading. If the curriculum is to be taught in English to non-native speakers, the recommended minimum language proficiency is B2.

Overall learning outcomes

The Aquaponics Curriculum has been designed using student-centred teaching methods such as problem based learning and peer learning in order to enable HE students to acquire expert knowledge as well as the skills desired by employers. The didactic techniques employed, such as workshops, wikis, discussion forums and social bookmarking, are intended to encourage a mixture of student dialogue and collaboration, autonomy, critical thinking, and creativity. Instructional scaffolding has been used in order to build up student knowledge as they progress through each module, with different Moodle tools used to address different levels of Bloom’s revised taxonomy: remember (glossary), understand (wiki), apply (database), analyse (workshop), evaluate (workshop, forum) and create (e-portfolio).

The overall learning outcomes are:

- Acquisition of the skills necessary to conduct inquiry and research and show independence in learning
- Development of transversal skills such as digital skills and the use of appropriate terminology in relevant professional areas (aquaculture, horticulture, etc.)
- Acquisition of in-depth knowledge and development of understanding across a range of disciplines
General concept of learning and teaching methods

The general framework of learning and teaching methods implemented in this course is as follows:

<table>
<thead>
<tr>
<th>Type of course</th>
<th>Type of content</th>
<th>Didactic elements</th>
</tr>
</thead>
<tbody>
<tr>
<td>Default (Basic) course</td>
<td>Standard content</td>
<td>Videos</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Readings</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Exercises</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Interim quiz for formative assessment</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Final quiz for summative assessment</td>
</tr>
<tr>
<td>Optional content</td>
<td>Gamification</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Interactive videos and presentations</td>
<td></td>
</tr>
<tr>
<td>Student activities</td>
<td>Moodle glossary</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Moodle wiki</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Moodle forum</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Moodle workshop</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Social bookmarking (Moodle database)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Image sharing (Moodle database)</td>
<td></td>
</tr>
<tr>
<td>Optional (depending on the organization at the learning institution)</td>
<td>Inputs for problem based learning (PBL)</td>
<td></td>
</tr>
<tr>
<td>Contact learning</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Blended learning</td>
<td>Flipped classroom</td>
<td></td>
</tr>
</tbody>
</table>

The Aqu@teach Moodle contains the standard content and student activities. Optional content, such as gamification using Moodle badges, which is a useful way of motivating students, can easily be added. For more information see [https://docs.moodle.org/38/en/Badges](https://docs.moodle.org/38/en/Badges). Interactive videos and presentations can also be added using the H5P plugin ([https://moodle.org/plugins/mod_hvp](https://moodle.org/plugins/mod_hvp)).

Typical progress through a module

The modules consist of some core elements:

- Introductory video lecture outlining the contents of the module
- Course reading material
- Additional videos on specific topics
- Exercises
- An interim 5 question true/false quiz for formative assessment
- A final 10 question multiple choice quiz for summative assessment

During their study the students should be active in:
- social bookmarking – sharing websites in **Moodle database**
- image sharing – sharing images in **Moodle database**
- contributing to discussions in **Moodle forum**
- contributing definitions to the **Moodle glossary**
- contributing to a short articles in **Moodle wiki**
- evaluating other students’ work in **Moodle workshop**

The students should document all these activities in their e-portfolios. The recommended e-portfolio platform is Mahara, which is a Moodle plugin (see *Aqu@teach O1: Toolbox of Innovative Didactic Techniques for Higher Education*). However, if Mahara is not available, alternative free e-portfolio platforms can be used, such as FolioSpaces (https://www.foliospaces.org) and Google Sites (https://sites.google.com/new). Instructions for using these e-portfolio platforms can be found in the Aqu@teach Moodle.

**Suggested learning and teaching methods**

The activities for each module have been designed using Learning Designer (see *O1: Toolbox of Innovative Didactic Techniques for Higher Education*) in order to achieve an appropriate balance between the six types of learning (see the figure on page 10):

- **Acquisition** – reading, watching, listening
- **Inquiry** – researching
- **Practice** – interim and final quizzes
- **Production** – producing something for teacher or peer evaluation
- **Discussion** – asking questions
- **Collaboration** – shared student activities resulting in a shared output

<table>
<thead>
<tr>
<th>Learning type</th>
<th>Activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acquisition</td>
<td>Textbook and supplementary reading&lt;br&gt;Introductory video and supplementary YouTube videos</td>
</tr>
<tr>
<td>Inquiry</td>
<td>Internet search</td>
</tr>
<tr>
<td>Practice</td>
<td>Interim module quiz (formative assessment)&lt;br&gt;Final module quiz (summative assessment)</td>
</tr>
<tr>
<td>Production</td>
<td>Assignments/exercises to upload to Moodle workshop for peer evaluation&lt;br&gt;Assignments/exercises to upload to e-portfolio&lt;br&gt;Assignments/exercises to upload to Moodle for tutor feedback</td>
</tr>
<tr>
<td>Discussion</td>
<td>Moodle discussion forum</td>
</tr>
<tr>
<td>Collaboration</td>
<td>Contribute to a Moodle database (websites and photos)&lt;br&gt;Contribute to a Moodle wiki&lt;br&gt;Contribute to the Moodle glossary&lt;br&gt;Evaluate another student’s work in Moodle workshop</td>
</tr>
</tbody>
</table>
Assessment

Formative assessment

The interim quizzes, which are placed approximately half way through each module, have been designed so that students can check the progress of their learning, and have been set up so that the students can retake them as many times as they wish. In addition, some modules include activities which require the tutor to give feedback on a piece of work uploaded to Moodle.

Summative assessment

The final module quizzes can only be attempted once by a student, and are time limited to 30 minutes.

Successful completion of the Aquaponics Curriculum will result in the award of 5 ECTS. Assessment of the e-learning course consists of three elements:

1. At the end of each of the 15 modules there is a multiple choice quiz with 10 questions (1 mark awarded for each correct answer; maximum marks available is 10 for each module, and 150 for the whole curriculum). The pooled marks for the module quizzes will comprise 50% of the final grade.

2. The e-portfolios, which comprise 30% of the final grade, should be assessed according to the following criteria:
   - All 15 modules represented (maximum 10 marks)
   - Structured presentation (maximum 10 marks)
   - Quality of material submitted (maximum 10 marks)

3. A quantitative rather than qualitative assessment of active engagement with the various teaching and learning tools in Moodle (glossary, wiki, forum, workshop, database) will comprise 20% of the final grade.

Grading should be done according to achieved total percentage. This grading scheme can be converted to the grading system used in different countries:

<table>
<thead>
<tr>
<th>Achieved %</th>
<th>Grade</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt;90%</td>
<td>Excellent</td>
</tr>
<tr>
<td>&gt;80% - 90%</td>
<td>Very good</td>
</tr>
<tr>
<td>&gt;70% - 80%</td>
<td>Good</td>
</tr>
<tr>
<td>&gt;60% - 70%</td>
<td>Pass</td>
</tr>
<tr>
<td>&lt;60%</td>
<td>Fail</td>
</tr>
</tbody>
</table>
Bibliography

Readings for the students are outlined in the Module Guide. The sources below are recommended for the teacher.

MODULE 1: AQUAPONIC TECHNOLOGY

Main authors: Ranka Junge, Nadine Antenen, Jena Jamsek
Main authors' institution: Zurich University of Applied Sciences

Overview

<table>
<thead>
<tr>
<th>Topic</th>
<th>Total student workload</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.1 Introduction to aquaponic technology; why use aquaponics?</td>
<td>50'</td>
</tr>
<tr>
<td>1.2 &amp; 1.3 Elements of aquaponic systems and classification</td>
<td>2 h 15'</td>
</tr>
<tr>
<td>Interim Quiz</td>
<td>15'</td>
</tr>
<tr>
<td>1.4 History of aquaponics</td>
<td>1 h 10'</td>
</tr>
<tr>
<td>1.5 Examples of aquaponic systems around the world</td>
<td>1 h 40'</td>
</tr>
<tr>
<td>1.6 Current research themes in aquaponics</td>
<td>1 h 20'</td>
</tr>
<tr>
<td>Final Quiz</td>
<td>30'</td>
</tr>
<tr>
<td></td>
<td>8 hours</td>
</tr>
</tbody>
</table>

Learning content

- What is aquaponics?
- Elements of aquaponic systems
- Classification of aquaponic systems (closed/open loop, sensu stricto/sensu lato, intensive/extensive)
- History of aquaponics
- Examples of aquaponic systems around the world
- Current research topics in aquaponics

Objectives and competences

The main objective of this module is to familiarize students with aquaponics in general, including new vocabulary, the basic components of aquaponic systems, and international examples in different climates and social conditions.

Competences

1. Understand the basic technological principles behind aquaponics;
2. Understand the advantages and disadvantages of aquaponic systems;
3. Be familiar with the ‘hardware’ of an aquaponic system;
4. Understand which elements originate in hydroponic technology and which in aquaculture, and the principles behind them;
5. Be able to classify aquaponic systems according to different design principles, their operational mode, their water cycle management, their type of hydroponic system and their use of space;
6. Know about the history of aquaponics;
7. Know about the international distribution of aquaponics and the different types adjusted to their geographical location;
8. Be familiar with current research in aquaponics.

Suggested learning and teaching methods

1.1 What is aquaponics? Introduction to aquaponic technology

Watch – 5 minutes
Watch the introductory video.

Read and collaborate – 45 minutes
Read section 1.1 of the textbook and write down any unfamiliar words. Look up these words and add them to the Moodle Glossary.

1.2 & 1.3 Elements of aquaponic systems and classification of aquaponics

Read – 60 minutes
Read sections 1.2 and 1.3 of the textbook to learn more about the two main elements of an aquaponic system (aquaculture and hydroponics) and the way systems are classified.

Investigate and collaborate – 30 minutes
Find an image for each of the following categories of aquaponic system, and share it in the Moodle Database:

- Commercial crop production
- Domestic production
- Education
- Social enterprise
- Greening and decoration

Produce – 45 minutes
Build your own aquaponic system in Moodle using the 'Get Creative!' tool. Produce a document (word doc or pdf) containing your screenshot from the 'Get Creative!' task and the answers to the following questions:

1. What do you need to add regularly to your system in order to keep it running?
2. What are the advantages and disadvantages of your selected operation mode?
3. Which values do you have to check regularly to guarantee the safe keeping of the fish?
4. What challenges might you expect when running a system at your selected location?

Upload the document to your e-portfolio.

Practice – 15 minutes
5 question true/false quiz to check your learning so far. The results will not count towards your final grade.

1.4 History of aquaponics

Read – 10 minutes
Read section 1.4 of the textbook to learn more about the history of aquaponics.

Produce and collaborate – 60 minutes
Calculate the current hype ratio for ‘aquaponics’, ‘hydroponics’ and ‘aquaculture’ using the method explained in section 1.4 of the textbook. Compare your results for each word with the results in Junge et al. (2017) by creating a barplot. Write a short text about the similarities and differences, upload it to the Moodle Workshop, and evaluate the work of one of your fellow students.

1.5 Examples of aquaponic systems around the world

Read – 40 minutes
Read section 1.5 of the textbook about aquaponic systems around the world.

Investigate and collaborate – 60 minutes
Search the internet to find examples of aquaponic systems around the world in the areas which are missing from the textbook: Africa and Latin America. Write an entry in the Wiki for at least one system, describing it according to the criteria in Table 2 of chapter 1, and add some text in which you further classify the system according to the criteria you learned in section 1.2.

1.6 Current research themes in aquaponics

Read – 30 minutes
Read section 1.6 of the textbook about current research in aquaponics.

Investigate and discuss – 50 minutes
Use the internet to find:

1) one institution/NGO/business which is doing serious research in the field of aquaponics.
   Look on twitter, facebook or instagram and post the link to the Moodle Forum in order to share it with your fellow students;
2) one topic in the field of aquaponics which you find interesting and which was not mentioned in the textbook. Write a short entry in the Moodle Forum with the title: 'Aquaponics and ... (your topic)' and explain to your fellow students why you think this is interesting.

**Practice – 30 minutes**

10 question multiple choice quiz. The results will be recorded and will count towards your final grade.

**Bibliography**


MODULE 2: AQUACULTURE

Main authors: Ranka Junge, Nadine Antenen, Fridolin Tschudi
Main authors’ institution: Zurich University of Applied Sciences

Overview

<table>
<thead>
<tr>
<th>Topic</th>
<th>Total student workload</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.1 Introduction to aquaculture</td>
<td>2 h 35'</td>
</tr>
<tr>
<td>2.2 Recirculating Aquaculture Systems (RAS) technology</td>
<td>3 h 30'</td>
</tr>
<tr>
<td>Interim Quiz</td>
<td>15'</td>
</tr>
<tr>
<td>2.3 Recirculating Aquaculture Systems (RAS) management</td>
<td>1 h 50'</td>
</tr>
<tr>
<td>2.4 Planning a recirculating aquaculture system (exercise)</td>
<td>3 h 20'</td>
</tr>
<tr>
<td>Final Quiz</td>
<td>30'</td>
</tr>
</tbody>
</table>

|                                                                 | 12 hours               |

Learning content

- Principles and development of aquaculture
- Different production forms in aquaculture
- Important steps for planning and designing a recirculating aquaculture system
- Solids removal
- Biofiltration
- pH
- Pumps and sumps
- Pathogen reduction
- Oxygenation and degassing CO₂
- Nutrient recycling from RAS: Aquaponics

Objectives and competences

The main objectives of this module are to understand the principles of fish farming; to be able (at least on a basic level) to plan, design and manage a recirculation system; and to know the components which are necessary when aquaculture is combined with plant production systems.

Competences

1. Understand the principles of fish cultivation in recirculating aquaculture systems (RAS) and the important role of water treatment;
2. Understand which technical components of RAS are necessary when they are being combined with soilless plant cultivation;
3. Know how to plan and design a RAS.

Suggested learning and teaching methods

2.1 Introduction to aquaculture

*Read – 10 minutes*

As an introduction to the topic, read section 2.1 of the textbook.

*Investigate and collaborate – 60 minutes*

Find a webpage for an aquaculture production company for each of the four types of aquaculture system in Figure 3 of chapter 2 in the textbook, and one for RAS. Each of the five examples should be from a different region in the world. Share the pages in the Moodle Database. Add comments with information on the annual production (t/a) and total size (m³) of the systems.

*Read and collaborate – 25 minutes*

Read sections 1.1 and 1.2 of *Aquaculture - Farming aquatic animals and plants* by J.S. Lucas et al. (2019) and add two terms to the Moodle Glossary.

*Investigate and produce – 60 minutes*

Search the internet to find out more about the history of aquaculture. Write a 500 word summary on your findings and upload it to your e-portfolio. Don’t forget to cite your sources in your text.

2.2 Recirculating aquaculture system (RAS) technology

*Watch – 30 minutes*

Watch the video to get an overview on RAS technology. Note the most important facts on system components 1-6. Take your time and stop the video when required.

*Read and produce – 120 minutes*

Read section 2.2 of your textbook. Large grow out tanks are becoming more and more popular in large scale intensive RAS. Produce a table showing the advantages and disadvantages of these large tanks considering the following factors:

- Biosecurity
- Cost-benefit
- Fish welfare
- Space efficiency
- Monitoring equipment/effort

Upload your table to your e-portfolio.
Read and discuss – 60 minutes

Read chapter 8 from ‘A Guide to Recirculation Aquaculture’ by FAO. The chapter uses various case studies to illustrate the potential environmental and economic benefits of RAS. Can you think of any disadvantages? Use the Moodle Forum to discuss possible environmental, economic and other disadvantages.

Practice – 15 minutes

5 question true/false quiz to check your learning so far. The results will not count towards your final grade.

2.3 Recirculating aquaculture system (RAS) management

Watch – 10 minutes

Watch the video about the management of a RAS and take notes.

Read – 40 minutes

Read section 2.3 of your textbook.

Investigate and produce – 60 minutes

Find information about desirable levels (ranges) for different physical and chemical water quality parameters in a RAS. Consider the following parameters:

- Oxygen
- Nitrogen
- Carbon dioxide
- Ammonium
- Ammonia
- Nitrite
- Nitrate
- pH
- Suspended solids
- Biological oxygen demand

Put the information together in a table and upload it to your e-portfolio.

2.4. Planning the recirculating aquaculture (RAS) part for an aquaponic system

Read – 10 minutes

Read section 2.4 of your textbook.

Produce – 190 minutes

In this exercise you will dimension the recirculating aquaculture part of an aquaponic system using the following procedure:
1) Read the manual on ‘Planning Basis for Dimensioning the Recirculating Aquaculture Part of an Aquaponic System’;

2) Read the task description;

3) Use the Excel spreadsheet to go through the different tasks in the manual;

4) Answer the questions and upload your documents to your e-portfolio.

Practice – 30 minutes

10 question multiple choice quiz. The results will be recorded and will count towards your final grade.

Bibliography


MODULE 3: FISH ANATOMY, HEALTH & WELFARE

Main author: Morris Villarroel
Main author’s institution: Technical University of Madrid

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Learning content

- General external anatomy
- General internal anatomy
- Respiration physiology
- Fish welfare
  - Introduction
  - Legislation in the EU
  - Specific measures to evaluate welfare
  - The HPI axis and the stress response
  - Operational welfare indicators

Objectives and competences

The main objective of this module is to familiarize students with fish in general, including new vocabulary, in order for them to be better able to assess possible problems in aquaponic units. Part of the process involves learning about the critical needs of fish and about external signs which might indicate when things are going wrong.
Competences

1. Understand the basic external and internal anatomy of fish in order to diagnose possible problems;
2. Understand how fish breathe and the importance of dissolved oxygen levels;
3. Understand the key concepts regarding fish welfare and fish health;
4. Know how to use operational welfare indicators and apply solutions.

Suggested learning and teaching methods

Watch – 5 minutes
Watch the introductory video which gives you an outline of the topics that will be discussed and the activities you will be asked to carry out.

3.1 General external anatomy

Read – 40 minutes
Read section 3.1 of the textbook and make notes on the main external anatomical features of fish.

Investigate and collaborate – 30 minutes
Use the internet to find at least one picture/photograph of fish from cartoons, movies, or other media (not photos of real fish). Upload the pictures to Moodle Database and comment on any anatomical aspects which are false or exaggerated, such as fish with eyelids. Reference the source of the image and annotate with 3 keywords, including species.

Investigate and collaborate – 40 minutes
Search the internet to find out more about possible abnormalities in the external anatomy of fish. Write an entry in the Wiki on at least two possible malformations and the species involved. Make sure you cite the source of the information.

3.2 General internal anatomy

Read – 30 minutes
Read section 3.2 of the textbook and make notes on the main internal anatomical features of fish.

Investigate and collaborate – 30 minutes
Search the internet for definitions of internal anatomical organs, and add these to the Moodle Glossary.

Practice – 15 minutes
5 question true/false quiz to check your learning so far. The results will not count towards your final grade.
3.3 Respiration physiology

Read  – 10 minutes
Read section 3.3 of the textbook and make notes on the efforts that fish must make to breathe underwater.

Discuss  – 30 minutes
As ectotherms, fish are very efficient animals but they live in an environment with very little oxygen. Make at least two entries in the Moodle Forum on how fish solve this problem and how much energy they spend for respiration, compared to reptiles and mammals.

3.4 Fish welfare

Read  – 40 minutes
Read section 3.4 of the textbook and make notes on the importance of fish welfare in the context of aquaponic systems.

Produce and collaborate  – 120 minutes
Write a short document (500 words) on two operational welfare indicators that could be used in an aquaponic unit and explain why you think they could be useful. In the second stage of the Moodle Workshop, you will evaluate the work of a fellow student (assigned by the tutor).

Investigate and collaborate  – 30 minutes
Use the internet to find websites on fish welfare in order to get an idea of the international relevance of the topic. Share the websites in the Moodle Database.

Discuss  – 30 minutes
Most of the discussion and technological developments related to fish welfare assume that fish feel pain. Consider the evidence for this and make an entry on this topic in the Moodle Forum. Comment on at least one other entry made by a fellow student.

Practice  – 30 minutes
10 question multiple choice quiz. The results will be recorded and will count towards your final grade.

Bibliography

MODULE 4: FISH FEEDING AND GROWTH

Main author: Morris Villarroel, Fernando Torrent
Main authors’ institution: Technical University of Madrid

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Learning content

- General introduction to fish feeding
- Energy requirements
- Main interactions between ingestion and environmental factors
- Abiotic factors
- Biotic factors
- Proximate composition of fish feeds and essential nutrients
- Types of feeds
- Feeding strategies
- Automatic feeders
- Production plan and monitoring the evolution of the farm
- Designing feeds for aquaponics
  - Fish growth and nitrogen retention
Objectives and competences

The main objective of this module is to introduce the basic concepts of fish nutrition, especially in terms of practical aspects related to feeds and feeding schedules. Since the feed provides the primary source of nitrogen waste in the recirculation system, it has to be under strict control in relation to fish growth.

Competences

1. Understand the basic composition of fish feeds;
2. Understand feeding regimes and how to measure fish growth;
3. Calculate how fish feed can affect dissolved ammonia in water and other nutrients;
4. Compare fish needs depending on species and unit size.

Suggested learning and teaching methods

Watch – 5 minutes

Watch the introductory video which will give you an idea of the topics that will be discussed and the activities you will be asked to carry out.

4.1 General introduction to fish feeding

Read – 20 minutes

Read section 4.1 of the textbook and make notes about the main differences between feeding terrestrial animals compared with fish, as well as the main problems with wasted or non-ingested feed.

Investigate and collaborate – 20 minutes

Search the internet for at least one picture/photograph of fish that are feeding, either on the surface of the water or in the water, and either by hand or by automatic feeders. Share these in the Moodle Database, including the name or web page of the source, and annotate with 3 keywords, including species.

4.2 Energy requirements

Read – 10 minutes

Read section 4.2 of the text book and make notes about the main reasons why fish make more efficient use of the energy in feed than mammals.
4.3 Main interactions between ingestion and environmental factors

Read – 20 minutes

Read section 4.3 of the textbook and make notes about the main abiotic and biotic factors that affect fish growth, including source water, recirculated tank water, and fish density.

Discuss – 30 minutes

Aquaponics is touted as a very sustainable process, but that depends on the feed being used. Make at least two entries in the Moodle Forum about your ideas for developing a sustainable feed. What qualities would a sustainable feed need to have?

4.4 Proximate composition of fish feeds and essential nutrients

Read – 15 minutes

Read section 4.4 of your textbook and make notes about the relative importance of protein, carbohydrate, and fats in the fish diet. Why are minerals important for aquaponics?

Investigate and collaborate – 30 minutes

Search the internet to expand on the information about minerals present in fish feeds and their normal concentrations. Write an entry in the Wiki on at least one mineral and its normal range of concentration for salmonids or tilapia, and provide the units of measure.

4.5 Types of feeds

Read – 10 minutes

Read section 4.5 of the textbook and make notes about the types of fish feeds used over the history of aquaculture and modern preparation.

Investigate and collaborate – 30 minutes

Search the internet for different types of fish feeds, based on what you have learned so far. Add one definition to the Moodle Glossary (for example, moist feed, pelleted feed, extruded feed).

Practice – 15 minutes

5 question true/false quiz to check your learning so far. The results will not count towards your final grade.

4.6 Feeding strategies

Read – 30 minutes

Read section 4.6 of the textbook and make notes about why it is easy to overfeed and how this can be avoided. Think about what indices are used to help measure the efficiency of feeding.
4.7 Automatic feeders

Read – 15 minutes

Read section 4.7 of the text book and make notes about the design of automatic feeder systems.

Investigate and collaborate – 30 minutes

Search the internet for companies that sell fish feeders that could be suitable for aquaponics, and share the links in the Moodle Database.

4.8 Production plan and monitoring the evolution of the farm

Read – 20 minutes

Read section 4.8 of the text book and make notes about some of the most important data to collect regarding production.

4.9 Designing feeds for aquaponics

Read – 25 minutes

Read section 4.9 of the text book and make notes about the method used to calculate dissolved ammonia in water based on the protein content of fish feed.

Watch – 5 min

Watch the video on feeding tilapia and and take notes on how they calculate the feed quantity for juvenile tilapia in their aquaponic system. Use that information to help you with the exercise that follows.

Produce and collaborate – 120 minutes

In this exercise you will answer two questions which are related to the information you have just read in section 4.9 of the textbook.

1. Say that in a small aquaponics unit you are growing tilapia in one 250 litre tank. The fish density is 25.6 kg/m$^3$ and the average weight of the fish is 400 g. At that size, tilapia are provided with a feed ration of 2.4% live weight. How many fish are in the tank? How much feed should you provide per day in kg? How much feed is that per month?

2. Then use the following information to calculate the total amount of TAN produced (in grams) by the fish in the above tank, which receives X g of feed per day (based on your answer to question 1): the feed contains 40% protein; the dry weight of the fish is approximately 27% of its live weight; the efficiency of the feed is 85%; the percentage of protein in the whole fish is 53%; the percentage of feeds lost as solids is 10% of what is provided to the tank; and the percentage of nitrogen in the solids is 4.2%.

Upload your answers to the Moodle Workshop, and evaluate the answers of one of your fellow students.
Read and produce  – 120 minutes

Read sections 13.3.2 and 13.4 of Fish Diets in Aquaponics by Robaina et al. (2019). Write a 500 word summary about the problems of formulating feed for fish used in aquaponics, and why feeding time is so important. Upload your document to your e-portfolio.

Practice  – 30 minutes

10 question multiple choice quiz. The results will be recorded and will count towards your final grade.

Bibliography


MODULE 5: NUTRIENT WATER BALANCE

Main author: Ranka Junge
Main author’s institution: Zurich University of Applied Sciences

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Learning content

- Macro- and micronutrients and their role in organisms
- Nitrogen cycle
- Phosphorus cycle
- Nutrient supply in aquaponics

Objectives and competences

The main objective of this module is to give an overview of the most important nutrient cycles that are relevant to aquaponics.

Competences

1. Understand the role of macro- and micronutrients in general and specifically in aquaponic systems;
2. Understand the nitrogen cycle and its implications for the operation of aquaponic systems;
3. Understand the phosphorus cycle and name the causes of possible losses;
4. Be able to calculate the nutrient supply for the main macronutrients in an aquaponic system.
Suggested learning and teaching methods

5.1 Macro- and micronutrients

*Read and watch – 30 minutes*

As an introduction to the topic, learn about the elements of the universe, and their role in organisms. Read section 5.1 of the textbook and watch the introductory video.

5.2 The biogeochemical cycles of major nutrients in aquaponics

*Read and watch – 50 minutes*

Read section 5.2 of the textbook. Watch the YouTube video about nitrogen cycling and take notes.

*Produce – 60 minutes*

Write a short report (500 words) on the following question: What are the differences between the nitrogen cycle in general and the nitrogen cycle in aquaponic systems? Upload your work to your e-portfolio.

5.3 Plant nutrition

*Read – 80 minutes*

As an introduction to the topic and in preparation for the exercise, read section 5.3 of the textbook.

*Investigate and collaborate – 35 minutes*

Search the internet for pictures of plant nutritional disorders for one crop of your choice. Consider crops that are often cultivated in aquaponics, such as lettuce, tomato, cucumber, spinach, strawberry, kale, swiss chard. Try to find pictures of nutrient deficiencies for all essential elements (apart from C, H, O).

Label your pictures with information about species/variety, nutritional disorder of which element, and name of the symptom. Share them with your fellow students in the Moodle Database.

*Practice – 15 minutes*

5 question true/false quiz to check your learning so far. The results will not count towards your final grade.

5.4 Nutrient supply in aquaponics

*Read – 30 minutes*

Read section 5.4 of the textbook as an introduction to the topic and in preparation for the exercise that follows.
Produce and collaborate – 90 minutes

The aim of calculating the nutrient balance is to ensure that just enough macronutrients (N, P and K) are supplied to the system for the plants to absorb, but at the same time the fish must also have sufficient nutrients for their welfare. To help with this calculation, a model based on the nitrogen model from Timmons and Ebeling (2010) and the phosphorus model from Brinker (2006) has been created and implemented in an Excel spreadsheet (Tschudi 2016). The nutrient composition of the fish feed must first be specified (Feed Emissions sheet). The next step is to calculate how many fish are in the system at what times and how many of which nutrients they excrete (Fish Planning sheet). Then the desired plant cultures can be indicated with the respective cultivation area size (tomato, lettuce or basil) (Plants Uptake sheet). Finally, the nutrient balance of the system is calculated (Nutrient Balance sheet). The 'Nutrient Balancing in Aquaponic Systems' document contains a detailed description and explanation of the individual steps.

As an exercise, adjust the following parameters: 35 g N/kg feed; 5 g P/kg feed; same fish stock; 40 m\(^2\) tomato area during the entire cultivation period (01.01-20.05.2017) and 20 m\(^2\) lettuce from 01.04-15.05.2017 (lettuce nutrient demand phase 1 01.04-07.04.2017, after phase 2). Save the customized Excel spreadsheet. In the empty text field describe the course of the three curves (nitrogen, phosphorus and potassium). What should be done to prevent the plants from nutrient deficiency? Upload your spreadsheet to the Moodle Workshop, and evaluate the work of one of your fellow students.

Practice – 30 minutes

10 question multiple choice quiz. The results will be recorded and will count towards your final grade.

Bibliography


MODULE 6: HYDROPONICS

Main author: Sarah Milliken
Main author’s institution: University of Greenwich
Contributing author: Ranka Junge
Contributing author’s institution: Zurich University of Applied Sciences

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Learning content

- Introduction to hydroponics
  - The principles of hydroponics
  - Advantages of hydroponics
  - Disadvantages of hydroponics
- Hydroponic systems
  - Media bed hydroponics
  - Nutrient film technique
  - Deep water culture
  - Aeroponics
- Plant anatomy, physiology, and growing requirements
  - Plant anatomy
  - Plant physiology
    - Photosynthesis
• Respiration
• Osmosis and plasmolysis
• Transpiration
• Phototropism
• Photoperiodism
  o Growing requirements
    ▪ Light
    ▪ Water
    ▪ Carbon dioxide
    ▪ Temperature
    ▪ Relative humidity
• General cultivation practices
  o Transplants from seeds
  o Transplants from cuttings
  o Transplants using grafting
• Fertigation
• Greenhouse control systems
  o Light
  o Temperature and humidity
  o Carbon dioxide
  o Air circulation
  o Environmental control systems

Objectives and competences

The main objective of this module is to introduce the basic principles of hydroponic cultivation, the growing requirements of plants, nutrient supplementation, and the role of environmental factors in the optimisation of crop yields.

Competences

1. Understand the basic principles of hydroponics, and its comparative advantages and disadvantages as a method of cultivation;
2. Understand basic plant anatomy, physiology, and growing requirements;
3. Be able to calculate the required amounts of nutrient supplementation;
4. Be familiar with greenhouse control systems, including those for lighting, heating, cooling, relative humidity, and carbon dioxide enrichment.

Suggested learning and teaching methods

Watch – 5 minutes

Watch the introductory video to familiarise yourself with the contents of this module.
6.1 Introduction to hydroponics

*Read – 10 minutes*

Read section 6.1 of the textbook and make notes on the advantages and disadvantages of growing crops using hydroponics.

6.2 Hydroponic systems

*Read – 100 minutes*

Read section 6.2 of the textbook and make notes on the different types of hydroponic systems. Then read the article on Hydroponic systems and water management in aquaponics and make notes on the role of the design and management of the hydroponic component on the overall performance of aquaponic systems.

*Investigate and collaborate – 30 minutes*

Search the internet for different types of substrate (LECA, coco coir, rockwool etc.) that are commercially available in your country. Share the webpages in the Moodle Database.

*Collaborate – 30 minutes*

In collaboration with your fellow students, produce a Wiki on the five types of substrate that are most widely available. Each student should write about a different substrate type. How do different brands of the same substrate type vary in terms of their cost and constituent elements? How do the different substrate types compare in terms of cost?

6.3 Plant anatomy, physiology and growing requirements

*Read and collaborate – 60 minutes*

Read section 6.3 of the textbook and make a list of any unfamiliar terms. Look up the terms and add them to the Moodle Glossary.

*Watch – 30 minutes*

Watch the following videos and make notes:

Plant Physiology for Growers Part 1: How Plants Think.
Plant Physiology for Growers Part 2: Conditions that Affect Plant Growth.

*Produce – 60 minutes*

Write a short (500 word) summary on the influence of light on plant physiology and upload it to your e-portfolio.

*Collaborate – 30 minutes*

Upload your summary to the Moodle Workshop, and evaluate the summary of one of your fellow students.
6.4 General cultivation practices

Read – 20 minutes
Read section 6.4 of the textbook and make notes on the cultivation practices commonly used in aquaponics.

Produce – 30 minutes
Based on what you have learnt so far, write a list of the things you would need to start hydroponic production of lettuce in a small greenhouse. Indicate which type of hydroponic system you would be using, and whether any of the items on your list are optional. Upload the list to your e-portfolio.

6.5 Fertigation

Read – 20 minutes
Read section 6.5 of the textbook and make notes.

Investigate and collaborate – 30 minutes
Use the internet to research hydroponic fertilizers that are commercially available in your country. Share the webpages in the Moodle Database.

Collaborate – 30 minutes
In collaboration with your fellow students, write a Wiki on the range of hydroponic fertilizers available in your country. How do they differ in terms of their constituent elements and their price?

Read – 30 minutes
Read A Recipe for Hydroponic Success and make notes on how to formulate a nutrient solution recipe.

Investigate – 30 minutes
Use the internet to research the constituents of the municipal water where you live. Make a note of the concentrations of sulphate, iron, zinc, boron, copper, molybdenum, sodium, manganese, silicon and chloride.

Produce – 60 minutes
HydroBuddy is a tool for calculating the necessary additions of fertilizer to the water in a hydroponic system (or to tap water, if you are starting the system from scratch). In this exercise you will learn how to use the tool by calculating the fertilizer additions for a sample of local tap water. Upload your calculation to your e-portfolio.
6.6 Greenhouse control systems

Read – 40 minutes

Read section 6.6 of the textbook and make notes.

Investigate and collaborate – 30 minutes

Use the internet to research different types of hydroponic lighting systems that are commercially available in your country. Share the webpages in the Moodle Database.

Collaborate – 30 minutes

In collaboration with your fellow students, produce a Wiki on the different types of lighting systems. How do they compare in terms of function and cost?

Produce – 30 minutes

Look at the list you produced in module 6.4 of the things you would need to start hydroponic cultivation of lettuce in a small greenhouse. Based on what you have learnt in the second half of this module, add to the list, and indicate which items are optional. Upload the final list to your e-portfolio.

Practice – 30 minutes

10 question multiple choice quiz. The results will be recorded and will count towards your final grade.

Bibliography


Rorabaugh, P.A. 2015. Introduction to Controlled Environment Agriculture and Hydroponics. Controlled Environment Agriculture Center, University of Arizona, Tucson.

MODULE 7: PLANT VARIETIES

Main author: Sarah Milliken
Main author’s institution: University of Greenwich

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10 hours

Learning content

- Introduction to plant varieties
  - Plants that are suitable/not suitable for hydroponic cultivation
  - Monoculture vs polyculture
  - Companion planting
  - Planting densities
  - Production rates
  - Nutrient demand

- Plant selection: the leafy greens, herbs and fruiting crops most commonly grown in aquaponic systems
  - Ideal growing conditions
  - The length of the growing cycle
  - Common pests and diseases
  - Recommendations for harvesting and storage
  - Crop selection for different systems

- Crop scheduling
Objectives and competences

The main objective of this module is to introduce the basic principles that should inform plant selection, including space requirements, nutrient demand, ideal growing conditions, the length of the growing cycle, and common pests and diseases.

Competences

1. Understand which plants can be expected to thrive in aquaponic systems;
2. Understand the basic principles of cultivar selection;
3. Understand how to draw up a crop schedule for commercial production.

Suggested learning and teaching methods

*Watch* – 5 minutes

Watch the introductory video which gives you an overview of the topics covered by this module.

**7.1 Introduction to plant varieties**

*Read and collaborate* – 30 minutes

Read section 7.1 of your textbook and add two words to the Moodle Glossary.

*Read* – 30 minutes

Study the chart on companion planting and make a note of good and bad companions for the kinds of plants that are suitable to grow in aquaponic systems.

*Investigate and collaborate* – 45 minutes

Use the internet to search for seed companies in your country. Share the webpages in the Moodle Database.

*Discuss* – 15 minutes

Based on your reading so far, choose one variety that would be suitable to grow as a monocrop in a small (120 m²) commercial aquaponic greenhouse. Make a posting in the Moodle Forum justifying your choice.

**7.2 Plant selection**

*Read* – 170 minutes

Read section 7.2 of your textbook and make notes on the ideal growing requirements of the different plant species.

*Investigate* – 15 minutes

Using the seed company websites stored in the Moodle Database, choose three species to grow as a polyculture in a small (120 m²) commercial aquaponic greenhouse.
Discuss – 15 minutes

Make a posting in the Moodle Forum justifying your choice of species to grow as a polycrop in a small commercial greenhouse.

Produce – 60 minutes

In your aquaponic system you want to harvest 50 heads of leafy greens per week. Calculate the required growing area, fish biomass (kg) and feed (g per day), and upload your calculations to Moodle to receive feedback from your tutor.

Produce – 60 minutes

In your aquaponic greenhouse you want to grow two fruiting crops using Bato buckets. The floor area for the buckets is 16 square metres. Choose two compatible species, and calculate the number of plants for each species, the fish biomass (kg) and the feed (g per day). Upload your calculations and the justification for your choice of species to Moodle to receive feedback from your tutor.

Practice – 15 minutes

5 question true/false quiz to check your learning so far. The results will not count towards your final grade.

7.3 Crop scheduling

Read – 20 minutes

Read chapter 7.3 in your textbook and make notes on how to create a crop schedule.

Produce and collaborate – 90 minutes

In your aquaponic system you want to grow a polyculture of leafy greens, herbs and flowers as a commercial enterprise. The growing area is 300 m². Choose your species and varieties (cultivars), and write down your justification. Calculate the fish biomass (kg) and feed (g per day). Using Excel, create a crop schedule. Upload your documents to the Moodle workshop and evaluate the work of one of your fellow students.

Practice – 30 minutes

10 question multiple choice quiz. The results will be recorded and will count towards your final grade.

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Learning content

- The concept of integrated pest management (IPM)
- Prevention methods in integrated pest management
  - Hygiene of cultivating conditions
  - Tolerant and resistant crop varieties
  - Appropriate plant spacing
  - Adequate supply of nutrients
  - Monitoring
- The most common pests and diseases
  - Identification of pests and diseases
  - Common pests
  - Common diseases
- Biological pest control
  - Natural enemies of pests
  - Examples of biological agents
Objectives and competences

The main aim of this module is to familiarize students with the basic concept of Integrated Pest Management (IPM) in aquaponics.

Competences

1. Understand the principles of integrated pest management;
2. Be able to identify common pests and diseases;
3. Understand the principles of biological control;
4. Understand how to use beneficial organisms;
5. Understand the effects of the beneficial organisms on the target pest;
6. Be able to prepare an IPM protocol for at least one culture for a small-scale aquaponic unit.

Suggested learning and teaching methods

Watch – 5 minutes

Watch the introductory video which gives you an outline of the topics that will be covered in this module.

8.1 The concept of integrated pest management (IPM)

Read – 40 minutes

Read section 8.1 of the textbook to familiarise yourself with the concept of integrated pest management. Then read Appendix 2 – Plant pests and disease control in the FAO guide to small-scale aquaponic food production, and make notes on the plant-derived insecticides and inorganic compounds that can be used in aquaponic systems.

Investigate and collaborate – 30 minutes

Search the internet for pest and disease control substances sold by hydroponic retailers in your country that you think would be safe to use in an aquaponic system. Store and share the webpages using the Moodle Database.

Discuss – 15 minutes

Then make a posting on the Moodle Forum explaining why you think your chosen products would be safe to use.

8.2 Prevention methods in integrated pest management

Read – 60 minutes

Read section 8.2 of the textbook and make notes on the various prevention methods used in IPM. Then read ‘The key to success in integrated pest control management’ and add to your notes.
**Collaborate – 30 minutes**

In collaboration with your fellow students, write a Wiki on the five stages of an IPM programme suitable for aquaponics:

- Prevent
- Monitor
- Identify
- Evaluate
- Action

**Practice – 15 minutes**

5 question true/false quiz to check your learning so far. The results will not count towards your final grade.

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**8.3 The most common pests and diseases**

**Read – 30 minutes**

Read section 8.3 of the textbook and make notes on the most common pests and diseases in aquaponic systems.

**Investigate and collaborate – 45 minutes**

Use the internet to find photographs of damage caused by pests on the types of plants commonly grown in aquaponic systems. Label the photos with the type of pest, and the type of plant, and share them in the Moodle Database.

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**8.4 Biological pest control**

**Read – 50 minutes**

Read section 8.4 of the textbook and make a list of matching pairs of pests and beneficials.

**Investigate and collaborate – 70 minutes**

Explore the Biobest biological pest control products, and make a table of the different types of beneficial insects and mites, nematodes and biopesticides that are suitable for controlling pests that can occur on the kinds of plants grown in an aquaponic system.

Then explore the Biobest monitoring and scouting products, and make a table of the different products that are available for monitoring pests that can occur on the kinds of plants grown in an aquaponic system.

Upload your tables to the Moodle Workshop and evaluate the work of one of your fellow students.

**Produce – 60 minutes**

Put together a step-by-step integrated pest management programme for the biological control of aphids on sweet peppers in an aquaponic system. The end user of this programme would be an
aquaponic farmer. Include pictures of the pests, plants and biological control agents. Upload the
document to your e-portfolio.

Practice – 30 minutes
10 question multiple choice quiz. The results will be recorded and will count towards your final
grade.

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based agricultural systems: Aquaponics as an example. In Proceedings of the International Plant
Protection Congress (IPPC), Berlin, Germany Vol. 2427.

FAO 2018. Pest and Pesticide Management. Food and Agriculture Organization of the United
Nations, Rome.

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Pantanella, E., Stankus, A. & Lovatelli, A. Small-scale Aquaponic Food Production: Integrated Fish and
Plant Farming, pp. 183-186. FAO Fisheries and Aquaculture Technical Paper No. 589. Food and
Agriculture Organization of the United Nations, Rome


European Parliament and of the Council of 21 October 2009 establishing a framework for
Community action to achieve the sustainable use of pesticides. Official Journal of the European
Union L 309/71.

MODULE 9: MONITORING OF PARAMETERS

Main authors: Franja Prosenc, Tjaša Griessler Bulc
Main authors’ institution: University of Ljubljana

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Learning content

- Introduction to monitoring
  - Definition of a scientific parameter: variable, quantification, units, and standard deviation on measurements
  - Why monitor?
    - Legislation: environment and safety
    - Management: operation and maintenance
    - Cost-benefits of monitoring approaches
  - Classification of monitoring parameters and their variability
  - Frequency of monitoring

- Parameters of interest: importance, monitoring and follow-up
  - Aquaponic technology
    - Monitoring of performance of the technology for the removal of solids
    - Monitoring of the biofilter
- Monitoring of water and air pumps
- Checking the screens in the fish tank

○ Water quality
  - Water temperature, pH, dissolved oxygen
  - Nitrogen (total nitrogen, ammonium, ammonia, nitrite, nitrate)
  - Phosphorus and other nutrients
  - Water hardness
  - Algae contamination, settleable solids

○ Plant health
  - Disease
  - Relative humidity
  - Air temperature
  - Light intensity

○ Fish health
  - Feeding rates
  - Growth
  - Indicators for assessing fish stocks: behaviour, clinical signs
  - Stress
  - Disease

○ Parameters of special interest

Objectives and competences

The main objective of this unit is to acquaint yourself with the parameters which need to be monitored in an aquaponic system, why they are important, how you monitor them, and what actions need to be taken if these parameters are outside of the desired range.

Competences

1. Understand the concept of why monitoring is important for regulation and farm management, and the cost-benefits of different monitoring approaches;
2. Understand which parameters are of importance in aquaponic systems, and how these should be monitored;
3. Know the advantages and disadvantages of the various analytical methods that are generally available for monitoring: from the simplest (such as indicator paper strips) to the most advanced (probes and spectrophotometric analysis);
4. Be able to prepare a sampling and analysis plan for monitoring aquatic environments, fish and plant health.
Suggested learning and teaching methods

Watch – 5 minutes
Watch the introductory video lecture to familiarise yourself with the contents of this module.

9.1 Introduction to monitoring
Read and produce – 100 minutes
Read section 9.1 of the textbook and write a document of up to one page explaining why monitoring in aquaponics is important and some pointers for monitoring (what should be monitored, how frequently, keeping a record, which tests can be used ...). Then upload the document to Moodle to receive feedback from your tutor. The assignment is for formative assessment.

9.2.1 Aquaponic technology
Read – 30 minutes
Read section 9.2.1 of the textbook and make notes on the different technology factors that need to be monitored, why they are important, and what is the follow-up procedure in case they are found to be performing sub-optimally.

9.2.2 Water quality
Read, watch and investigate – 70 minutes
Read section 9.2.2 of the textbook, watch the first 2:03 minutes of the video on monitoring an aquaponic system, and do online research to find out more about nitrogen in aquaponics. Take notes on the water quality parameters that need to be monitored, their importance, and what remediation measures need to be taken if these parameters are outside of the desirable range.

Produce and collaborate – 60 minutes
In this exercise you will try to identify the parameter that is causing abnormal behaviour in fish, estimate the value of the parameter causing stress based on the given data, and propose an action for remediation.

In your imaginary aquaponic system, your lettuce looks healthy and is growing well, but your fish look stressed (lethargy, loss of appetite, gasping at the surface). The pH of water in the fish tank is 7.6 and the temperature of the water is 18 °C. TAN in your water is at 4 mg/L, whereas nitrite and nitrate ions are below 0.01 mg/L. Explain what is causing the abnormal behaviour in fish, estimate the value of the parameter causing stress based on the given data, and explain the measures you would take to remediate the problem. Record your findings and explanations.

Upload your findings and explanations to the Moodle Workshop. In the second stage of the workshop, your document will be evaluated by one of your fellow students, and you will evaluate someone else’s work.
9.2.3 Plant health

*Read* – 30 minutes
Read section 9.2.3 of the textbook and take notes on the parameters that need to be monitored in terms of ensuring the health of plants, and how to monitor them.

*Discuss* – 15 minutes
Consider the following situation: in your imaginary aquaponic system, the pH of the water was measured at pH 8, and the water temperature was 16 °C. Upon inspection of your plants, you notice that there are necrotic patches all over the leaves, and the young leaves appear white. Discuss the possible reasons for this with your peers in the Moodle forum, identify the nutrient deficiency responsible for the symptoms in the plants, and propose a possible remediation plan.

*Practice* – 15 minutes
5 question true/false quiz to check your learning so far. The results will not count towards your final grade.

9.2.4 Fish health

*Read and watch* – 40 minutes
Read section 9.2.4 of the textbook and familiarise yourself with the monitoring procedures, and then watch the video (from 2:03 onwards) to see some of the monitoring procedures in practice. The video provided is from an aquaculture production unit based in the United States and one key difference in practice is that while weighing fish, it is generally advisable to anaesthetise fish using a suitable anaesthetic, such as tricaine methanesulphonate. An appropriate amount of tricaine methanesulphonate should be dissolved in a separate container of water, which is of a suitable size for fish. Fish should then be placed in the water until they become limp and safe to handle.

*Practice* – 15 minutes
Solve a mix and match quiz on fish health. The results will not count towards your final grade.

9.2.5 Parameters of special interest

*Read* – 10 minutes
Read section 9.2.5 of the textbook and make notes on parameters of special interest and how to avoid any problems arising from the presence of these substances/organisms.

*Produce* – 60 minutes
Imagine you are setting up an aquaponic system. You need to consider the total volume of water in your system, how many fish tanks will you have, how many hydroponic units and of which size, the kind of fish you will be growing, the type of plants you will be producing, and the source of water which you will put in your system. The optimum ranges of parameters such as DO, pH and temperature will differ depending on the type of fish and plants you choose. Prior to setting up a
system, it is good practice to prepare a monitoring plan, outlining the parameters to be monitored, their upper and lower limits, sampling points, the procedure for monitoring, the frequency, and the person(s) responsible for monitoring. Prepare a monitoring plan using the template provided in Moodle. Include a description of your imaginary system and an annotated sketch, labelling the sampling points for monitoring your chosen parameters. Upload the document to your e-portfolio.

**Practice – 30 minutes**

10 question multiple choice quiz. The results will be recorded and will count towards your final grade.

Bibliography


MODULE 10: FOOD SAFETY

Main authors: Andrej Ovca, Tjaša Griessler Bulc
Main authors’ institution: University of Ljubljana

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12 hours

Learning content

- Food safety legislation and regulations
- Food safety in aquaponics
- Good agricultural practice (GAP) and good hygiene practice (GHP) in aquaponics
- Hazard Analysis and Critical Control Points (HACCP) system

Objectives and competences

The main objective of this module is to teach the actions/activities which are necessary during aquaponic food production in order to prevent, eliminate, or reduce significant hazards for consumer health.

Competences

1. Understand food safety-related legal frameworks, with particular emphasis on the responsibilities of the food business operator towards consumers, and official controls;  
2. Identify food safety hazards and risk factors associated with food production in an aquaponic unit;  
3. Critically assess the hygienic and technical conditions of an aquaponic unit for food production;
4. Develop prerequisite programmes in an aquaponic system in relation to good agricultural practice (GAP) and good hygiene practice (GHP);
5. Develop a simple HACCP system

Suggested learning and teaching methods

Watch – 5 minutes
Watch the introductory video which gives you an outline of the contents of the module.

10.1 Food safety legislation and regulations
Read – 30 minutes
Read section 10.1 of the textbook and the following EU legislation key points:
- 178/2002 – General principles and requirements
- 852/2004 – Hygiene of foodstuffs (Food safety - from farm to fork)
- 2006/88 – Animal health requirements for aquaculture animals

Collaborate – 30 minutes
In collaboration with your fellow students, produce a Wiki of the legislation relevant to aquaponic food production in your country. Pay special attention to the fields of aquaculture and primary production of vegetables.

10.2 Food safety in aquaponics
Read and watch – 45 minutes
Read section 10.2 of the textbook and watch videos on the European Food Safety Authority (EFSA) YouTube channel to familiarize yourself with the sources of biological, chemical and physical hazards in food. Then watch the video on Food safety considerations for aquaponics to familiarize yourself with the source of hazards in food produced in aquaponic systems.

Discuss – 15 minutes
Which microbiological, chemical, physical hazards and allergens are most likely to be expected in aquaponic food production? Post your thoughts on the discussion forum, and respond to at least one entry made by a fellow student.

Read – 30 minutes
Read the sections on ‘Food Safety and Water Quality’ and ‘Foodborne Pathogens and Aquaculture’ in the paper on ‘Microbial water quality related to food safety in recirculating aquaponic fish and vegetable production systems’.
Investigate and produce – 90 minutes

Investigate the potential foodborne pathogens related to different types of water source, and the different types of water treatment applicable to aquaponics. Write a short summary (approx. 500 words) of the potential foodborne pathogens related to the water source, and make a table showing the advantages and disadvantages of each type of water treatment applicable to aquaponics. Upload both documents to your e-portfolio.

Practice – 15 minutes

5 question true/false quiz to check your learning so far. The results will not count towards your final grade.

10.3 Good agricultural practice (GAP) and good hygiene practice (GHP) in aquaponics

Read and watch – 120 minutes

Read section 10.3 of the textbook and watch the video on Food Safety in Action at Waipoli Hydroponic Greens to familiarize yourself with GAP and GHP.

Produce and collaborate – 120 minutes

In the first stage of the workshop, prepare a document (approx. 500 words) briefly describing working procedures as part of GAP/GHP. As a starting point use the properties of the aquaponic system at your institution. If there is no real aquaponic system, you can use the theoretical aquaponic system provided in Moodle. Each student should prepare a different procedure (assigned by your tutor):

- Standard procedures for workers in aquaponic units
- Visitor policy document
- Signs encouraging workers and visitors to apply GAP/GHP
- Plan for daily, weekly, and monthly cleaning of the aquaponic system
- Procedures for removing and disposing of dead fish and plant debris

Upload your document to the Moodle Workshop. In the second stage of the workshop, evaluate the document submitted by one of your fellow students. After the evaluation, upload the final version of your work to your e-portfolio.

10.4 Hazard Analysis and Critical Control Points (HACCP) system

Read and watch – 30 minutes

- Read section 10.4 of the textbook to familiarize yourself with the basic principles of the Hazard Analysis and Critical Control Points (HACCP) system
- Watch the Hazard, Risk & Safety video to familiarize yourself with the differences between the terms ‘hazard’, ‘risk’ and ‘safety’.
Produce – 160 minutes

Develop initial steps of food safety plan following the principles of HACCP system described in section 10.4 of the textbook. As a starting point use the properties of the aquaponic system at your institution. If there is no real aquaponic system, you can use the theoretical aquaponic system provided in Moodle. Using the template and worksheet provided in Moodle, upload the following documents to your e-portfolio:

- a flowchart of the working process and description of the product (product description for live fish, and for lettuce or some other vegetable used in aquaponics)
- hazard analysis for microbiological, chemical, physical and allergen hazards at each step of the working process listed on the flowchart

Practice – 30 minutes

10 question multiple choice quiz. The results will be recorded and will count towards your final grade.

Bibliography


Copa - Cogeca / European Farmers European Agri-Cooperatives. 2018. EU Guide to Good Hygiene Practice (GGHP) for the primary production of foodstuffs.


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Learning content

- Basics of scientific research
  - General definitions: what is research, science and scientific research?
  - Research vocabulary: definition of important concepts (variables, reliability, validity, level of measurement)

- Fundamentals of scientific research methodology
  - General overview of different research designs: survey (exploratory, descriptive and explanatory study) and experimental (laboratory and field experiments; isolate the variables of interest and control for extraneous variables)
  - Preliminary steps
    - Key questions to start: problem formulation (what is to be studied? when to study? where to study? how to study?)
- Literature review: research literature sources, how to review and synthesise the literature
- Objectives: define the final objectives of the study
- Hypothesis: what is a hypothesis and how to formulate good research hypotheses/questions

  o Protocol design
    - Sampling plan, method and techniques, data collection
    - Good laboratory practice: test systems (physical/chemical, biological), ethics, test and reference items, laboratory procedure, handling, sampling and storage, characterisation, standard operating procedure (validation, maintenance, security, controls)
    - Conduct of the study: staff, laboratory diary, troubleshooting

  o Analysis of results
    - Presentation of results: graphs, tables, units
    - Quantitative and qualitative results: the differences
    - Basics of statistics: replicates, average, standard deviation

  o Research report and publication
    - Function of the main sections of the scientific paper (IMRaD)
    - Plagiarism

- Scientific research methodology applied to aquaponics
  o What is specific about aquaponics in terms of its building blocks and social aspects (very short outline)
  o Case studies: Plant selection, fish health, water quality, nutrient balance (based on scientific publications)

### Objectives and competences

The main aim of this module is familiarize students with how to design a research proposal and to promote the scientific approach to help solving problems that might arise when working with aquaponics. The module also aims to train the students for correct and transparent presentation of research outcomes.

**Competences**

1. Understand the main characteristics of scientific research and identify non-scientific approaches;
2. Understand the function of the main sections of a scientific paper (IMRaD);
3. Know how to organise data in spreadsheets and how to present them in tables and figures;
4. Be able to formulate a research question, select and use information from the literature, and set the objectives of a study;
5. Be able to design a simple research protocol, analyse the results obtained and write a report/publication;

6. Understand how to apply a scientific research methodology considering the multidisciplinary nature of aquaponics.

Suggested learning and teaching methods

*Watch* – 5 minutes

Watch the introductory video to familiarise yourself with the contents of this module.

11.1 What is science, what is research? Basic terms

*Read and collaborate* – 30 minutes

Read section 11.1 of the textbook and add two terms to the Moodle Glossary.

*Watch* – 20 minutes

- Watch the video on what research is, and relate the contents to what you read in the textbook.
- Watch the video explaining dependent and independent variables, and think about what those variables could be in aquaponics.
- Watch the video about how different variables have different levels of measurement, and think of an example of a construct which has different variables with different levels of measurement.

*Produce* – 20 minutes

Define a construct in aquaponics and identify its variables with different levels of measurement. Write down or draw your construct and its variables covering the four levels of measurement, and upload your work to your e-portfolio.

*Watch* – 10 minutes

Watch the video on precision, accuracy, reliability and validity explanation, and think of other examples of the four terms.

11.2.1 Fundamentals of scientific research methodology

*Read* – 25 minutes

Study the scheme showing scientific method as an ongoing process. Then read the introductory paragraphs of chapter 11.2 and section 11.2.1 of the textbook and think about applying different research designs to aquaponics.
11.2.2 Preliminary steps: problem formulation, literature review, objectives and hypothesis

Read – 30 minutes

Read section 11.2.2 in the textbook and think about the key points in problem formulation, literature review, setting objectives, and preparing hypotheses.

Investigate – 60 minutes

Browse different databases – ScienceDirect, SpringerLink, GoogleScholar, WebOfScience, PubMed, Scopus – and check how they work and what they offer. Search for articles on aquaponics and try different key words. Download papers of interest and order them according to relevance or topic in your own database organized as folders in your computer. Since academic databases are extensive and offer an enormous amount of papers, you should limit their browsing and data organization to 1 hour.

Practice – 15 minutes

5 question true/false quiz to check your learning so far. The results will not count towards your final grade.

11.2.3 Protocol design

Watch – 10 minutes

- Watch the video on sampling techniques and think about which ones would be most appropriate for aquaponics.
- Watch the video on the basic rules on behaviour in the laboratory.

Read and collaborate – 40 minutes

- Read section 11.2.3 in the textbook, and add two terms to the Moodle Glossary.

11.2.4 Analysis of the results

Read – 40 minutes

- Read section 11.2.4 in the textbook and think about the tables and figures you have designed so far and what their deficiencies were.
- Read the document on formatting tables for research publications. Similar rules can also be applied to figures.

11.2.5 Research publication

Read – 40 minutes

Read section 11.2.5 in the textbook and make notes on the most important steps of writing a scientific publication.
Investigate – 40 minutes

Browse different reference management programmes – EndNote, RefWorks, Mendeley – examine what the programmes offer and how they work, choose your preferred one, and download it. Check some YouTube tutorials on their use, such as this one. Transfer your database of literature from previous exercise to the selected management programme.

Read – 20 minutes

Read a document about when to quote in scientific publications, and think if you have found any quotes in the scientific papers you have read so far.

11.3 Scientific research methodology applied to aquaponics

Read – 30 minutes

Read section 11.3 of the textbook and make notes on the different research methodologies used in the case studies.

Investigate and produce – 120 minutes

In the database that you made when studying the literature review, find a peer-reviewed scientific paper on the relationship between fish stocking density and plant yield in aquaponics systems. Study the paper giving special attention to the research methodology.

Write a 500 word report about the paper and the methodology that was used, and upload it to your e-portfolio.

Discuss – 15 minutes

Use the Moodle Forum to discuss the most appropriate methodology for researching the fish and plant yield in aquaponic systems with your fellow students and tutor. The first person in the discussion is encouraged to propose a methodology for researching fish or plant yield while the following persons are encouraged to question or enhance the first proposal, or to come up with better idea.

Practice – 30 minutes

10 question multiple choice quiz. The results will be recorded and will count towards your final grade.

Bibliography


MODULE 12: DESIGN AND BUILD

Main author: Uroš Strniša
Main author’s institution: Biotechnical Centre Naklo
Contributing authors: Ranka Junge, Morris Villarroel
Contributing authors’ institutions: Zurich University of Applied Sciences, Technical University of Madrid

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Learning content

- Designing an aquaponic system
- Location considerations
- Choosing component to build an aquaponic system
- Designing and building a small-scale aquaponic system
- Operating an aquaponic system

Objectives and competences

Students will learn how to assemble the components of an aquaponic system in the correct order, and to design and build their own aquaponic system.

Competences

1. Be able to identify suitable locations for an aquaponic system;
2. Know how to assemble the basic components of an aquaponic system, and understand the importance of water flow from one component to another;
3. Be familiar with the wide range of options for purchasing the components for an aquaponic system on the market, and low-cost DIY options;
4. Know how to design and build a small-scale aquaponic system;
5. Be familiar with the importance of standard operating procedures, maintenance procedures, troubleshooting procedures, and data documentation for operating an aquaponic system.

Suggested learning and teaching methods

Watch – 5 minutes
Watch the introductory video which gives an overview of the contents of this module.

12.1 Designing an aquaponic system

Read – 20 minutes
Read sections 12.1 and 12.2 of the textbook.

Read and collaborate – 70 minutes
Read the DIY aquaponics guides and add three words to the Moodle Glossary.

12.2 Choosing components to build an aquaponic system

Read – 85 minutes
Read sections 12.3 to 12.6 of the textbook to learn more about the main components of an aquaponic system.

Investigate and collaborate – 60 minutes
Use the internet to find companies which sell aquaponic systems and fish farm equipment that could be suitable for aquaponics. Share the webpages in the Moodle Database.

Discuss – 15 minutes
In the Moodle Forum, discuss the suitability of the different systems and fish farm equipment that you found online for improving food security in developing countries.

Produce – 60 minutes
Write a short (500 word) summary of suitable aquaponic systems and fish farm equipment for improving food security in developing countries, and provide links to relevant websites. Upload your work to your e-portfolio.

Investigate and collaborate – 60 minutes
Find images of fish tanks, solids removal devices, biofilters, and grow beds. Upload at least one picture/photograph of each item to the Moodle Database.
Collaborate – 30 minutes

In collaboration with your fellow students, produce a Wiki on the different types of fish tank, solids removal devices, biofilters, and grow beds, with a description of the main characteristics, and the advantages and disadvantages of the different types.

Practice – 15 minutes

5 question true/false quiz to check your learning so far. The results will not count towards your final grade.

12.3 Designing and building a small-scale aquaponic system

Read – 30 minutes

Read sections 12.7 of your textbook and make notes.

Investigate and collaborate – 60 minutes

Search the internet for different types of water and air pumps for aquaponic systems. Share the webpages in the Moodle Database.

Collaborate – 30 minutes

In collaboration with your fellow students, produce a Wiki on the different types of water and air pumps.

Produce – 60 minutes

Now you will begin to design a small-scale aquaponic system for improving food security in developing countries. Define its location (e.g. indoors, outdoors, rooftop) and make a list of all the factors that you will need to consider, such as the type and size of the system, the types and quantities of fish and plant species that you will use, etc. Upload your list to Moodle to receive feedback from your tutor.

Produce – 90 minutes

Draw a diagram of your small-scale aquaponic system. Scan it and paste it in a Word document. Describe all the elements of your system (fish tank, filtration system, hydroponic component, etc.) in detail (size, materials, costs etc.). Upload your document to the Moodle workshop, and evaluate the work of one of your fellow students. After the evaluation, upload the final version of your work to your e-portfolio.

12.4 Operating an aquaponic system

Read – 20 minutes

Read section 12.8 of your textbook and make notes.
Produce – 40 minutes

On the diagram of the small-scale aquaponic system you designed previously, mark the points for taking water samples. Make a table of the parameters you would monitor in your system, and the frequency of monitoring. Upload your documents to your e-portfolio.

Practice – 30 minutes

10 question multiple choice quiz. The results will be recorded and will count towards your final grade.

Bibliography


MODULE 13: URBAN AGRICULTURE

Main author: Sarah Milliken
Main author’s institution: University Greenwich

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Learning content

- What is urban agriculture?
- Typology of commercial indoor urban farms
  - Rooftop greenhouses
  - Free-standing greenhouses
  - Vertical farms and plant factories
  - Container farms
- The sustainability of commercial indoor urban farms
  - Environmental sustainability
  - Economic sustainability
  - Urban farming and the circular economy
- Legislation and governance
- Urban agriculture business models
Objectives and competences

The aim of the module is to introduce the different types of commercial indoor urban farms, their environmental and economic sustainability, the pertinent legislation and governance, and different types of urban agriculture business models.

Competences

1. Understand the need for urban agriculture;
2. Understand the different types of commercial indoor farms;
3. Understand the environmental and economic sustainability of different types of commercial indoor farm;
4. Understand the concept of the circular economy, and how it can be applied to urban agriculture;
5. Be familiar with pertinent legislation and governance;
6. Understand different types of urban agriculture business models;
7. Know the basics of developing a concept for a commercial urban agriculture business.

Suggested learning and teaching methods

Watch – 5 minutes

Watch the introductory video to familiarize yourself with the contents of this module.

13.1 Introduction to urban agriculture

Read and watch – 30 minutes

Read section 13.1 of your textbook. Then watch the videos about two commercial urban agriculture start-ups: Localize, which is growing herbs in a plant factory in Minnesota, and Gotham Greens, which is growing lettuce, herbs and tomatoes in a rooftop greenhouse in New York City. Make notes on the factors that motivated these entrepreneurs to start an urban agriculture business, and how they went about it.

Investigate and discuss – 60 minutes

Over the course of this module you are going to develop a concept for a commercial indoor urban agriculture business selling fresh, local produce. You will develop your ideas in a series of distinct stages. At any time during the process you can change your mind – about the produce you will grow, your target customers, your USP, the type of system, and the type of farm you will use – based on the feedback you receive along the way.

The first stage is to understand who your competitors are. Search the internet for urban agriculture enterprises operating in your city. These are likely to be operations dependent on soil-based cultivation. What are the features of these enterprises, in terms of their business model (non-profit, for-profit, or non-profit/for-profit hybrid) and the products and/or services they provide? Discuss
your findings with your fellow students in the Moodle Forum. Can you identify a gap in the market which you could potentially exploit?

**Produce – 60 minutes**

Having identified the competition, or lack of competition, from other urban agriculture enterprises in your city, you need to choose the crop(s) that you will grow using either hydroponics or aquaponics. Use the internet to help you find crops that have a high retail price in your country. You also need to identify your target customers – who is going to buy your produce? Define your USP (unique selling proposition) – what makes your product stand out from that of your competitors? Summarise your reasons for your choice of crop(s), the type of system you will use, your target customers, and your USP, and upload your work to Moodle for feedback from your tutor.

**13.2 Typology of commercial indoor urban farms**

**Read and watch – 60 minutes**

Read section 13.2 of your textbook and think about the potential yields of the different types of indoor farm. Follow the links to the companies mentioned – how do they market themselves and their produce? Then watch the videos on Lufa Farms, which grows a variety of leafy greens in rooftop greenhouses in Montreal, and Badia Farms, which grows microgreens, herbs and lettuce in a plant factory in Dubai, to see how two very different types of indoor farm operate.

**Produce and collaborate – 75 minutes**

Having chosen your crop(s), the type of system you will use, your target customers, and your USP, you now need to choose the most suitable type of farm for the produce you want to grow. Summarise the reasons for your choice, and write a list of your anticipated capital and operational costs. Upload the summary and your list to the Moodle Workshop, and evaluate the work of one of your fellow students.

**Practice – 15 minutes**

5 question true/false quiz to check your learning so far. The results will not count towards your final grade.

**13.3 The sustainability of commercial indoor urban farms**

**Read – 40 minutes**

Read section 13.3 of your textbook and, if necessary, revise your list of anticipated capital and operational costs.

**13.4 Legislation and governance**

**Read – 25 minutes**

Read section 13.4 of your textbook.
Investigate and collaborate – 75 minutes

Search the internet for legislation that you need to be aware of in order to bring your indoor urban farm to fruition in your city. Summarise your findings in the Wiki.

13.5 Urban agriculture business models

Read and produce – 95 minutes

Read sections 13.5 and 13.6 of your textbook. Make a table with two columns and five rows. Put van der Schans’ urban farming business model typology (Differentiation, Diversification, Low cost, Reclaiming the commons, Experience) in the first column (one type per row). In the second column, write the names of the companies mentioned in the text which fit each type. How many of these companies use a mixture of business models? Make notes on the kind of business model you think would be most profitable for your indoor urban farm.

Produce – 30 minutes

You have now developed a concept for a commercial indoor urban agriculture business selling fresh, local produce. Upload your final documents to your e-portfolio: the results of the analysis of competitors; the rationale for the choice of crop(s); the target customers; your USP; the type of growing system (hydroponic vs aquaponic) and the type of farm; the list of anticipated capital and operational costs; your notes on the relevant legislation; and the kind of business model you are going to adopt according to van der Schans’ typology.

Practice – 30 minutes

10 question multiple choice quiz. The results will be recorded and will count towards your final grade.

Bibliography

Association for Vertical Farming 2017. Controlled Agriculture & Ecosystem Economies.
Specht, K., Siebert, R. & Thomaier, S. 2016a. Perception and acceptance of agricultural production in and on buildings (ZFarming): a qualitative study from Berlin, Germany. Agriculture and Human Values 33, 753-769.


MODULE 14: VERTICAL AQUAPONICS

Main author: Sarah Milliken
Main author’s institution: University Greenwich

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Learning content

- Different types of vertical growing technologies
- Technical advantages and disadvantages of vertical growing technologies
- Financial advantages and disadvantages of vertical growing technologies
- The suitability of different vertical growing technologies for aquaponics

Objectives and competences

The main objective of this module is to familiarise students with different types of vertical growing technologies, including their technical and financial advantages and disadvantages, and their suitability for combining with aquaponics, and to develop the students' commercial awareness of aquaponics.

Competences

1. Be familiar with the different types of vertical growing technologies;
2. Understand the advantages of vertical growing technologies;
3. Understand the disadvantages of vertical growing technologies;
4. Understand the potential for combining aquaponics with vertical growing technologies;
5. Understand how to calculate production and revenue rates for a greenhouse using vertical aquaponics.

Suggested learning and teaching methods

Watch – 5 minutes
Watch the introductory video which introduces the topics that will be covered in this module.

14.1 Introduction to vertical aquaponics
Read and watch – 15 minutes
Read section 14.1 of your textbook and start to make a list of the pros and cons of vertical aquaponics compared with conventional horizontal aquaponics. You will continue to add to this list during the course of the module. Then watch the video of Dickson Despommier talking about vertical farming.

14.2 Growing towers
Read and watch – 50 minutes
Read section 14.2 of your textbook. Watch the video on Square Roots, a shipping container farm which grows herbs using the Bright Agrotech ZipGrow growing tower system. Explore the Refarmers website, and then read Zipgrow – Vertical, Easy, Efficient and make notes on the technical specifications for using these towers for aquaponic cultivation.

Produce and collaborate – 120 minutes
You have an urban rooftop greenhouse in an area with high-end restaurants and delicatessens. The floor area is 32 square metres and needs to accommodate the plants, the fish tanks, and any other equipment you think you might need for aquaponic cultivation using ZipGrow towers. Search the internet to find wholesale prices for different leafy greens and herbs in your country. Choose the plant species that you would grow, and calculate the floor space of the hydroponic component of your greenhouse. Then use an adapted version of the Refarmers Production Estimates Calculator to generate production, revenue and seedling estimates. Summarise all your calculations in a Word document, including the justification for your choice of crop. Upload the Word document and the Excel spreadsheet to the Moodle Workshop, and evaluate the work of one of your fellow students.

14.3 Stacked bed systems
Read and watch – 25 minutes
Read section 14.3 of your textbook. Then watch the videos on Aerofarms which grows microgreens using aeroponics, and Edenworks which grows microgreens using stacked DWC beds and aquaponics.
Investigate and discuss – 60 minutes

Read Top 25 Vertical Farms and make notes on the amounts of money invested in these enterprises. Follow the links to the websites of the farms mentioned in the article to find out more about their systems and the produce they grow. Given the levels of investment required, what sort of crops and fish would you need to grow to make vertical aquaponics commercially viable? Discuss your thoughts with your fellow students and your tutor on the Moodle Forum.

Practice – 15 minutes

5 question true/false quiz to check your learning so far. The results will not count towards your final grade.

14.4 A-frame systems

Read and watch – 15 minutes

Read section 14.4 of your textbook. Then watch the video on Sky Greens which grows leafy greens using a rotating A-frame system.

14.5 Living walls

Read – 25 minutes

Read section 14.5 of your textbook.

Produce – 60 minutes

Create a table which summarises the various pros and cons of using the four main types of vertical growing system – growing towers, stacked beds, A-frames and living walls – for aquaponic cultivation, and upload it to your e-portfolio.

Practice – 30 minutes

10 question multiple choice quiz. The results will be recorded and will count towards your final grade.

Bibliography


MODULE 15: SOCIAL ASPECTS OF AQUAPONICS

Main author: Darja Rugelj, Marija Tomšič
Main authors’ institution: University of Ljubljana
Contributing authors: Sarah Milliken, Ranka Junge
Contributing authors’ institutions: University of Greenwich, Zurich University of Applied Sciences

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Learning content

- Aquaponics in the context of food security, food sovereignty and food networks
- Suitability of aquaponics for educational and social activities
- Aquaponics as a therapeutic tool
- Development of cognitive-behaviour, sensory-motor integration, and motor skills using aquaponics
- The potential of aquaponics for the wellbeing of elderly citizens

Objectives and competences

The main objective of this module is to familiarize students with the broader social aspects and potential of aquaponics in the context of food production, education and therapy.

Competences

1. Understand the role and potential of aquaponics in the fields of food security and food sovereignty, community cohesion, education, and therapy;
2. Understand how to tailor an aquaponic unit to different types of population groups (e.g. people with mental and physical health problems, the elderly, etc.);
3. Understand the effect of animals and plants on sensory stimulation, sensory integration and cognitive process;
4. Identify fall hazards and fall prevention strategies in an aquaponic unit.

Suggested learning and teaching methods

Watch – 5 minutes
Watch the introductory video which provides an overview of the contents of the module.

15.1 Social aspects of aquaponics

Read and watch – 70 minutes
Read section 15.1 of the textbook and make notes on how aquaponics is being used to address issues of food security and food sovereignty. Then watch the video on how Colorado Aquaponics is trying to address the problem of food deserts.

Investigate – 45 minutes
Use the internet to find out about the Za’atari refugee camp in Jordan, and think about how aquaponics might be used to improve food security and food sovereignty there. Things to consider include the number of systems, their size and type, the type of fish and plants, and the operational logistics.

Produce – 60 minutes
Write a short (500 words) account about how aquaponics might be used to improve food security and food sovereignty in the Za’atari refugee camp, and upload it to your e-portfolio.

Discuss – 15 minutes
Discuss your ideas with your fellow students and tutor in the Moodle Forum.

15.2 Aquaponics and social enterprise

Read – 90 minutes
Read section 15.2 of the textbook and make notes on how social enterprises are using aquaponics to increase food security and social cohesion. Then read Start Your Social Enterprise and think about a mission for a social enterprise involving aquaponics.

Investigate – 45 minutes
Use the internet to research your mission for a social enterprise involving aquaponics: is the problem being tackled by anyone else in your area, and who will the customers be? How would you measure the social impact?
Produce – 60 minutes

Write a short (500 words) account about your idea for a social enterprise involving aquaponics, and upload it to your e-portfolio.

Discuss – 15 minutes

Discuss your idea for a social enterprise involving aquaponics with your fellow students and tutor in the Moodle Forum.

Practice – 15 minutes

5 question true/false quiz to check your learning so far. The results will not count towards your final grade.

15.3 Aquaponics as an educational tool

Read and watch – 15 minutes

Read section 15.3 of the textbook and make notes on the various subjects that are being taught in schools using aquaponics. Then watch the video on Connecting schools to urban farming through aquaponics.

Investigate – 45 minutes

Use the internet to research your national primary school curriculum, and consider how an aquaponic system could be used in the various subjects taught.

Produce and collaborate – 90 minutes

Devise a 45 minute primary school lesson plan, including appropriate activities, for using an aquaponic system to teach either Science, Maths, or Design and Technology. Upload your lesson plan to the Moodle Workshop, and evaluate the lesson plan of one of your fellow students.

15.4 Aquaponics and wellbeing

Read – 20 minutes

Read section 15.4 of the textbook and look at the hyperlinked texts, and make a note of the various kinds of therapeutic benefits provided by horticultural activities.

Collaborate – 60 minutes

In collaboration with your fellow students, create a Wiki list of all the different activities carried out in an aquaponic unit (e.g. feeding the fish), and their associated therapeutic benefits (e.g. sense of responsibility).
15.5 The potential of aquaponics for the wellbeing of elderly citizens

Read – 40 minutes

Read section 15.5 of the textbook and make notes on the potential benefits of aquaponics to the sensory-motor integration and wellbeing of elderly people.

Investigate and collaborate – 60 minutes

Use the internet to identify at least four herbs with a very pronounced fragrance and which are suitable for growing in an aquaponic unit. Share pictures of the herbs in the Moodle Database, along with the species names and a short description of their properties.

Produce – 60 minutes

Working with and caring for an aquaponic unit has the potential to improve the social, cognitive and physical wellbeing of elderly people. However, aquaponic units can also represent a slip and trip hazard. Download the photos of the aquaponic units, and mark and label the features that might be potentially dangerous for elderly users. Upload the annotated photos to your e-portfolio.

Practice – 30 minutes

10 question multiple choice quiz. The results will be recorded and will count towards your final grade.

Bibliography


