RENEWABLE ENERGY TECHNOLOGY

USE OF GEOTHERMAL ENERGY IN FISH FARMS

CURRICULUM

Ankara, 2021

- This module is an individual learning material with the purpose of guiding course attendees in order to attain competence that is specified in the Framework Teaching Programs applied at occupational and technical schools/institutions.

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INTRODUCTION

Dear Trainee

The production of fish under human control in net cages in seas and lakes or in ponds on land is called "Aquaculture". Aquaculture is one of the most supported and developing world food sectors. In this study, some examples developed within the scope of using geothermal energy in aquaculture are briefly explained. Afterwards,

Examples in the World and Turkey

Use of Geothermal Resources in Aquaculture

Aquaculture Methods

Some Fish Species Cultivated by Geothermal Resources

Fish Farming and Nutritional Needs in Thermal Water

System and Features of Thermal Water Pools

Opportunities and Prospects in Geothermal Aquaculture

Barriers to Geothermal Aquaculture

Above subjects have been considered. The aim is to provide trainings on the applications operated in the pools by using geothermal energy in aquaculture.

In order to increase production amounts in aquaculture, fresh water or marine organisms must be provided a controlled environment. With this method, carp, catfish, sea bass, tilapia, frog, mullet, eel, salmon, sturgeon, shrimp, lobster, crayfish, crab, oyster, bivalves, scallops, mussels, abalone, cichlids and various crocodiles' types can be produced. In aquaculture, it has been observed that more production is achieved in a shorter time with the use of geothermal energy against the solar heat energy. When the water temperature drops below the desired values, the body metabolism of the fish is adversely affected and the fish lose their ability to feed.

This negativity can be eliminated by providing a constant temperature value with a geothermal water with the desired properties. It can be said that ambient temperature is generally more important for aquatic species compared to terrestrial creatures.

Land animals can be well produced in a wide temperature range between 10°C to 20°C. Aquaculture species such as shrimp and catfish are capable of breeding at higher temperatures and within a narrow temperature range. However, the reproductive ability of the trout is at a lower temperature. Aquaculture is carried out in countries such as mainly China, the United States, Turkey, Israel, Iceland, Japan and Georgia.

LEARNING ACTIVITY-1

AIM

You will learn the definition of occupational health and safety and learn about its importance. You will learn the risk factors related to occupational health and safety. You shall learn to perform risk assessment and risk management for occupational safety.

RESEARCH

Do a preliminary research on occupational health and safety.

You shall study occupational health and safety procedures for aquaculture facilities.

1. What Is Occupational Health and Safety?

Occupational health and safety (OHS) is intensely used in business. OHS can be described as "systematic and scientific studies in order to protect from possible hazardous conditions at workplace during operation which may arise due to various reasons.

Occupational health and safety - OHS fact has been started to be handled mainly in European Union dating from 1980's. Occupational Health and Safety directive numbered 89/391/EEC has been accepted as framework directive and many individual directives have been published with regard to this framework. Occupational Health and Safety code numbered 6331 has been settled in 2012 in accordance with the European Union harmonization process.

The purpose of occupational health and safety studies is to ensure the safety of workers, production and business.

OHS is a teamwork. In workplaces with more than a certain number of employees, there is an obligation to establish an OHS board and meet at varying intervals depending on the hazard class (less dangerous: once in 3 months, dangerous once in 2 months, very dangerous once a month), and discuss and decide on the OHS needs and non-compliances of the enterprise. In general, the workplace doctor determines the nonconformities related to occupational health, and the occupational safety expert determines the ones related to occupational safety and presents them to the OHS board. The board also includes employer

representative and employee representatives varying according to the number of employees.

1.1. Risk Factors Regarding Occupational Health and Safety

Risk factors that will adversely affect the health of employees at workplaces can be listed as; physical, chemical, biological, electrical, ergonomic, psychosocial and so on.

1.1.1. Physical Risks

Physical risk factors

- Illumination
- Vibration
- Noise
- Thermal comfort conditions.

In addition to the special precautions described in each section, the following general precautions should also be implemented in order to eliminate or reduce the negative effects of physical risk factors.

- Collective protection should be prioritized without departing from personal protection.
- It is necessary to ensure that appropriate personal protective equipment is used even if all kinds of precautions are taken.
- Employees must be provided with the necessary occupational health and safety trainings and periodic health examinations.
- Occupational health and safety risk assessment covering the whole workplace should be ensured.

1.1.1.1. Illumination

Various health and safety risks may occur due to insufficient illumination of the working environment.

These are;

- Injuries due to tripping and falling,
- Eye disturbances,
- Biological and psychological disturbances such as employee unwellness, depression and fatigue.

1.1.1.2. Vibration

Vibration occurs as a result of the oscillating movements of the tools and machines used in the working environment or during the operation of tools which are not well balanced. In terms of affecting health and safety, vibration is divided into two groups as "**hand-arm vibration**" and "**whole body vibration**".

Measures to be taken against vibration exposure can be listed as:

- Choosing tools that do the job best and give the least vibration exposure,
- Planning the necessary maintenance works such as sharpening the tools, lubricating and adjusting the engine,
- Reducing the hours worked by the employee with the vibrating tool,
- Arranging the work so that vibrating and non-vibrating tools are used alternately,
- Arrangement of working style and workplace in accordance with ergonomic principles in order to minimize vibration stress,
- Supporting the vibrating tool handle or the place where the tool and worker is in contact with vibration-absorbing materials,
- Fingers and palms of the gloves are supported by vibration-absorbing materials.

1.1.1.3. Noise

Noise can be defined as unwanted disturbing sounds. The most negative effect of noise is that it causes hearing loss. A person who is constantly exposed to noise during work may experience occupational hearing loss. It has been determined that noise can cause various mental disorders with nervous and digestive system diseases as well as hearing loss.

Measures to be taken to eliminate or reduce noise exposure can be listed as;

- If possible, replacing the equipment causing the noise with the non-noiseless equipment, if not with the appropriate equipment that emits the least noise,
- Designing the workplace and work environment considering the exposure to noise,
- Moving the noise source into a separate compartment,
- Covering places such as walls, ceilings and floors where sound can transfer and reflect with sound absorbing material,
- Maintenance of work equipment at regular intervals,
- Limiting the employee's exposure to noise,
- Organizing working periods by giving adequate rest breaks.

1.1.1.4. Thermal Comfort

For the working environment that will ensure the comfort of the employees, all thermal comfort conditions created by environmental (such as humidity and heat sources in the workplace), work-related and personal factors (such as clothing, weight, age, metabolism) must be met. The high temperature of the environment may have negative effects on the employee such as excessive sleepiness, fatigue, low blood pressure, dizziness, decreased body resistance, excessive sweating, decreased work efficiency, red spots that cause itching, hypersensitivity, anxiety and concentration disorders.

The cold environment may have negative effects on the employee such as distraction, decrease in physical and mental efficiency, increase in body internal temperature, shivering, shaking, nutrition and energy requirement.

There are many ways to control thermal comfort in the workplace. Some of these are very easy to implement.

Some of the control measures can be listed as;

- **Environmental control;** checks of ventilation and air conditioning systems,
- **Control of the task;** control of the amount of work done by the employee, the clothes with the equipment used and the working time
- **Administrative controls;** work scheduling, planning, scheduling and control of rest times,
- **Engineering controls;** control of the measures taken as a result of engineering studies.

1.1.2. Biological Risks

Biological risk factors are organisms that are the products of living things or living things, including bacteria, viruses, fungi, parasites and their related toxins. Biological risk factors to the human body; It can enter through respiration, digestion, skin absorption, eyes, wounds, mucous membranes and eardrums. As a result, it can adversely affect human health by causing mild or fatal allergic reactions and diseases.

In order to protect against biological risk factors, it should be ensured to:

- Ventilate the environment,
- Inform employees against biologic risk factors,

- Comply with hygiene rules,
- Immunize employees,
- Proper disposal of wastes,
- Observe health and safety signs.

1.1.3. Electrical Risks

Electrical energy plays a very important role in human life. However, it is also the reason why most of the occupational accidents occur. A significant part of the occupational accidents that occur in our country every year are the electric shocks caused by electric current.

Although electrical risks are encountered in all sectors, they are more common especially in electricity generation distribution facilities and metal industry.

Risk factors in working with electricity can be listed as;

- The control, maintenance and repair of the electrical installation is not carried out by persons with a vocational training certificate,
- The bare metal parts of the machines or tools are not grounded or the necessary insulation is not made,
- The impairment of grounding for the tools or machines that are considered to have been grounded over time or as a result of external factors, The employees are not given sufficient and appropriate PPE or they are not used,
- Failure to provide necessary training to the employees on occupational health and safety or the employees' failure to comply with the rules set in the workplace,
- Employees do not have the necessary training, knowledge and experience about electrical risks, have excessive self-confidence and do not show the necessary attention and care against electricity,
- Employees intervening in electrical failures without taking the necessary instructions or outside of their duties,
- Abrasions on the cables through which the electric current passes.

Measures to be taken against electrical risks are as follows:

- Machines and devices used in laboratories, workshops and factories must have separate stop mechanisms and switch mechanisms that can stop them all.

- No material should be left on the front of the electrical panels that can prevent access.
- Where power tools are required to be used, there should be sockets suitable for the plugs of the tools (grounded socket). In case of absence, the cables should not be plugged into sockets by cutting the plugs, and appropriate (grounded) extension cables should be used.
- Devices with broken on-off switches should be repaired. Switches must not be disabled.
- Electrical cables should be laid regularly, cables should not be left in the open, broken sockets and plugs should be replaced with new ones, fuses should be kept in a closed cabinet.

1.1.4. Ergonomic Risks

Ergonomics is a collection of natural and technical research and development studies of human-machine-environment harmony by examining human physical and psychological characteristics. Ergonomics, by definition, covers many different areas from hand lifting to thermal comfort and lighting. Ergonomic risk factors are frequently encountered in fields of activities such as construction, mining, health care, logistics, furniture, textile industries and office work.

Ergonomic risk factors are listed below.

In material storage and hand lifting works;

- If the load is heavy, large, difficult to grasp, unstable and the contents are displacing, it may cause back and waist injuries, especially if it is in a position that requires bending and twisting.
- The loads carried by one side of the body can cause injuries along with back, shoulder and neck pain.
- Improper working postures during the transportation of the materials can cause back, neck and shoulder discomfort.
- Risks such as slipping, falling and stumbling can be encountered on uneven or slippery floors.

The use of hand tools;

- Vibration caused by hand tools can damage tendons, nerves and veins.

- Working with heavy tools, repetitive and uninterrupted use and improper working postures may cause musculoskeletal system disorders.

Machine and bench use:

- The working area of the machines and benches is not designed in accordance with the body size of the employee, incorrect positioning or misuse of buttons and pedals may cause musculoskeletal disorders.
- The use of machine pedals requires a special posture, which restricts the movement of the operator, especially when standing. Continuous pedal use with single foot can lead to unilateral strain and stress and back pain.

1.1.5. Psychosocial Risks

The likelihood of work design, work organization and social and environmental conditions in which work is carried out causing psychological, social or physical damage is called psychosocial risk.

Psychosocial risks can cause the following negative situations on employees:

- Stress,
- Psychological disorders such as work-related depression and burnout syndrome,
- Behavioral disorders such as increased smoking, consumption of tea and coffee, substance abuse, sleep disorders,
- Diseases that disrupt the working rhythm of internal organs and resulting physiological disorders.

Work environments are especially susceptible to stress factors. Work stress is a mood disorder that is a mixture of feelings such as guilt, anger and fear that significantly affects the well-being and production capacity of the employee.

The employee can be protected from psychosocial risks with the following measures:

- **Collective protection**; In order to protect the body, mind and social well-being of employees, it aims to identify and eliminate psychosocial risk sources, as well as establishing collective protection methods such as the establishment of social support units and counseling services.
- **Personal protection;** It includes increasing the awareness of employees through training and improving their ability to cope with stress. It may include relaxation techniques, time and problem-solving methods, counseling and planning on

lifestyle. Programs that support personal protection are health monitoring and health value enhancement programs and the development and dissemination of healthy attitudes and behaviors in the workplace.

1.2. Risk Assessment and Risk Management for Occupational Safety

Risks in occupational health and safety can never be eliminated or reduced. Taking all precautions is not to eliminate or reduce the risk, but to prevent danger or dangerous situation. Any compromise made from the measures will return as either a work accident or an occupational disease.

Risk; in case of danger, is the realization of the danger, it is a possible outcome. It is not revealed until the conditions are mature, if it does, it means that the damage has been done. Risk is always an element of danger.

1.2.1. Forming Risk Assessment Teams and Instructing the Team

A separate team should be established for each part of the workplace. The team structure should be as follows.

- A Manager (team leader)
- Sufficient number of employees
- Occupational Safety Specialist
- Workplace Physician

The team members should be informed about the benefits of this work, how to do the work, etc.

Note: The team leader will act as a bridge that provides communication between technical support members and team members.

1.2.2. Specifying Labor

Team members make a list of the work they did during a shift, in other words, the jobs on this step. According to legislation, occupational accidents happen when doing a job. In this regard, it is important to list the works done. Each work done means a danger or dangerous situation.

1.2.3. Determination of Labor Risks

We have defined all the work done up to this stage, in other words, the dangers / dangerous situations. Now it is necessary to identify the risks within these hazards. Add a potential risk column to the list of final works done. Print it out and distribute it to team members.

Team members should write down the risks they anticipate "in their own way" along with every work they perform.

At this stage, the Workplace Physician, Occupational Safety Specialist and, if deemed necessary, a sufficient number of technical personnel must be involved in the study. Lists of risks found by the workers shouldn't be considered to be sufficient. It is necessary to determine all possible risks with technical support.

After making sure that all the risks have been identified, the precautions to be taken should be determined in order not to reveal each risk. Let's open another column in Excel spreadsheet and distribute the print-outs to team members. Let's ensure that the question of what precautions should be taken against each risk is answered by the workers.

1.2.4. Classification of Precautions

It is necessary to clarify and then classify all necessary precautions with the support of the workplace doctor and occupational safety specialist and, if deemed necessary, sufficient technical personnel. The classification result will be as follows;

Corrections that can be made with the present resources of the workplace, corrections to be applied after procuring goods and / or services from outside, corrections that can be made with the investment project / plan, etc.

Creating Control Tables and Statistics. The obtained data must be supported by statistics and the "business risk prevention tree" must be entered into the business risk assessment form. In this way, almost all of occupational accidents and occupational diseases that may occur in each part of the workplace can be defined.

ASSESSMENT AND EVALUATION

ASSESMENT-1

Determine what information you have gained within the scope of this activity by answering the questions below. Tick the correct option below.

Read the following questions carefully and mark the correct option.

1. What is the name for the set of measures to be taken to create a safe working environment in order to prevent employees from suffering work accidents?

a. Occupational health and safety

b. Job

c. Sales and Marketing

d. Employee

e. Production

2. Which of the following does not occur due to the risks arising from hand tools?

a. Hearing loss

b. Hand-arm vibration

c. Exposure to acid vapor

d. Hand-arm injury

3. Which of the following is not a threat to occupational safety in buildings?

a. Plumbing

b. Electrical installations

c. Heating installations

d. Landscape arrangement

4. What is the main purpose of occupational health and safety?

a. It is to protect and watch over the safety of life and property of shopkeepers, merchants and employees.

b. To protect workers against work accidents and occupational diseases and to ensure their spiritual and body integrity.

c. To protect and watch over the life and property safety of the employer.

d. Improving the economic conditions of the employees.

5. Who are the parties to Occupational Health and Safety?

a. Employees only

b. Employers only

c. Government, Workers and Employers.

d. Government and Employers

6. In which of the following situations does the fire occur?

a. Heat only is enough for a fire to break out.

b. Presence of flammable material is enough for a fire to break out.

c. Flammable material and oxygen is enough.

d. Combustible material, oxygen and heat must be together for a fire to break out.

7. Which of the following is not a measure to be taken to avoid electrical accidents?

a. Using a voltage less than 65 volts,

b. Using isolation transformer (safety transformer).

c. Grounding the metal bodies of electrically operated tools and equipment.

d. Using high voltage.

8. Which of the following are the duties and responsibilities of the employees regarding Occupational Health and Safety at workplaces?

a. Operating a machine without protective equipment.

b. To comply with all measures taken on Worker's Health and Work Safety in the workplace.

c. Not using personal protective equipment.

d. To immediately intervene in a breakdown in the workplace without notifying the employer or employer representatives.

9. What is the most important event affecting the health and safety of employees in the workplace?

a. Worker's diseases

b. Occupational accidents

c. Traffic accidents

d. Overtime of employees

10. Which of the following materials does not conduct electricity?

a. Steel rod

b. Wet wooden rod

c. Saltwater

d. Plastic rod

EVALUATION

Compare your answers with the answer key. Evaluate yourself by setting your number of correct answers. Go back to the activity and re-examine the issues related to the questions you answered incorrectly or you hesitate to answer.

LEARNING ACTIVITY-2

AIM

- You will learn about fish farming using geothermal energy.
- You will learn the definition of geothermal energy, geothermal energy resources in Turkey and in the world with their aquaculture facilities by these sources.

RESEARCH

- What is being performed with renewable energy sources?
- Discuss what can be established with geothermal energy by brainstorming with your friends in the classroom.
- Research which fish species can be produced using geothermal energy in the world and in Turkey.

1. Examples in the World and Turkey

Picture 1. Geothermal Source

The fact that our world and our country will be involved with an energy bottleneck in the near future due to the limited primary energy resource reserves, fuel price increases, population growth, industrialization, the socio-economic structure of the 21st century and the negative effects of existing fossil fuels on the environment makes the renewable energy sources use inevitable. In addition to producing a certain amount of energy, our country is among the richest countries in the world in terms of geothermal energy potential, which is a renewable

energy source that can be used especially for sectional heating. The economic conditions in Turkey increase the significance of the studies that have been made and will be done in order to benefit from geothermal resources in the most economical way and to make their use more widespread in the regional sense. Today, energy consumption is accepted as one of the criteria of sophistication. The life style in our country, which is in the category of developing countries, is progressing in the direction of increasing energy consumption day by day.

Picture 2. Geothermal facility

A large part of the rapidly increasing energy demand all over the world will be able to be met with fossil fuels and hydraulic energy for a while. Besides the increase in energy costs, scientists predict that world oil reserves will be depleted in 2050, natural gas reserves in 2070 and coal reserves in 2150. Through these predictions of scientists, it is considered necessary to make short, medium and long-term plans for energy supply and consumption both in the industry, which is a heavy consumer of energy, and in other service areas.

Our country provides most of its energy needs from oil and natural gas import, and this situation leads to foreign dependency. The constant increase in energy prices due to the political developments in the world, the fact that fossil fuels will run out after a certain period of time and their production is quite expensive, necessitate the identification of alternative energy sources and the use of these sources with high efficiency.

Among the world's leading countries in the use of geothermal energy are Iceland, China, USA, Italy, Israel, Indonesia, Philippines, Japan, Central America, Mexico, but the use of geothermal energy in fish farming is also spreading rapidly in other countries, such as France, Greece, Hungary and New Zealand. In Iceland, where there are approximately 70 farms,

around 15-20 farms use geothermal water and grow freshwater sea bream, Arctic trout, turbot and Atlantic halibut.

1.1. The Examples of Fish Farming Projects Using Geothermal Energy

With the start of shrimp, lobster and fish farming in İZMİR Balçova Thermal Facilities in Turkey, the thermal water fish farming technique, which has been applied in 16 countries in the world and has become a serious sector in most of them, will be among the first examples launched in Turkey with the implementation of this project. With the 50 square meter insulated pool floor to be prepared in the garden of the facility and the system to be installed on the walls, waste thermal water at 40˚C will be passed through the pipes and heated. Production is planned to launch with freshwater shrimp and freshwater lobster (crawfish) as well as carp, sea bream and sea bass.

Picture 3. Freshwater Lobster

Carp and eel are the most widely grown species in Japan. The most profitable is the eel. Eels are grown in earthen pipes with a diameter of 25 cm and a length of 0.90 m. The water in the pipes is kept at 23°C by mixing hot spring water and river water. The weight of adult eels varies between 100 gr and 150 gr, and the annual total production is around 3800 kg. Various kinds of crocodiles are also grown in geothermal waters for tourism purposes.

Picture 4. Sea fishing

610,000 salmon and trout fry are produced annually by using geothermal water in fish production facilities in Iceland.

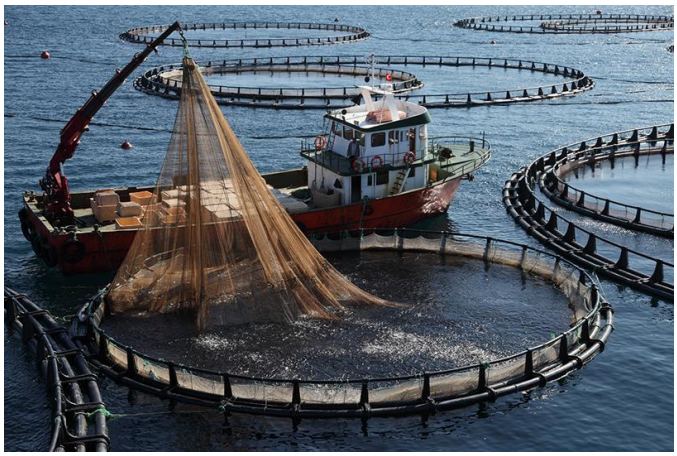
Picture 5. Eel

Such fish farms are also operating in Romania. There are also some farms in Greece where geothermal water is used at a temperature of 51 °C and a flow of 10 kg/sec to heat the water to 33-36 ˚C for spirulina algae cultivation. Other species raised on geothermal water-heated farms include carp, catfish, frogs, mullet, eel, salmon, sturgeon, shrimp, lobster, crayfish, crab oysters, scallops, crocodiles, mussels and abalones.

Picture 6. Spirulina Seaweed

Picture 7. A frame from the cultivation of spirulina algae produced in Yalova

In the United States, aquaculture projects using geothermal water are located in Arizona, Idaho, Nevada, Oregon, and California. An aquaculture company installed near Buhl in the United States has been producing catfish in waterways made of high-density concrete for nearly 30 years.



Picture 8. Harvest time in sea fishing

Water is supplied to the canals from artesian geothermal wells at 32°C at a flow rate of 380 liters/s. Cold water from springs and streams is used to cool geothermal water to temperatures between 27°C and 29°C, which is the best production temperature. The storage density of the fish produced varies between 80 kg/m³ and 160 kg/m³. Annual production is usually three or four times the carrying capacity. In addition to raising catfish, manufacturers also raise tilapia. Their production is at the level of 227 tons and 45 tons, respectively. Rainbow trout and sturgeon are grown in cold water on adjacent land. During the processing of these fish to be put on the market, over 90 tons of waste is generated annually. To solve this waste disposal problem, producers started breeding American alligators in 1994. Alligators feed on fish waste and are harvested annually for their meat and skin. Giant freshwater shrimp (Macro brachium rosenbergii) were bred from 1975 to 1988 at the Oregon Institute of Technology in the United States. Researches were also carried out on trout culture and mosquito fish (Gambuzia affinis) in this research area. These studies have shown that aquaculture and tropical arthropods can be grown even in cold climates with low temperatures as low as -7°C, when the water temperature is kept at an optimal level.

Picture 9. Alligator

Initially, two small outdoor ponds of 1.2 m depth were used before constructing the cultivation ponds of 0.2 ha (1 ha = 10000 m²) each were built. A selected group of breeding giant shrimp were housed in a small hatchery, where the larvae were hatched in artificial salt water and housed until the post-larval stage. For the highest animal density, 900 cm² surface area and 2 cm growth rates per month (twice that in tropical areas) were obtained. In order to provide the optimum temperature (27°C to 30°C), the system in the supply pools is composed of perforated distributor pipes, control valves and temperature control elements. With this system, equal distribution of geothermal energy to all sides of the pools was ensured.

Picture 10. Network system harvest

In 1987, one of the largest and most successful freshwater fish hatcheries was established on the North Island of New Zealand. A fish farm was established on this island to take advantage of the geothermal waste heat in the Wairakei power plant area.

Picture 12. Catfish

There are nine pools in the fish farm with sizes ranging from 0.2 ha to 0.35 ha and depths ranging from 1.0 m to 1.2 m. The water in the pools is kept at a temperature of 24°C and the temperature changes only 1°C as you go from one end of the pools to the other. The fish farm can produce shrimp up to 30 tons per year. Adult shrimps are harvested in about 9 months and 30 or 40 of them weigh 1 kg. An additional aquaculture farm will be built on the other side of the Wairakei power plant in the near future. Waste cooling water of a second power plant to be built in this fish farm will be used and thus 400 tons of annual production will be provided from these farms. Experiences at the Oregon Institute of Technology has shown that the best ponds for shrimp, mosquito fish and trout are those with a surface area of 0.1 ha. The most important issue to be addressed is water quality and diseases. If geothermal water is to be used directly, substances such as fluoride, chloride and arsenic must be investigated to determine whether fish or shrimp can survive in geothermal water.

Picture 11. Shrimp

Aerating the water before it is fed into the fishponds often solves the chemical problem. If necessary, a heat exchanger can be used to separate the geothermal water from the pool water.

ASSESMENT-2

Determine what information you have gained within the scope of this activity by answering the questions below. Tick the correct option below.

1. In which province was the first geothermal fish farming system project established in Turkey?

A. İzmir
B. Adana
C. Antalya
D. Muğla
E. Samsun

2. Which of the following is the most commonly farmed fish species in Japan?

A. Carp
B. Gray mullet
C. Bream
D. Crab
E. Shrimp

3. Which of the following types of algae is produced in Yalova, Turkey?

A. Seaweed
B. Spot algae
C. Sea beans
D. Spirulina
E. Beard algae

4. Which livestock raising has been started for the recycling of fish waste at the Oregon Institute of Technology in the USA?

A. Piranha
B. Shark
C. Alligator
D. Eel
E. Crab

EVALUATION

Compare your answers with the answer key. Evaluate yourself by setting your number of correct answers. Go back to the activity and re-examine the issues related to the questions you answered incorrectly or you hesitate to answer.

LEARNING ACTIVITY-3

AIM

- You will learn the use of geothermal resources in aquaculture.

RESEARCH

- Research use of geothermal resources in aquaculture.

2. Use of Geothermal Resources in Aquaculture

There are two options for transferring heat energy to the fishponds, a closed system using heat exchangers and a direct water supply to the fishpond. In the closed system, geothermal water is used to heat the fish pond through the heat exchanger.

A heat exchanger allows the flow of thermal energy between two or more streams of water at different temperatures. In conventional heat exchangers, one stream recovers some of the heat of the other stream and heat transfer takes place through a separation layer.

When direct geothermal water supply is used for system heating, the water is also used to remove organic matter from the pool that contributes to the pool's water quality. Water treatment plants typically include high-pressure pumps, a chlorine injection system (or other form of disinfection), and an automatic filtration system.

When using a direct geothermal water supply system, heat transfer is carried out by direct contact of cold and hot water. Depending on the type grown, mixing is continued until the desired temperature is reached. Water temperatures between 13-30˚C offer fish farms the opportunity to use a cheap and clean energy source.

Fish farming and aquaculture are possible with geothermal resources and fluids. Fish farming is performed at low temperatures (30˚C) aquaculture (Shrimp, Sea bass-yellow bass, Sea bream, Tilapia (bream type), Catfish, Carp, Catfish, Oyster, etc.).

Geothermal heating allows land or sea fishing, which can be performed in summer to be performed for 12 months and higher yields. Through geothermal aquaculture, a 50% - 100% increase is achieved in the growth rates of seafood with the appropriate temperature

environment. Where the geochemistry of the geothermal water is suitable, the geothermal fluid can be used directly for geothermal aquaculture.

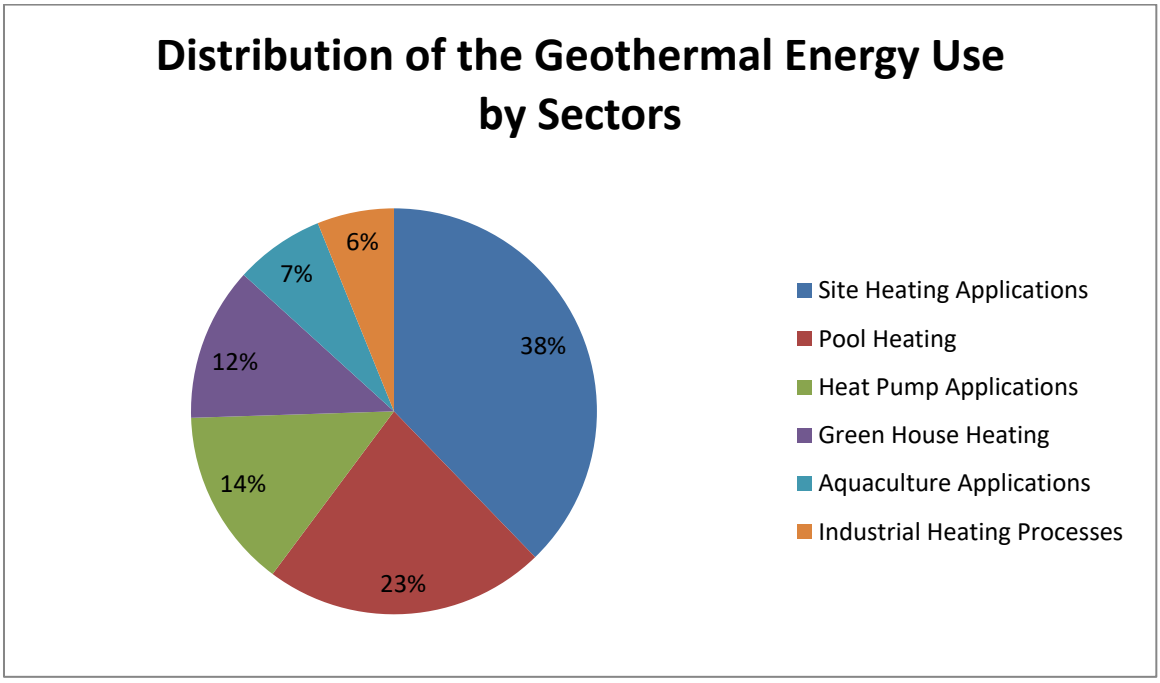


Diagram 1. Distribution of the Geothermal Energy Use by Sectors

Only 6% of the total geothermal potential has been utilized. In case of financial support, it is aimed to increase the installed power of 99 MW by 300 MW and the installed heat capacity of 2084 MW by 4,000 MW for 2015.

There are approximately 1500 hot and mineral water resources in Turkey, with temperatures ranging from 20-242 ˚C, and 195 geothermal fields that can be used on an economic scale. 800 geothermal exploration and production drillings and 200 gradient drillings have been carried out, and Turkey's geothermal heat capacity has been calculated as approximately 31500 MW. One of the important fields related to the direct use of geothermal energy is the aquaculture applications. With this application, many fish and other aquatic creatures living in seas and lakes can be raised more quickly and economically.

Fisheries production of our country is 594 thousand tons and 67 thousand tons of this production is obtained from aquaculture, 60% of the export is made from aquaculture. Aquatic creatures commonly produced in aquaculture applications are carp, sea bass, mullet, salmon, catfish, eel, tilapia. It has been determined that more fish can be produced in a shorter period of time in geothermal energy aquaculture applications compared to normal aquaculture applications. Studies show that if the water temperature drops below the optimum temperature level, the metabolism of fish is affected and they lose their ability to eat to a large extent in

ponds where fish production ponds are heated by sun. However, in applications with geothermal energy, the pool temperature is always kept constant, and production and time loss can be eliminated.

LEARNING ACTIVITY-4

AIM

- You will recognize aquaculture methods.

RESEARCH

- Research running water system aquaculture.
- Research closed circuit aquaculture.

3. Aquaculture methods

The amount of world aquaculture production was equalized with the production of fishing in 2012 and increased with an accelerating trend in the following years. It is known that aquaculture, which dates back to BC, is an important production method for the healthy nutrition of the world population, which is thought to exceed 9 billion by 2050. So much that the World Food and Agriculture Organization (FAO) has doubled it annually. Therefore, researches are continuing to develop environmentally friendly and sustainable methods, that use less water and land, and to obtain more products per unit area.

In Turkey, there is a proportional increase in the amount of aquaculture with the world. The aquaculture production, which was 118 thousand tons in 2005, exceeded 240 thousand tons in 2015, and it ranked first among the European Union member and candidate countries in fish production. The production target of aquaculture, which has increased with an increasing momentum in our country, is 500 thousand tons for 2023. Fisheries, the only animal originated food we can export to Europe is one of the important professions of today.

In our country, trout production in inland waters and sea bream, sea bass and white perch fish farming are carried out. Also, production of carp and tilapia species is increasing in inland waters.

Production in land aquaculture for freshwater and marine products is performed by 2 basic methods.

3.1. Running Water Method

It is the most widely used method in aquaculture, and this method is performed in inland fish pools. The water supplied from the water source enters the concrete pools used in trout production, and then the water that comes out is given back to the source or to the nearby stream or river. In this production method, which applies continuous water renewal, a large amount of water is used. The water used must be collected from the channels and cleared of solid wastes in the sedimentation ponds before it is discharged to the stream and river. This method, which is preferred especially in trout farms due to its high dissolved oxygen and low water temperature requirements, is the most widely used production method in inland fish production in our country.

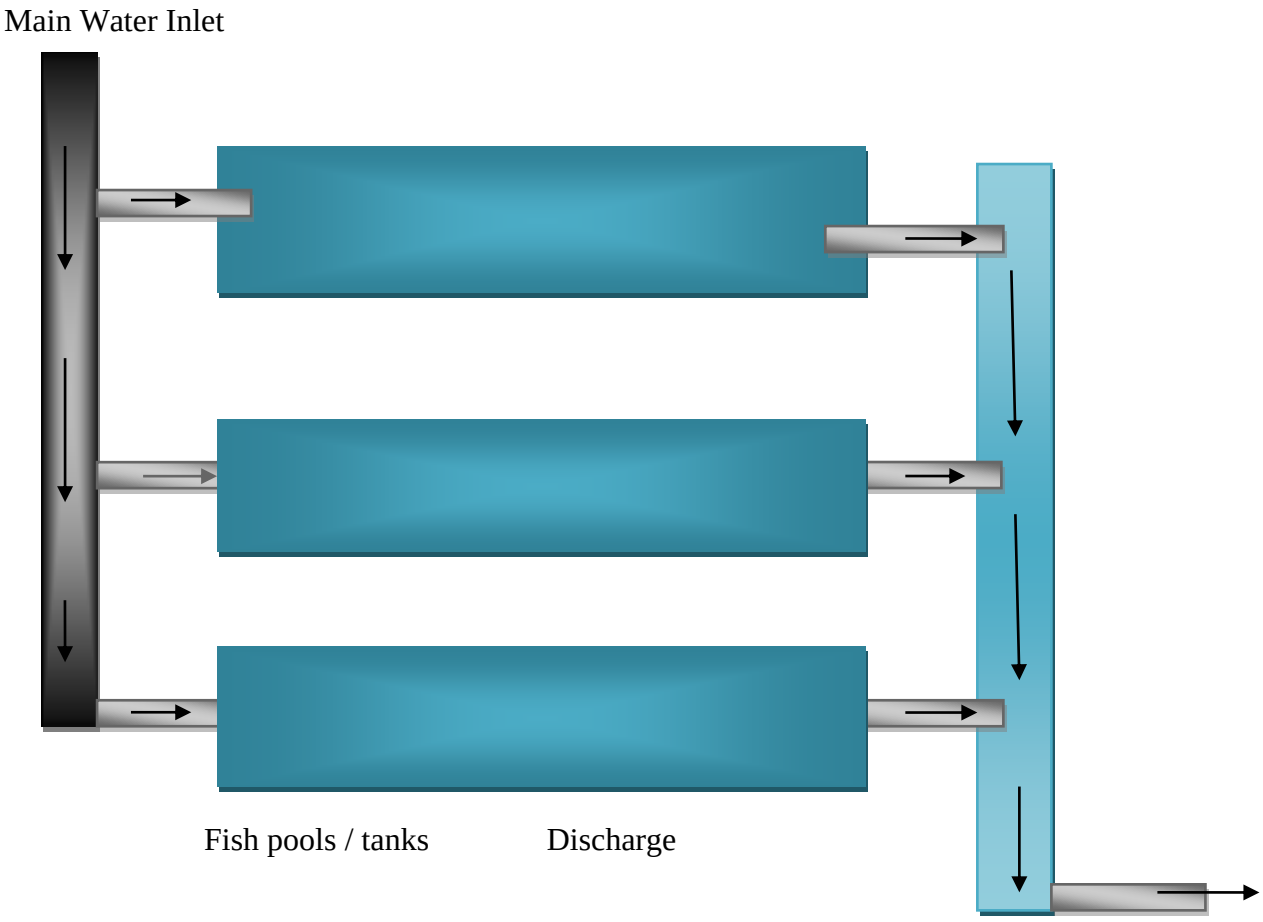


Fig. 1. Running Water System Aquaculture Diagram

3.2. Closed Circuit Aquaculture

It is a farming method mostly used in marine fish hatcheries on land, and it is a method of using the same water in fish tanks by collecting the water used from the channels and improving it after some filtration stages. Although the daily fresh water requirement varies according to the system mechanization, it is between 3-10% of the total water. This method, which is also used in the production of freshwater fish in many developed countries, is also used in research centers.

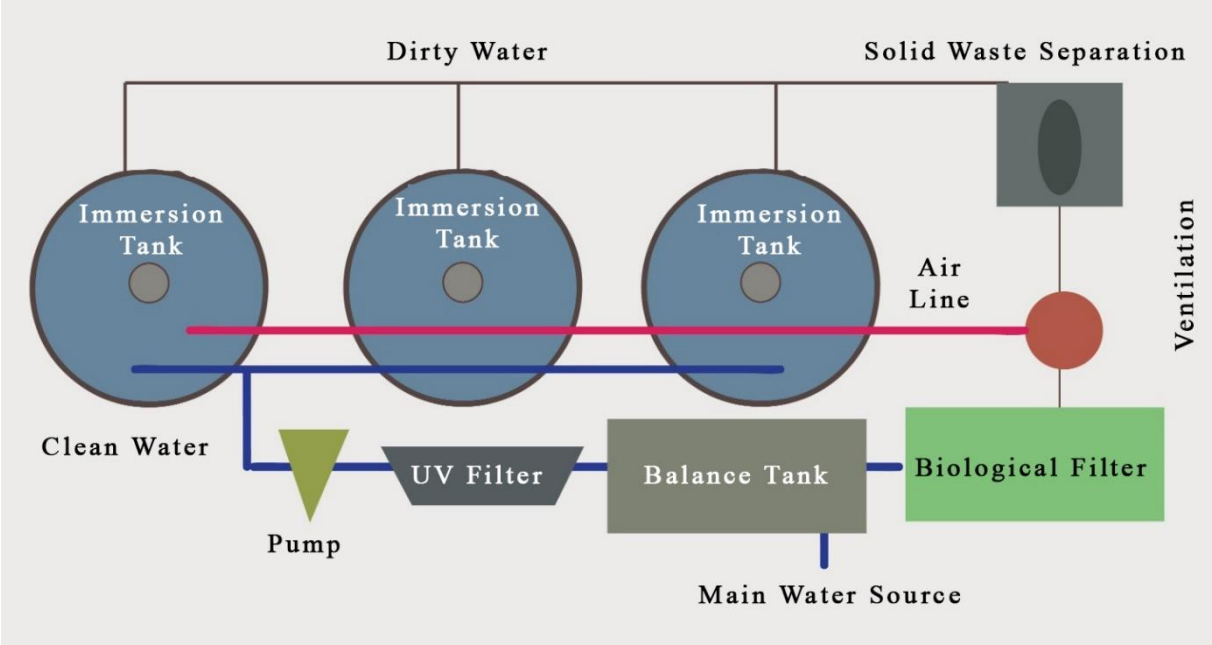


Fig. 2. Closed Circuit Aquaculture Diagram

In closed-circuit aquaculture, which is also the basis of the geothermal production system, dissolved ammonia compounds originating from the feces of fish in the tanks and inedible feeds are first passed through a solid waste filter. Then, by biological filtration, dissolved ammonia is converted to nitrite and nitrate by nitrification. As a result of the removal of nitrate from the water by aeration of the water, the water is made usable in fish tanks again. In the geothermal system, at this stage, nitrate water becomes fertilizer for vegetables produced by hydroponic application in plant tanks (pans), and after nitrate is taken by vegetables, water becomes available for use in fish tanks again.

LEARNING ACTIVITY-5

AIM

- You will recognize some fish species cultivated by geothermal resources**.**

RESEARCH

- Research which fish are grown the most in Turkey.
- Research which fish is grown the most in fish farming facilities with geothermal energy resources around the world.

5. 4. Some Fish Species Cultivated by Geothermal Resources

	Temperature °C	Time (month)
Catfish	17-24	4-6 months
Trout	12-18	4-6
Shrimp	26-30	6-9
Eel	27-30	6
Tilapia (Bream)	22-30	6
Shrimp	27-30	6-9
Cichlid	23-27	2-3
Carp	32-38	-
White Perch	22-30	10
Striped Bass	19-30	6-8
Salmon	15-25	6-12
Oyster	24-36	24
Lobster	24-31	24
Goujon	30-35	6
Pink Shrimp	29-40	6-8
Anostraca	28-32	6-12

Chart 1. Best Species for Aquaculture

Cichlids are generally the easiest fish to breed and high yields can be achieved with a small investment. Smaller pools than the values given above can be used for these fish. Large freshwater shrimps have a high market value, especially as fillets. Production rates vary according to water quality and flow rate.

Picture 13. Cichlid Fish

4.1. Tilapia

Although the tilapia species is not among the natural species in our country, they have been transferred to some lakes and streams with human intervention. In the Mediterranean region, Israeli sea bream is known as bream. It is the most suitable fish species for geothermal fish farming. Tilapia, which is a warm water fish, is a species with high tolerance in environmental conditions.

As warm water fish, tilapias are tolerant of a wide range of water quality. They can live in waters with a minimum temperature of 14°C and a maximum of 36°C, but they stop feeding below 17°C and may die below 12°C. The ideal growth and reproduction temperature is between 27-30˚C. When the temperature of the tank water drops in winter, it may be necessary to heat the water. Under ideal conditions, tiddlers with a size of 50 g reach 500 grams in a period of 6 months. Harvest weight can be around 300-400 g.

Picture 14 Tilapia (Oreochromis Niloticus)

Tilapias are mouth-breeding fish, and their production is relatively easy. Reproductive activity begins when the male fish attracting the female fish to a safe area on the bottom of the tank (putting pieces of pot, water pipe, and pot in the appropriate size on the bottom of the tank will make it easier for the male). The female lays the egg at the bottom and the male fertilizes the egg, the female returns and takes the fertilized egg into her mouth, and the egg incubation is completed in the female's mouth. During this period, the female does not feed. An adult female can lay eggs 3 times a year and lays 200-500 eggs at once. The tiddlers stay in the female's mouth for a while and then start free swimming around the female.

Tiddler should be collected during this period. Other fish and males in the tank may eat the defenseless tiddler. Raffia can be placed in the tank to protect the fry. When the female taking eggs in her mouth (it can be clearly observed that the lower part of the mouth expands in the form of a bag) is seen, the females can be separated and at the end of the incubation (when the fry are observed), the fry can be emptied into the water from the mouth of the females by gently squeezing their mouths, and they can be cared for separately in a separate tank / aquarium until they reach a certain size.

4.2. Carp

Carp species, which are the natural species of our country and found in many lakes and rivers in Central Anatolia, are very suitable species for geothermal fish farming. Since it is a fish that can easily adapt to rapid changes in environmental conditions (temperature, Ph, oxygen, etc.), it is very suitable for production in warm waters.

Picture 15 Scale Carp (Cyprinus Carpio)

Carps, like tilapias, are warm water fish with a high tolerance for low dissolved oxygen levels. Carp can survive below 4˚C and can withstand water temperatures as high as 34˚C. Growth slows down considerably in waters where the water temperature drops below 12˚C. Optimum growth and reproduction temperature in carp is between 25-30˚C water temperature. It can reach 500g in weight in less than a year at this temperature.

Adult individuals lay eggs once a year in spring. Eggs are relatively difficult to care for. Eggs can be taken artificially by hand milking method, or they can naturally lay eggs on the shelves of the tank. An adult female carp can lay 200-300 thousand eggs per 1kg body weight. The eggs are transparent and sticky and are about 1mm in diameter. The diameter of the fertilized egg is 1.6 mm. Eggs should be incubated in a well-ventilated and clean water source. Eggs laid on aquatic plants or raffia in tanks hatch in 3-4 days (60-70 days x degrees). The length of the larvae emerging from the egg is about 5 mm. Larvae hatching from the eggs should be fed with live food such as daphnia, rotifers and artemia naupili etc. After reaching a certain size, the fry can be fed with boiled egg yolk and formulated powder feeds. Procurement of carp with high tolerance to environmental conditions can be done from private and state hatcheries.

4.3. Trout

It is a cold-water fish species that is extensively cultivated with the river system in our country. Trout, which are carnivores, are fed with high protein feeds. Because it likes cold water, this kind of geothermal fish farming requires attention and experience.

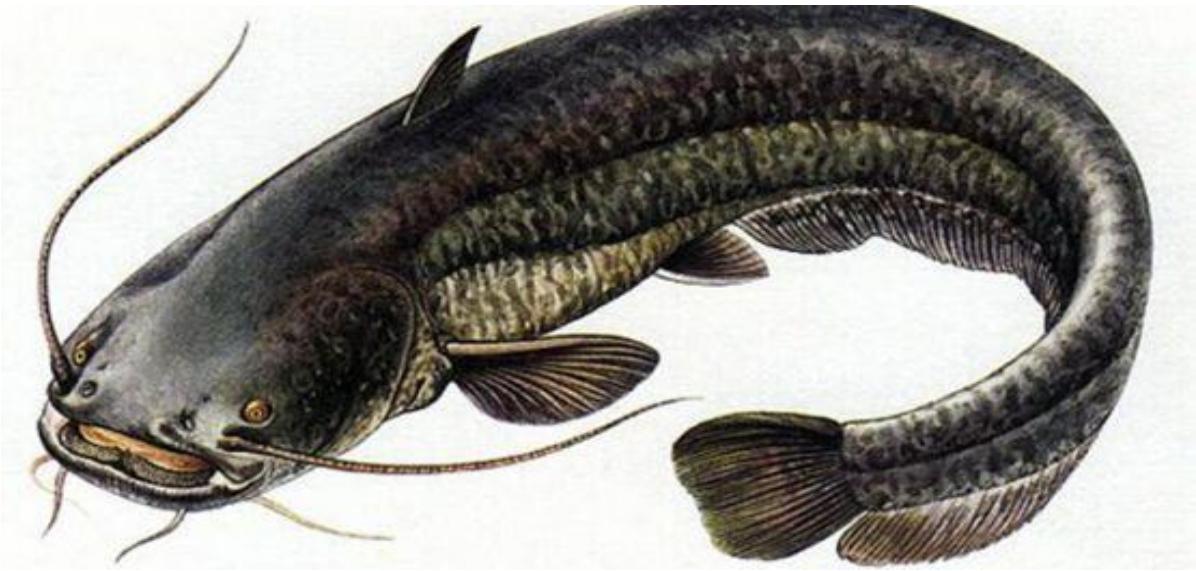
Trout production is a long and difficult task, which requires a separate hatchery to produce fry. Eggs obtained by artificial milking method are fertilized in a basin by milking sperm from male fish and the fertilized eggs are incubated in special hatchery cabinets produced for trout. These can be fed with formulated powder feeds. Trout eggs, which take a relatively long time to incubate, are relatively larger and are around 5mm.

Picture 16. Rainbow Trout (Oncorhynchus Mykiss)

Trout, a member of the salmon family, are cold water fish and prefer a water temperature of 10-18˚C. The optimum water temperature is 15˚C for trout. For this reason, trout can be preferred for geothermal systems mostly in the northern regions of our country, in the cold climate zone. Growth in trout slows down considerably when the water temperature rises above 21 ˚C, and since the oxygen level will drop at this temperature, trout farming will reach critical limits. (As the water temperature rises, the amount of dissolved oxygen will decrease). Abbots need a more sensitive water quality compared to Tilapia and Carp, therefore the aeration (oxygenation) of the water should be secured with spare pumps.

4.4. Catfish

Experiments on the production of catfish, whose commercial production has not yet started in our country, continue. However, catfish fry, which are naturally found in the inland waters of our country, can be collected from nature after the necessary permissions are obtained.



Picture 17. Catfish (Silurus Glanis)

The optimum growth temperature for catfish, which, unlike other fish, can survive at lower dissolved oxygen concentrations is 25-28˚C. Reproductive activation begins at 22˚C and occurs in spring. Offspring production is relatively difficult. There is no fry production in our country, except for a few commercial enterprises. After obtaining the necessary legal permissions, breeding can be done by collecting offspring from nature.

Daily Feeding Rate					
Fish Type	Limit	Optimal	Total Ammonia	Nitrite	Oxygen
Carp	4,34	25-30	>1	>1	>4
Tilapia	14-36	27-30	>2	>1	>4
Trout	10-18	14-16	>0,5	>0,3	>6
Catfish	10-30	25,28	>1	>1	>3

Table 1. Water quality needs of some fish species in geothermal fish farming

ASSESMENT - 3

1. Which of the following is the most suitable fish species for geothermal fish farming?

A. Tilapia
B. Trout
C. Eel
D. Carp
E. Cichlid Fish

2. What is the hatchability property of tilapia fish?

A. Hatching in the mouth
B. In the hatchery
C. Among stones
D. Hatching in the tank
E. In aquarium

3. What is the incubation period of fish?

A. Ovulation
B. Fertilization
C. Breeding
D. Hatching
E. Adult

4. Which of the following is a freshwater fish naturally found in our country?

A. Carp
B. Catfish
C. Shrimp
D. Goujon
E. Cichlid Fish

5. Which of the following fish species is intensively grown in the river system of our country, but requires attention and experience to be raised in the geothermal system?

A. Cichlid Fish
B. Catfish
C. Carp
D. Trout
E. Gray mullet

EVALUATION

Compare your answers with the answer key. Evaluate yourself by setting your number of correct answers. Go back to the activity and re-examine the issues related to the questions you answered incorrectly or you hesitate to answer.

LEARNING ACTIVITY-6

AIM

- You will learn aquaculture in thermal water and their nutritional needs.

RESEARCH

- Discuss in the classroom about the possible problems that may occur in aquaculture in thermal water. List these negativities and make a research on what measures can be taken.
- Research at least one subject from the fish farming unit in thermal water and explain it to your friends in the classroom environment by using visual materials.

5. Fish Farming and Nutritional Needs in Thermal Water

5.1. Nutrition Types of Fish

Like other animals in nature, the diet of fish is divided into three: carnivores (carnivores), herbivores (herbivores) and omnivores (both carnivores and herbivores). While some species maintain this nutritional characteristic at all stages of their lives, some other species may show different nutritional needs at different life stages. For example, while trout are carnivorous in all life stages (larva, fry, fattening, brood), some carp may be omnivorous in the early stages of their lives, and then herbivorous.

According to the feeding behavior of the fish, there may be differentiations in their morphological structures. Digestive system also varies in fish whose mouth structures differ according to their feeding habits. For example, with herbivorous carps, the stomach is elongated in the form of a tube and merged with the intestine, while carnivorous fish such as trout have a stomach with strong muscles.

In order to minimize the cost of feed, which is an important economic expense in the production of aquaculture, it is important to know the type of fish nutrition in the selection of

the fish species to be used in the geothermal system. Protein, fat and energy needs of fish according to different diets also differ.

5.3. Raw Materials of Fish Feeding

The most important raw material of fish feeds is fish meal. Fish meal obtained from fish with low economic value such as sprat, anchovy and herring is an expensive and important feed raw material that has not yet been matched due to its high protein content and essential nutrients. Fishmeal, whose protein content may vary depending on the type of fish from which the fish meal is obtained, the time of fishing, cold chain conditions and processing methods contains crude protein rate of approximately p.

In addition to fish meal and fish oil raw materials, vegetable feed raw materials such as soybean meal and corn gluten are also used in fish feeds. Vegetable feed raw materials, which are a protein source and are formed by turning the pulp or gluten into flour after removing the oil, can also be used in fish feeds between 0-60% depending on the diet of the fish.

Apart from these feed raw materials, which are a protein source, feed raw materials such as wheat flour and corn flour, which are energy sources, can also be used between 10-30% in feeds, depending on the nutritional preference of the fish.

Another important energy source for feed raw material is fish oil. Vegetable oil sources such as sunflower oil and corn oil can be used as an alternative to fish oil that is obtained by extracting the oil in oil factories from the widely caught fish such as sprat, anchovy and herring, which have low economic value. The amount of oil in fish feed may differ according to the fish species and fish life phase. Especially in breeding fish, high energy is needed during the breeding period, so fish feeds with high oil content are used.

Apart from these feed raw materials, vitamins and minerals needed by the fish according to their life phases are met by using 1-2% of vitamin and mineral mixtures in fish feeds.

5.3. Composition of Fish Feed

Protein and energy are the most important nutrients in fish feeds prepared in feed factories with different rations according to the nutritional needs of the fish. Ammonia, which will be a nitrate source for plants in the geothermal system, consists of protein in fish feed. Therefore, it is very important to know the protein amount of the fish feed and to know the nutritional needs of the fish species that will be used in the geothermal system.

According to the species and life stages of the fish, feeds with different protein contents are used. For example, while the crude protein ratio is 45-50% in carnivorous trout raising feeds, this ratio drops to 0 in herbivorous carp feeds. Since tilapia cultivation is not done intensively in our country, it is very difficult to obtain the feed, but carp feeds can be used in tilapia nutrition. Crude protein requirement of tilapia fish is similar to carp and is around 0-35%.

Again, depending on the fish species and the life phase of the fish, the crude oil content in the feed can vary between 10-20%.

5.4. Calculation of Fish Feeding in Geothermal System

Before installing the system in the geothermal system, it is important to know the type of fish to be raised and the nutritional characteristics of this species. Because the life phase and water temperature of that species are important criteria in calculating the daily amount of feed to be provided to the fish. The amount of feeding will decrease as you move away from the optimum growth temperature of the fish species.

While 5-7% of the total fish weight in the system is used daily at optimum water temperature for juvenile fish, the daily feed rate will decrease as the fish grow, and it will decrease to 1-2% in harvested fish.

For example, for feeding 5000 pieces of 50 g carp grown at 25°C with a daily feeding rate of 6%;

5,000 pieces x 50 g = 250,000 g = 250 kg total fish weight.

250 kg fish weight x 0.06 feeding rate = 15 kg daily feeding amount.

This amount of feeding can be given to the fish as 3-4 meals a day (4-5 kg) per meal, in the form of morning-lunch-afternoon and evening meals.

It is necessary to renew this calculation monthly according to the average weight taken from the fish and the daily measured water temperature. In order to get the average weight of the fish, the water of the tanks is reduced and 20-30 fish are caught at random, the total weight is measured with the scale and divided by the number of samples and the average weight of a fish is calculated.

Another example is the feeding calculation with 2% daily feeding rate for 5000 pieces of 200 g tilapia fish at 28°C;

5000 pieces x 200 g = 1.000.000 gr = 1000 kg total fish weight.

With a feeding rate of 1000 kg x 0.02 = 20 kg of total feeding per day

As seen in the two examples given above, our daily feed amount has doubled, although the daily feeding rate has been halved in the feeding of fish with the same number but different average weights. This difference is due to the size of the fish.

Calculation of the daily amount of feed used in fish feeding will be used to calculate the required surface area for vegetables to be produced in the future geothermal system installation and the amount of nitrogenous compounds to be loaded into the system.

In the tables below, daily feeding rates of some fish at certain temperatures and average weights are given. These values may also vary according to the protein content of fish feed. The most accurate feeding diet chart should be requested from the dealer from whom the fish food is purchased.

Daily Feeding Rate

Average Fish Weight	Daily Feeding Rate
5-20	14-12
20-40	7,0-6,5
40-100	6,0-4,5
100-200	4,0-2,0
200-300	1,8-1,5

Daily Feeding Rate

Average Fish Weight	15 C	18 C	21 C	24 C
5-20	6,0	7,0	10,0	12,0
20-50	5,0	6,0	8,0	11,0
50-100	4,0	5,0	6,0	8,0
100-300	3,0	4,0	5,0	6,0
300-1.000	2,0	3,0	4,0	5,0

Table 2. (Top) Daily feeding rates of Tilapia fish in relation to weight and temperature.
Table 3. (Top) Daily feeding rates of Carp fish in relation to weight and temperature.

Daily Feeding Rate

Avarage Fish Weight	14-15 c	16-17 c	18-19c
15-30	3,2	3,6	3,4
40-100	4,5	4,8	4,9
100-300	5,6	5,9	6,0

Daily Feeding Rate

Avarage Fish Weight	15 C	18 C	21 C	24 C	27 C	30+ C
20-60	1,3	1,7	2,2	2,8	3,6	3,4
60-150	1,1	1,4	1,6	2,2	4,8	4,9
150-300	0,9	1,1	1,3	1,7	5,9	6,0
300-500	0,7	0,9	1,0	1,3	1,3	1,5

Table 4. (Top) Daily feeding rates of Rainbow trout in relation to weight and temperature.
Table 5. (Top) Daily feeding rates of catfish in relation to weight and temperature.

5.5. Fish Care

Fish care in aquaculture is an important job that needs to be taken care of. Fish and fish tanks should be checked every morning before feeding, water levels, water inlets and outlets should be checked, and fish swimming behavior should be observed. In case of death in tanks or pools is observed, immediate measures should be taken. If there is an unexpected high mortality rate in the tank or an unexpected swimming behavior in the fish (3-5 deaths per week is normal depending on the stock density), the weirs should be lowered (water evacuation should be done), fresh water intake and aeration should be increased. Oxygen amount, temperature and pH level should be controlled from the water outlet and necessary precautions should be taken.

If there are bleedings in the body, bleeding in the mouth and head region, and abnormalities in the fins in the morphological external examination of the dead fish, the fish may be sick. A fish diseases specialist should be contacted immediately and necessary actions should be taken.

If there is no problem in the first control in the morning, fish feeding should be started and the feed should be given to the fish tank little by little and spread out at each feeding, and the feed-taking behavior of the fish should be observed. Although we need to determine the feed to be given to the fish as a meal with the calculations made in the fish feeding section and

give this amount of feed, the fish may be unappetizing on some days/meals. If the fish are not getting the feed, feeding should be stopped and this should be noted.

The average weight of the fish should be noted monthly. For this process, 20-30 fish are caught randomly from the fish tank according to the stock density, and the fish are transferred into a container filled with tared water, after the water is filtered, and the total weight is measured and recorded with a scale. By dividing the total amount of weight recorded by the number of fish sampled, the average weight of one fish in tanks is determined. In tanks with high stock density, this process can be repeated 2-3 times. The important point to be considered while doing this process is to choose the fish randomly and to avoid taking especially large or small fish while sampling. If necessary, the tank water level can be lowered and sampling can be performed more easily.

Fish will grow after a certain period of time and will reach a greater weight than the weight in the first place. However, not all fish will grow equally, some fish will grow faster, some will remain smaller. This may happen due to the genetic origin of the fish, the pre-grading processes carried out in the hatchery produced, or the success or failure of the fish in accessing the feed. A large size difference in the same tank will affect the growth performance of the fish in the tank, causing large and small fish to be harvested during the harvesting of the fish. In order to prevent this, the fish should be sorted at certain time intervals and the large and small fish in the same tank should be separated from each other. This process is called fish grading. Mechanical grading devices or grading machines are available for the fish grading process, but in low-tonnage enterprises, manual grading can be done with two workers.

For this process, all the fish in the tank will be gathered aside with a long net with a lead rope knitted bottom and a float on the top, through the appropriate mesh opening, and the other part of the tank will be full of water but without fish. With the help of a small scoop, the fish caught in a part of the tank are selected by hand and started to be separated according to their size by eye. The excess group is left in the same tank, and the lesser group is moved to another tank or a container filled with water. After this process is applied to all tanks, big fish and small fish will have been separated from each other. The feed needed by both groups should be calculated by taking the average weight as described before. Again, the feed particle size should be determined according to the size of the fish.

During these processes, the fish collected at the edge of the tank should not be compressed too much, they should be kept in such a way that they can swim freely but also be caught easily,

and additional air should be given to the compressed fish. If necessary, fish tranquilizers, sedatives (egg clove oil 40-60 mg/L) can be used. However, using fish tranquilizer is a specialist job and it should be applied by experienced people.

Another important issue in fish care is the precautions to be taken regarding the health of the fish. First of all, every fish that comes to the facility should be quarantined for a while and observed for a few days in a well-ventilated tank that is not included in the geothermal system. Items such as scoops, feed buckets, feed shovels from other businesses should not be transported to the business. At the entrance to the business site, there should be a disinfectant pool on the ground and everyone entering the facility should step into this pool with their shoes. For hygiene purposes, after harvest, fish tanks should be cleaned, dried and then filled with water again. It is important to take these and similar hygiene measures to protect the health of the fish.

Contrary to what everyone knows, fish, like all other living things, are stressed animals. The approach of unemployed people to the ponds, feeding other than meals, sudden water quality changes, water quality exceeding the optimum values stress the fish. In some cases, such as bad weather, lightning, etc. sometimes there may be situations that create stress for the fish. Stressed fish swim reluctantly, react quickly, are restless and become darker in color. Stressed fish take less food and tend to hide. As a result of stress, the risk of fish getting sick will increase. Necessary measures should be taken in the establishment to prevent your fish from getting stressed. Adding vitamin C (5 g/kg feed) to fish feeds in tanks that are under stress or at risk of getting sick for a week will reduce the stress a little bit and strengthen the immune system.

In the sale of fish, the water level in the tank should be thoroughly reduced, a small amount of water and plenty of ice should be added to a separate harvest tank. Fish should be quickly scooped into the harvest tank, which is filled 1/3 of the way with watery ice consistency, and it should be ensured that the fish die quickly with the sudden heat shock. Especially carp and tilapia species take time to die because they are heat-tolerant fish. Killing the harvested fish quickly will improve meat quality and extend shelf life.

Fish tanks should be numbered and all operations (feeding, water quality controls, grading, vitamin supplementation, harvesting, etc.) should be recorded daily, filed and archived in a folder belonging to that tank.

5.6. Water Temperature

Temperature has a key influence on the physiological processes of fish. Each fish species is known to have a species-specific temperature index for survival and growth. Maximum growth is achieved at optimal temperatures within this thermal tolerance range. With the increase in temperature, the food intake also increases towards the maximum, and then a decrease is seen in this increase as the thermal upper limit is reached. Usually, maximum feed intake occurs a few degrees above the specified optimal water temperature for growth. The metabolic rate increases exponentially with increasing temperature, and the difference between feed intake and metabolic rate at any given temperature determines the energy available for growth. These parameters are indeed very important for cultivated species. In other words, temperature is very important in maximizing the efficiency in converting the received nutrients into growth.

Temperature affects all vital activities of fish as well as all living organisms. Many important activities, from ovarian development to egg development, from immune system to body weight gain, take place under the influence of water temperature. The importance of temperature in terms of aquaculture can only be better understood after understanding its biological importance. The optimum temperature range determined for egg development is almost the first steps to success in fry rearing. Determining the optimal water temperature and monitoring the live weight gain of the fish are among the most important concepts considered in the preparation of feeding protocols. Food intake and digestive physiology under the thermal effect are the most interesting subjects in the field of cultivation. The most important arguments in the breeding race are the conditions and protocols under which conditions and protocols can be forced to achieve the highest level of performance, as well as the species characteristics of the grown species.

Fish and crustaceans are “poikilothermic” or cold-blooded creatures. This means: the body temperature of such creatures is roughly the same as the temperature of the water they are in. For this reason, when the water temperature of fish or crustaceans changes, their body temperature also changes frequently. All biochemical processes are temperature dependent. It is so dependent that every 10ºC increase in temperature roughly doubles the rate of biochemical processing, depending on the species and its habitat.

5.7. Lime Content and Properties

Liming is an effective tool in fish production and pond management. However, lime is randomly used to describe two different types of materials used for very different purposes. Agricultural limestone refers to calcite (calcium carbonate) and dolomite (calcium magnesium carbonate). Calcium and magnesium compounds increase the overall water hardness, which is essential for the health of many water species. The carbonate component raises total alkalinity and pH, buffers daily fluctuations in pH, increases microbial activity in the pond soil, and increases the availability of phosphorus to phytoplankton. Pool water with a total alkalinity of less than 20 ppm can benefit from calcification. Hydrated lime (calcium hydroxide) is an inexpensive and effective pool sterilizer that quickly and dramatically raises the pH above tolerable levels for aquatic organisms. It should be used with caution, avoiding contact with the applicator, and should never be used in pools containing desirable fish.

Lime application in fish ponds has three main purposes:

1. Increasing the utility of nutrients.

2. To increase pH and buffer against daily pH fluctuations.

3. Sterilizing pools before stocking.

(While these applications use lime, they contain different chemical compounds.)

IMPLEMENTATION

Taking care of fish in tanks.

Process Steps	Suggestions
Put on your work clothes. Put on your bonnet.	
Disinfect your hands.	
Put on your work clothes.	
Follow the codes of cleanliness and hygiene in your work.	
Check past maintenance schedules and prepare for new maintenance.	
Comply with the work organization..	
Please select the feed according to the type of fish.	Make sure that the feed is suitable for the fish.
Prepare vitamin supplement.	Make it suitable for application.
Prepare to feed the fish at the right rate and time.	Use your time well. Be careful and thorough. Comply with hygiene rules.
Measure the feeding amount regularly every month.	Make the measurements accurately and carefully. Record the measurements made regularly for each month.
Check for the sick fish. Check for signs of illness. Measure the weight. Separate the fish showing signs of disease.	Be careful in disease control. Do the weighing correctly. Be careful when separating sick fish.
Measure the oxygen content of the water in the tanks. Measure the pH level. Measure the temperature in the tanks accurately.	Measure the amount of oxygen correctly. Measure the pH level accurately. Measure the temperature carefully.
Measure the water quality.	Measure the water quality carefully.
Follow the rules when cleaning the pool.	Check the cleanliness of the pool.
Use the tools carefully by following the work safety principles.	
Use your time well.	
Follow the provided instructions.	
Take of your work clothes and hang them.	

Take out your disposable materials and throw in the trash.
Clean your working environment.

ASSESMENT – 4

1. Which of the following is the correct way to give the stages of fish as carnivorous-herbivorous-both carnivorous and herbivorous, respectively?

A. Carnivores - Herbivores - Omnivores
B. Herbivores - Omnivores - Carnivores
C. Omnivores - Carnivores - Herbivores
D. Omnivores- Herbivores - Carnivores
E. Herbivores - Carnivores - Omnivores

2. Which of the following is a trout diet?

A. Carnivorous
B. Herbivorous
C. Both carnivorous and herbivorous
D. Herbivores
E. Carnivores

3. Which of the following is not a sign of fish getting sick?

A. Bleeding in the body in morphological examination
B. Bleeding in the mouth area
C. Bleeding in the head area
D. Abnormalities in the fins
E. Shine in the eyes

4. Which of the following is not a cause of differences in growth rates in fish?

A. Genetic origin of fish
B. Pre-sorting processes in the hatchery
C. Fish's success in access to food
D. No size-sorting
E. The quality of the feed used in the facility

5. Which of the following is the name given to the process of separating large and small fish in the same tank at certain time intervals in fish farming?

A. Sizing
B. Incubation
C. Fertilization
D. Sequence
E. Separation

6. Which of the following is not a factor that causes fish to get sick?

A. Non-meal feeding
B. Bad weather conditions
C. Water quality changes
D. Water quality out of optimum values
E. Not checking pool

7. Which of the following is not a positive effect of pool temperature on fish development?

A. Growth
B. Ovarian Development
C. Egg Development
D. Immune Development
E. Weight Loss

EVALUATION

Compare your answers with the answer key. Evaluate yourself by setting your number of correct answers. Go back to the activity and re-examine the issues related to the questions you answered incorrectly or you hesitate to answer.

CHECKLIST

As part of this activity, please rate yourself by placing an (X) in the Yes box for the skills you have gained from the behaviors listed below, and the No for the skills you cannot acquire.

Evaluation Criteria	Yes	No
1. Did you put on your work uniform?		
2. Did you put on bonnet?		
3. Did you take off your jewelry?		
4. Have you disinfected your hands?		
5. Did you select the feed according to fish species?		
6. Have you provided vitamin supplements for healthy nutrition of fish?		
7. Did you correctly calculate the amount of food for the fish?		
8. Did you feed the fish at the right ratio and time?		
9. Have you measured the feeding amount regularly every month?		
10. Have you done the health checks of the fish?		
11. Did you check the sick fish and observe the symptoms correctly?		
12. Do you know what to do if there is a disease in the tanks?		
13. Have you checked the oxygen amount, temperature and pH level?		
14. Have you measured the water quality?		
15. Have you cleaned of the pool?		
16. Did you follow the codes of cleanliness and hygiene in your work?		
17. Did you pay attention to the use of tools and equipment?		
18. Were you elaborative and careful while doing your work?		
20. Did you complete the work in the given time?		
21. Did you clean your work environment?		
22. Did you keep a record of your work?		
23. Did you take of your work clothes?		

EVALUATION

At the end of the evaluation, review your "No" answers once again. If you have any hesitations about your answers, repeat the learning activity. If all your answers are "Yes", move on to the next activity.

LEARNING ACTIVITY-7

AIM

- You will learn the system and features of thermal water pools.

RESEARCH

- Research system and features of thermal water pools.

6. System and Features of Thermal Water Pools

The first calculation to be made in aquaculture projects where geothermal energy resources will be used is to determine the dimensions of the geothermal pool. In many projects involving such applications, the size of the pools is limited to the maximum amount of heat that can be drawn from geothermal energy sources. Preliminary calculations including the possible heat losses from the pools of the use of geothermal energy resources in aquaculture. In order to calculate the heat losses, it is necessary to determine the temperature that the pool should have first.

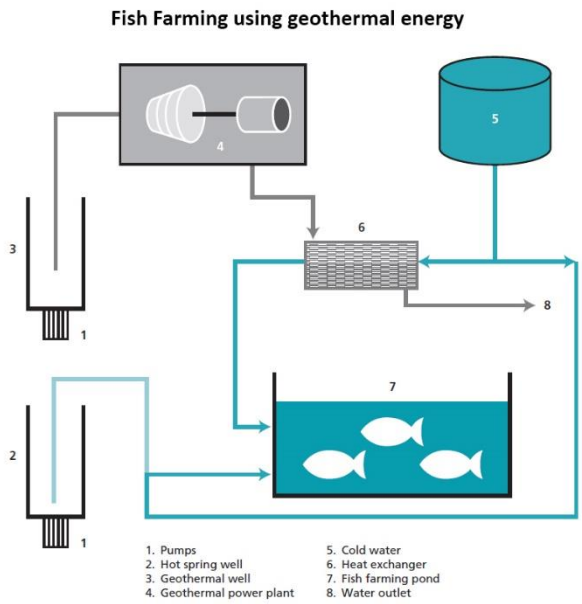


Fig. 3. The system used in geothermal energy sources

6.1. Fish Tanks

Fish tanks may differ according to the materials they are produced and their shapes. Different types of tanks can be used for different purposes and sizes, as well as for fish of different sizes and life stages.

Plastic drums and IBC tanks can be used as fish tanks in amateur geothermal systems. It is important that the materials used in the construction of the tanks are long-lasting materials that will not harm the fish, will not change the quality of the water. For example, a fish pool made by welding iron sheets will rust after a while and change the water quality in the future and become harmful to the fish. In addition, since the iron carries heat quickly, it will be very difficult to control the water temperature. The most suitable materials for the production of fish tanks are polyester, fiber polyethylene (PE), etc.

Picture 18 Plastic materials used for different purposes but also can be used as geothermal tank, barrel (left) IBC tank (right)

6.1.1. Rectangular Tanks

They are rectangular or square shaped tanks. In fish production, they are mostly used for fish transport, but the ones with less depth can be used as larvae and juvenile fish tanks. They are not very suitable for fattening fish production. Although the water is ventilated and homogeneously distributed all over the tank, dead spots in the corners and blind spots where the water does not change remain.

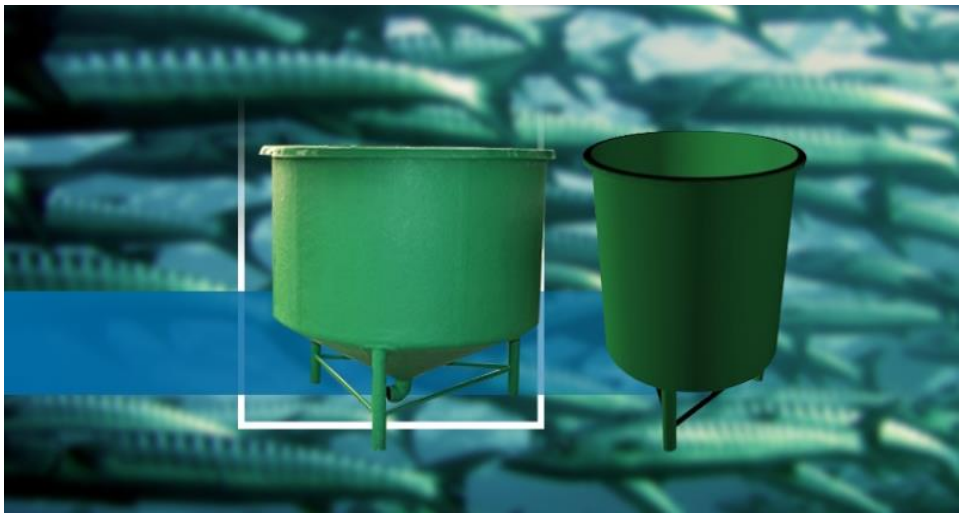
Another variant of rectangular tanks is rectangular shape tanks with rounded corners. They are mostly ideal for juvenile fish. In these tanks with a flat bottom, the water inlet and outlet

are made from the short sides. They can be produced from polyester, fiber or PE material. They can vary in size and be quite long.

Picture 19-20 Fish tanks of different shapes, rectangular tank (left), tank with rounded corners (right)

6.1.2. Cylindrical Tanks

It is the most ideal tank type in fish farming. It is a tank system where the water enters from the upper edge of the tank and there is a water outlet from the opposite side of the water inlet or in the middle of the bottom, and the water level is adjusted by pipe type weirs. Compared to other tank shapes, it is advantageous in terms of homogeneous distribution of water in the tank and no dead spots in the tank. The tank shape is more suitable for the swimming movement of the fish. It can be produced in various diameters, sizes and depths. Especially in tanks where there is water discharge in the middle of the bottom of the tank, the conical bottom will help inedible feeds and fish excrement to collect in the middle and remove away from the tank. They can be produced from polyester, fiber or PE material.



Picture 21 Cylindrical fish tank

6.2. Solid Waste Filter

In the geothermal system, they are the filters used for the separation of inedible feed, fish excrement and other suspended solids accumulated in tanks from the water. It can be in different sizes and shapes according to the purpose of use and the size of the system. Amateur geothermal producers can create a simple and convenient solid waste separator themselves using barrels and PVC pipes. However, commercial type manufacturers use more professional solid waste filters since it is important for the continuity and automation of the system.

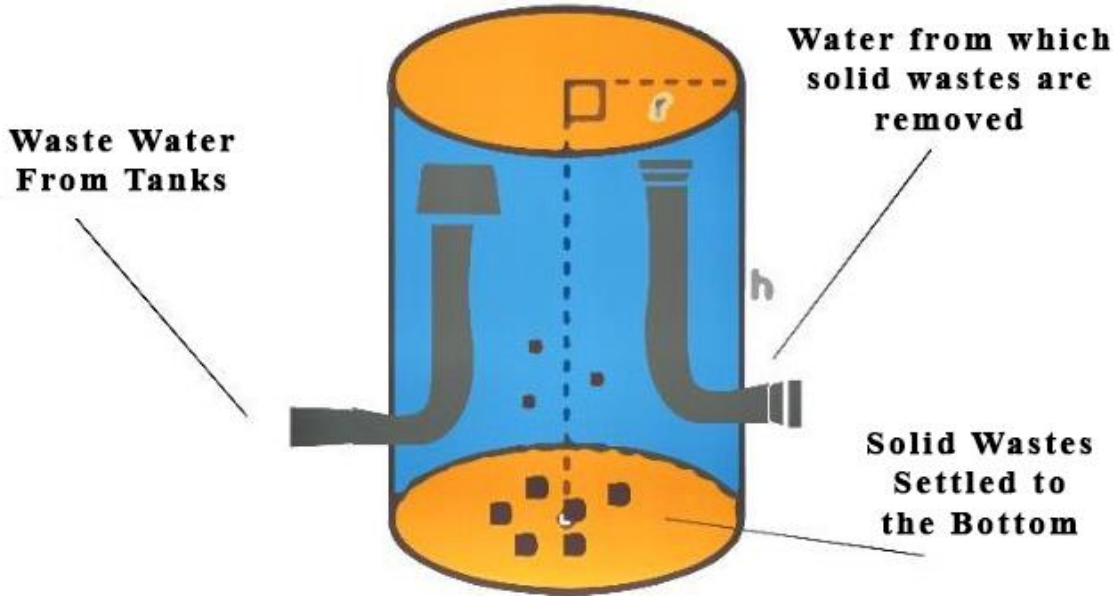
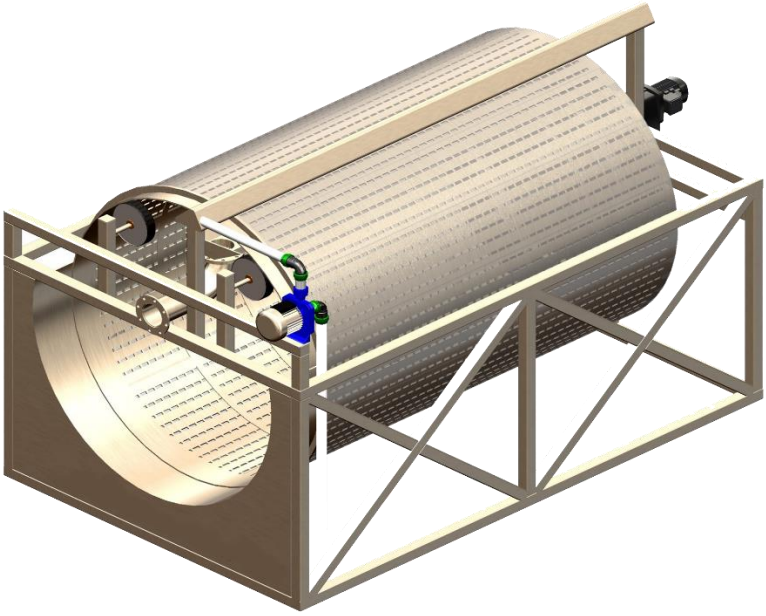


Fig. 4. Simple solid waste filter

6.2.1. Drum Filter

Drum filter is a type of filter where the water from the fish tanks is collected and drained from a cylindrical drum and separated from the solid wastes. Here, the top of the drum-shaped part is covered with a special cloth with pores of different sizes (such as 5-200 microns), and this drum rotates continuously and ensures that the solid wastes in the water passing through it are attached to the cloth. The cloth, whose pores become clogged over time, is cleaned automatically by spraying water from the buttons on the reverse, and solid wastes are thrown out of the system through a channel.



Picture 22. Drum Filter

It is the most useful and economical among solid waste filters. By using two drum filters with cloths with different mesh openings, all suspended substances in the water (such as inedible feed, feces, etc.) can be cleaned. It can be used especially in geothermal enterprises engaged in commercial production.

6.2.2. Bag Filter

It is a type of filter that works by filtering the water collected from fish tanks through a cloth bag. By using cloths with different mesh openings, smaller particles can be separated from the water. Cloths need to be cleaned or changed periodically. Otherwise, clogged cloths may cause the system to clog.

Picture 23. Bag Filter

6.2.3. Sand Filter

It works by ensuring that the water collected from fish tanks is passed through layers which contains sand and gravel grains of different particle sizes in a pressurized system and solid waste remains in these layers. Depending on the size of the system, sand and gravel should be washed reversely several times a day with the water in the system, and the polluted sand and gravel should be rinsed out (with the help of the valves in front of the filter), and the solid wastes kept in the filter should be discharged from the filter. Otherwise, the pressure in the filter will increase and it may cause clogging of the system.

Picture 24. Sand Filter

6.2.4. Sedimentation Pool

It is mostly used in enterprises with large water mass and intensive fish production. The water from the fish tanks is collected in a relatively deep pool, and the water is re-collected from the surface of the opposite side of the pool. As the water flows from one side to the other, unwanted solids settle to the bottom of the pool. In this pool type materials such as sand, gravel, etc. can be used for particle retention in terms of natural filtration. As seen in Figure 8.8, placing barriers to allow water to move up and down after the water inlet will increase the amount of solid wastes to be retained. Since the solid wastes accumulating at the bottom of the pool will deteriorate the water quality over time and must be cleaned continuously, its use in geothermal systems is relatively low.

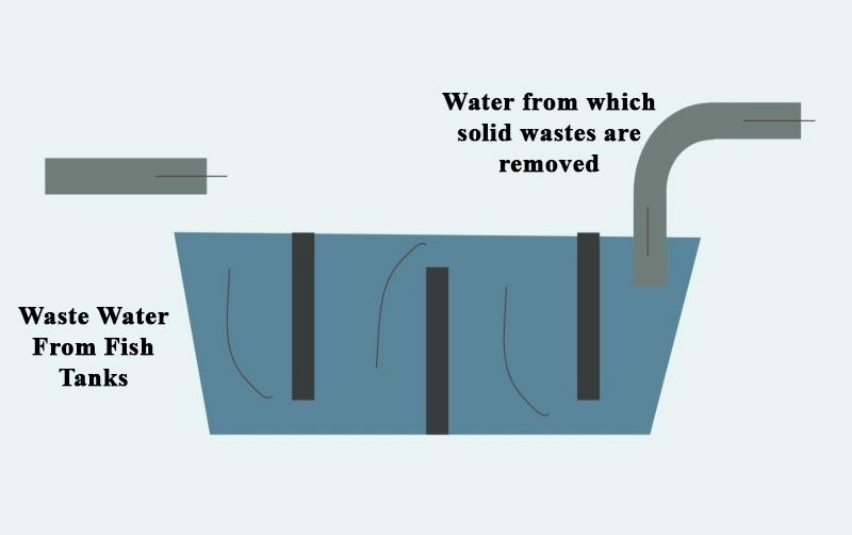


Fig. 5. Sedimentation basin cross section and working principle

6.3. Biological Filter

The most important element of the biological filter is the biological elements. Biological elements are surface enhancing plastic pieces of different shapes and sizes with different materials. These are important biological filter elements that are necessary during the nitrification process, in which ammonia in water is converted into nitrate, and that bacteria, which is an important creature of the geothermal system, adhere to these surfaces and that the nitrification process takes place with the oxygen provided by aeration. Biological elements are commercially sold under different names (bioball, bioelement, kaldnes). The most important feature to be considered while supplying biological elements is that they must not be produced from recycled plastics. Since the plastics used in recycling are produced from materials that are with unknown origins and for what purpose they were used in the past, they have a high probability of deteriorating the water quality. In addition, recycling plastics have very low resistance to UV from sunlight. Biological elements made of plastic material with known manufacturer and high UV resistance will be both safe and long-lasting. Another important property of biological elements is the amount of surface area in m^2. Although there are biological elements with a surface area of 350-500 m^2/m^3 in the market, it is possible to find biological elements with a surface area of 750 m^2/m^2.

There are biological elements produced in different densities according to the density of water. Salt water and fresh water productions have different densities. Biological elements float in water (0.9-1.0 g/cm') when they are first released into the water, and their density increases with the adhesion of bacteria on them over time and sinks to the bottom. In the biological filter stage, these biological elements should be aerated and dispersed

homogeneously in the water. This aeration is very important since it provides the oxygen required for nitrification.

6.4. Ultraviolet Filter

It is a filter for sterilizing water with ultraviolet (UV) light in order to remove pathogenic (disease-causing) microorganisms in the system, although some experts argue that it should not be used because it can kill nitrifying bacteria therefore it is controversial to exist in the geothermal system.

UV filters can be made of polyethylene or metal material according to their capacity. Different numbers of UV lamps are placed in the outer layer, which is mostly cylindrical, depending on the capacity of the filter. UV lamps operate in a quartz tube without contact with water. As the water flows at a certain speed between the outer layer and the quartz tubes inside, it is exposed to UV light and the fungi, bacteria and viruses in the water are largely removed.

Picture 25. HDPE body UV filters with different sizes and tube numbers

Fingerprints should not be left on the installation of UV filters, quartz tubes and UV lamps, dust should be prevented from adhering to them so that the efficiency of the filter does not decrease. The effective life of UV filters on the market is mostly 9000 hours (1 year). The UV lamps must be replaced at the end of this period. The filter has a panel showing the operating time and its control is performed through this panel.

The light intensity of the lamps of the UV filters is important for the efficiency of the filter. There are filters with a UV dose of 360-400 Joules/m² in the market. However, the important thing here is that it reaches these values after 9000 hours of operation. The effect of the UV dose applied per square meter is also related to the water flow rate. The UV dose applied at low and high flow rates will also change.

Although some experts talk about the redundancy of the UV filter in the geothermal system, it is recommended to use the UV filter in commercial and intensive productions in order to protect the health of the fish.

6.5. Aeration

It is the equipment to provide the necessary oxygen during nitrification in the geothermal system, in the fish tank water and in the biological filter . It is a system in which atmospheric air is transported by pressure and thin air pipes and air stones are used to dissolve the air in water faster. Compressors can be used for this process, but an important point to note is that there should be an oil and water trap at the air outlet of the compressors and a good air filter at the air inlets. Compressed air must be transported to tanks with a suitable piping system and the amount of air must be adjusted with air valves.

Picture 26. Compressor and aquarium air motor

To increase the water oxygenation, an air stone should be placed at the end of the air hoses. The smaller the pores on the air stones, the smaller and more the air bubbles will be, so the solubility of oxygen from the air in water will increase.

For small scale amateur geothermal systems, suitable size aquarium air motors may be sufficient.

6.6. Pump

Water pumps are used to provide water circulation in the geothermal system. These water pumps, which use electrical energy, can be of different sizes and modes of operation, depending on the size of the system. Amateur geothermal systems can use a powerful aquarium pump or a medium-sized submersible pump, while larger commercial geothermal systems should use steel or HDPE-bodied electric water motors.

Electric water motors have started to be produced with HDPE body with today's technology, corrosion is prevented with this material and the service life of the motor is increased. In addition, electricity consumption is minimized with hybrid technology in similar engines. Adjusting the flow rate of the water engine to be used will allow you to circulate the desired amount of water in the system.

Picture 27. Types of pumps that can be used in the geothermal system (left to right: submersible pump, steel-bodied electric water pump, HDPE-bodied flow-adjusted hybrid water pump)

In the geothermal system installation, the amount of pump/motor to be used in the system should be minimized by making the correct calculations and using the water level difference correctly. This will reduce electricity consumption. However, in case of any malfunction or maintenance, the presence of a spare water pump in the system will help you to guarantee the system in order to ensure the continuity of the water in the system.

6.7. Balance Tank/Pool

In the geothermal system, there should be a balance pool with water pump for the water circulation and if necessary biological filter which the water of the fish tanks is collected and the balance of the system is ensured. The size of this balance pool can be 5-10% of the total water volume in the system.

Daily fresh water entry into the system and discharge of the water in the system should be made through this balance pool. Covering the balance pool with an opaque canopy will reduce algae growth in the system. Algae explosion in the system may cause nutrient deficiency by these night-breathing vegetative organisms consuming the dissolved oxygen in the water, negatively affecting the water quality, and by sharing the nutrients of the vegetables in the system. Therefore, algae control in the system should first be performed by shading the balance pool (and fish tanks).

The balance pool can be made from plastic tanks or it can be made in the form of a concrete pool. The water level in the system should be adjusted and balance pool should be located in the most suitable place for the system, and its height and depth should be adjusted according to the water level of the system.

6.8. Piping

Pipes and fittings of different diameters made of polyethylene (PE), polyvinyl chloride (PVC) or polypropylene (PPRC) materials are used in the installations of water and air lines. The usage areas and usage patterns of these pipes and fittings produced from different materials are also different.

Polyethylene materials are pipes that can be found in coils up to 100 meters in desired thickness, and are mostly used to transport water to long distances in the geothermal system. Connecting these pipes or fittings to each other is made with threaded and compression materials called couplings. It is relatively affordable.

Polyvinyl chloride materials are mostly available in desired thickness and 6 meters in length (1 size). It is the most suitable material for the smooth extension of the pipeline at the water inlet and outlet to the tanks. These pipes, which can be resistant to different pressure levels with wall thicknesses, can be used by passing through muffs and sticking them with a special adhesive, or by compressing threaded materials.

Polypropylene materials are mostly thick-walled and pressure-resistant materials. Therefore, it is suitable to be used in compressed air line. In the assembly of this material, by using a special heating apparatus, the two ends of the pipes to be joined can be melted at high temperature and they can be joined.

While calculating the system piping and pipe diameter, it is important to determine in advance the amount of water to be circulated daily in the closed circuit. In a system where there are five fish tanks and each has a 50mm diameter water discharge, the pipe through which the water from these tanks is collected must be at least 90-110mm. Getting help from experts during the system installation will minimize possible errors.

6.9. Water Quality Measurement Devices

6.9.1. pH meter

In the geothermal system, pH, which is an important and critical parameter for both fish and bacteria, should be measured and recorded on a daily basis. Materials that work with 3 different methods for pH measurement are sold in the market. The simplest of these and the one that can be used in amateur geothermal systems is pH measurement with a solution. It is possible to approximately measure the pH in the water by comparing the color that will be formed by dropping a certain amount of pH measurement solution into a small amount of sample water taken from the water with the color scale in the color chart supplied with the kit. Although approximate values can be determined by performing this process with chemical analysis sets, daily pH measurements with a pH meter will provide both economical and more accurate results in the long run. pH meters are devices that require constant maintenance and calibration from time to time. It is necessary to thoroughly read and understand the user manual of the purchased device and to follow the directions in the manual. The pH meter probe (measuring part) must remain in a moist or special solution. Otherwise, the functionality of the probe will decrease over time and will need to be replaced. Another simple pH measurement method is pen pH meters. These more economical devices have a shorter lifespan and lower sensitivity.

Figure 28. pH measuring equipment (from left to right: pH meter with probe, electronic pH meter, solution kit)

Oxygen Meter

Oxygen meters used to measure the amount of dissolved oxygen in water, which is a very important parameter for both fish and bacteria, are of two types: membrane filter probe and optical probe. The filters of membrane-filtered oxygen meters should be filled with KCl solution and their electrodes should be cleaned over time. Calibration should be performed as it is used. Oxygen meters with optical probes are calibrated with air and do not need to be cleaned. It is easier to use and maintain. Oxygen meters measure temperature (C or F) and oxygen saturation (%) besides the dissolved oxygen (mg/L) in water.

Picture 29. Oxygen meter (membrane filter on the left, probe with an optical filter on the right)

ASSESSMENT AND EVALUATION -5

Determine what information you have gained within the scope of this activity by answering the questions below. Tick the correct option below.

1. Which of the following is the type of tank used in geothermal fish farming?

A. Rectangular Tanks

B. Cylindrical Tanks

C. Oval Tanks

D. Square Tanks

E. Round Tanks

2. Which of the following is not a tank material used in geothermal fish farming?

A. Polyester

B. Iron

C. Fiber Polyethylene

D. PE

E. IBC

3. Which of the following is the most useful and economical filter among solid waste filters?

A. Drum Filter

B. Bag Filter

C. Bag Filter

D. Sedimentation Pool

E. 7.3.Biological Filter

4. Which of the following filters is used to remove disease-causing microorganisms in the geothermal system but is controversial?

A. Drum Filter

B. Ultraviolet Filter

C. Bag Filter

D. Settling Pool

E. Biological Filter

5. In the geothermal system, which of the following is the tank where the water of the fish tanks is collected and the system is balanced?

A. Rectangular Tanks

B. Balance Tank

C. Oval Tanks

D. Square Tanks

E. Round Tanks

EVALUATION

Compare your answers with the answer key. Evaluate yourself by setting your number of correct answers. Go back to the activity and re-examine the issues related to the questions you answered incorrectly or you hesitate to answer.

LEARNING ACTIVITY-8

AIM

- You will learn about the opportunities and prospects in geothermal aquaculture.

RESEARCH

- Research on opportunities and prospects in geothermal aquaculture.

7. Opportunities and Prospects in Geothermal Aquaculture

Compared to normal fish farming, using geothermal water in fish farming is an affordable and sustainable solution to reduce dependency on fossil fuels. The availability of inexpensive geothermal water makes it possible to grow different types of fish inexpensively all year round, as the cultivation of freshwater and seafood in a controlled environment increases production rates by 50 to 100%, thereby increasing annual harvests.

However, unlike fossil fuels, geothermal resources are not available everywhere. Thus, although geothermal energy has the potential to provide long-term and safe energy for the aquaculture sector, its uses are limited to the Pacific Ocean and surrounding areas of the Pacific Plate, as well as European countries and deserts of North America and the Middle East.

Although they have access to geothermal energy, some countries are not yet using it for fish farming. For instance, in Lithuania, the use of geothermal energy in aquaculture is still under evaluation. Although there is access to geothermal energy one kilometer below the surface in the western part of the country, it is currently only used for heating purposes.

Geothermal power plants are labor-intensive and require well-trained personnel. This situation creates economic difficulties. Therefore, growth in the aquaculture sector, where geothermal energy is used, is slow. Despite all the negativities, the number of heat pumps using small-scale geothermal energy in the country tends to increase.

Natural springs and wells in Albania produce geothermal water up to 65 °C. For this reason, Albania has included in its plans to use geothermal heat for aquaculture. Albania already uses

geothermal energy in spas, baths and swimming pools, using geothermal heat pumps for heating and cooling.

Like Albania, Croatia uses geothermal energy for spa and recreation centers and for building heating. However, the country does not currently have clear plans to use geothermal energy for fish farming.

It is also similar in Poland. Although it has access to geothermal water, the country does not use it for aquaculture. In the period 2010-2014, geothermal energy was used for various purposes, especially for heating and spa activities. Total geothermal capacity has increased over the past five years, but the use of geothermal water in fish farming is still an area waiting to be developed.

8. Barriers to Geothermal Aquaculture

Geothermal energy is already used in many countries, but development in the use of geothermal energy has been very slow in many countries. Key constraints and challenges hindering the use of geothermal energy are policies, technical and financial barriers. High initial investment costs reduce the attractiveness of using geothermal energy in fish farming and is one of the main barriers to geothermal energy development in resource-constrained economies.

The intense use of fossil fuels has been an obstacle to the widespread use of renewable resources such as geothermal energy. The same situation has caused the development of aquaculture of geothermal energy to be slow. However, in parallel with the improvement in the economic situation of the countries, the public sector and private investors realized the advantages of using a renewable energy source and started to conduct studies and prepare inventory.

Financing plays an important role in geothermal programs. Government policies and legislation are important factors in creating a conducive environment for geothermal investment and resource mobilization and encouraging domestic and foreign private sector investment. However, very few governments have very low budget allocations for geothermal energy research and development activities.

Regulations aiming to protect and improve the environment also affect the development of geothermal systems. The main EU environmental regulations affecting the geothermal sector

are the regulations on water and environment. Thanks to this legislation, geothermal energy use targets become compatible with other environmental targets.

The use of geothermal energy is slowly increasing around the world. Some countries with access to this renewable resource use geothermal water in many areas. Although it is a sustainable method of fish farming, geothermal energy is having difficulties to be installed in aquaculture industry.

Some countries in Europe that have access to geothermal resource resources do not use it in aquaculture. However, the regulations and supports contribute to the increase in the number of countries using geothermal energy in aquaculture.

ANSWER KEYS

ANSWER KEY-1

1	A
2	A
3	D
4	B
5	C
6	D
7	B
8	B
9	B
10	D

ANSWER KEY-2

1	C
2	D
3	D
4	D

ANSWER KEY-3

1	A
2	A
3	D
4	A
5	D

ANSWER KEY-4

1	A
2	C
3	E
4	E

5	**A**
6	**E**
7	**E**

ANSWER KEY-5

1	**B**
2	**B**
3	**A**
4	**B**
5	**B**

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