WATER RESOURCE MANAGEMENT

WORKING IN WATER MANAGEMENT SECTOR

GDAŃSK, 2020

BALTIC SOUTH BRIDGE

FOR GREEN TECH FUTURE!

Materials developed within the framework of the " SB Bridge – building bridges for green-tech future" Project.

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President of Polish Ecological Club Pomeranian Branch (PKE OP) for two terms 2008-2011 and 2012-2015. Co-author of many international educational projects with members of PKE OP, e.g. “Green Academy”, „Microplastics in Baltic Sea ”, „Plastic Free Baltic”, ”Plastic free oceans” promoting knowledge of the plastic flood and other threats to species diversity in the Seas and Oceans and many educational activities addressed to the young people and local community.

Interreg South Baltic

EUROPEAN UNION

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Introduction

Water plays a significant role in our life physically and in the creation of everything we produce.

The movement of people into urban centers, changes in landscapes and growth in food and energy demanded are impacting the environment, including the cycle of water.

These activities impact the quantity and quality of available freshwater resources on which our survive is depended. Water plays a significant role in our life physically and in the creation of everything we produce. In the past, people have made decisions regarding the management of water resources that (i) have disrupted river flow regimes — sometimes to the point of drying them up, (ii) overdrawn groundwater aquifers, (iii) polluted many waterbodies, (iv) drained wetlands, and (v) degraded ecosystems. Despite the fact that water circulates in the environment, there is only a finite amount of it. Therefore, we have to save water and use it wisely. **[1,2]**

Introduction

Groundwater is often the primary source of drinking water and contributes significantly to irrigation, hence to food security in arid and semi-arid regions. The most significant declines in groundwater level are found by intensive groundwater exploitation over a long period of time. Four negative impacts of such groundwater extraction are considered: stream flow reduction and decline of lake levels, reduction or elimination of vegetation, land subsidence, and seawater intrusion into coastal aquifers. [3]

Wetlands are important and underrated element of environment. They have a capacity to provide important ecosystem services, such as binding and storage of carbon, cleaning water, providing flood protection and contributing biological production. Large parts of Sweden's wetlands have been drained in XIX century and many of remaining wetlands are impacted by drainage and other water operations, forestry, nitrogen deposition or other damage activities. Climate change and the establishment of alien species also negatively impact on wetlands. It is important to protect wetland environments in all BSR countries. Many bogs, wet meadows and wet woodlands are included in Natura 2000. [4]

Climate change is further projected to increase water shortages across Europe and previously improper water management contributes to the deepening of this state. The number of countries affected by drought per decade increased from 15 in the period 1971–1980 to 28 in the period 2001–2011. The most severe impacts are expected in southern and southeastern regions. In summer periods availability of water may decrease and lead to drought spells, while water availability generally increase in northern regions of Europe. [5]

Flooding is becoming more frequent, especially in these regions. More than 325 major river floods have been reported in Europe since 1980, of which more than 200 have been reported since 2000. This is partly caused by increased building in flood prone areas.

Water has a key role in electricity production – considering hydro power generation, but also the massive use of later in the production of power based on gas, coal, nuclear, and biofuels, not to mention the water use in the extraction and processing of those fuels. In turn, electricity is needed to pump, transport and use water, while also being required for the treatment of waste water and fresh water production through desalination. Hydropower production, fundamentally transforms rivers and their ecosystems by fragmenting channels and altering river flows. These changes reduce flow velocity and the number of rapids, and reduce or alter wetland, floodplain and delta ecosystems. Dams disrupt dispersal of riverine organisms and sediment dynamics and may alter riverine biodiversity composition and abundance. Freshwater ecosystems now belong among the world's most threatened ecosystems. Water managers are beginning to recognize the need to combine demands for social and economic development with the protection of the resource. Regulated rivers in Sweden were developed with little consideration of ecological effects, with most dams lacking migration pathways or minimum flow releases. **[6]**

Quality of rivers in EU is not good enough due to bacteriological pollution and high concentration of nutrients. One of sources of these pollutants are effluents. Nutrients are responsible for eutrophication of water bodies. On the second hand phosphorus, nitrogen and other nutrients can be valuable resources and recovered and reused in a circular economy. Wastewater is also source of micropollutants originating from the use of substances such as pharmaceutical products, veterinary drugs, personal

hygiene products or household chemicals, microplastics (from textiles, car tires etc.), nanoparticles and pesticides. Although the concentrations in water bodies are currently very low for most of them, these products can have a negative impact on aquatic ecosystems and it is supposed that the increase in their concentration may be hazardous for human health.

Wastewater management and sewer collecting systems play important roles in disease prevention. Untreated wastewater can contaminate the local environment and drinking water supply, thereby increasing the risk of disease development. COVID-19 pandemic has shown how proper hygiene education can reduce development of illness.

All the throw-away water with dissolved or suspended solids, discharged from homes, schools, hospitals, farms, and industries is wastewater. The wastewater that is produced due to human activities in households or schools is called domestic wastewater i.e. wastewater from the kitchen, bathroom, toilet and laundry. What is the composition of wastewater? Wastewater is a complex mixture containing significant concentrations of solids (sand, grit, tiny pieces of paper and textiles, tiny vegetables scraps, etc.), dissolved matter (urine, sugars, fats, detergents, etc.) microorganisms, nutrients (nitrogen and phosphorus), heavy metals and micropollutants (e.g. microplastics and medicines). What happens to our wastewater? They are collected and conveyed by a wastewater collection system from its points of origin (e.g. our houses, schools) to a point of treatment and disposal (municipal wastewater treatment plant).

How do we treat wastewater? Wastewater treatment includes mechanical wastewater treatment (by physical processes such as sedimentation, flotation), biological wastewater treatment (harnesses the action of bacteria and other microorganisms to clean wastewater), chemical

treatment (by chemical reactions e.g. P elimination), and sludge treatment (Figure 1). These processes are used to remove pollutants from industrial/domestic wastewater and convert wastewater into an effluent, that can be returned to the waterbodies with minimum impact on the environment or reused.

The primary wastewater treatment is mechanically removal of solids such as tiny textiles, and paper scraps, vegetables, sand, grit and others. These solid contaminants are quite easily separate from the wastewater. Sedimentation is used for the sand and sludge separation, respectively in grit chamber and preliminary clarifier. This process allows particles in suspension in water to settle out under the effect of gravity. The settling rate of a particle depends on its size, shape, and density. Sand particles have a small surface area to mass ratio, so their settling rate is accelerated more than are larger particles with low mass.

Biological treatment is based on the biodegradation of organic pollutants by microorganisms present in wastewater. Bacteria, or other small organisms organized in flocks called activated sludge, break down dissolved organic pollutants to environmental friendly compounds. Biological treatment is used worldwide because it's effective and more economical than many mechanical or chemical processes.

In all big cities of Poland, Germany, Danish, Sweden and Lithuania, the municipal wastewater treatment plants (WWTP) consist of similar treatment steps. In generally, the main steps are mechanical and biological treatment. Occasionally, the chemical treatment to phosphorous removal is applied. Nutrients (phosphorous and nitrogen) are mainly eliminated in the biological treatment. [7]

The Henriksdal wastewater treatment plant in Stockholm is very special object, not only due to it is built into a mountain. Moreover Henriksdal wastewater treatment

plant with the average daily flow of wastewater of 536 megaliters per day (MLD), will be the largest membrane bioreactor (MBR) plant in the world when it is complete. The commissioning of the membrane system is done in four phases from 2017 to 2022. The upgrade of the plant has been ongoing since 2013, and it is designed to treat anticipated wastewater flows in 2040. The difficulty is the fact that the upgrade of the facility needs to be done in the existing rock structure. [8]

Membrane bioreactor is more advanced biological wastewater treatment process. It is an improvement of conventional biological process based on activated sludge. The biological wastewater treatment is very effective in removal of organic matter and nutrients and energy saving process. Currently, medicines and microplastics (very small particles of plastics, you can see it in e.g some kind of toothpaste) effectively removal from wastewater is the serious problem. MBR can be more effective in removal of these pollutants then conventional system. Let us learn about these processes in detail.

Wastewater treatment process

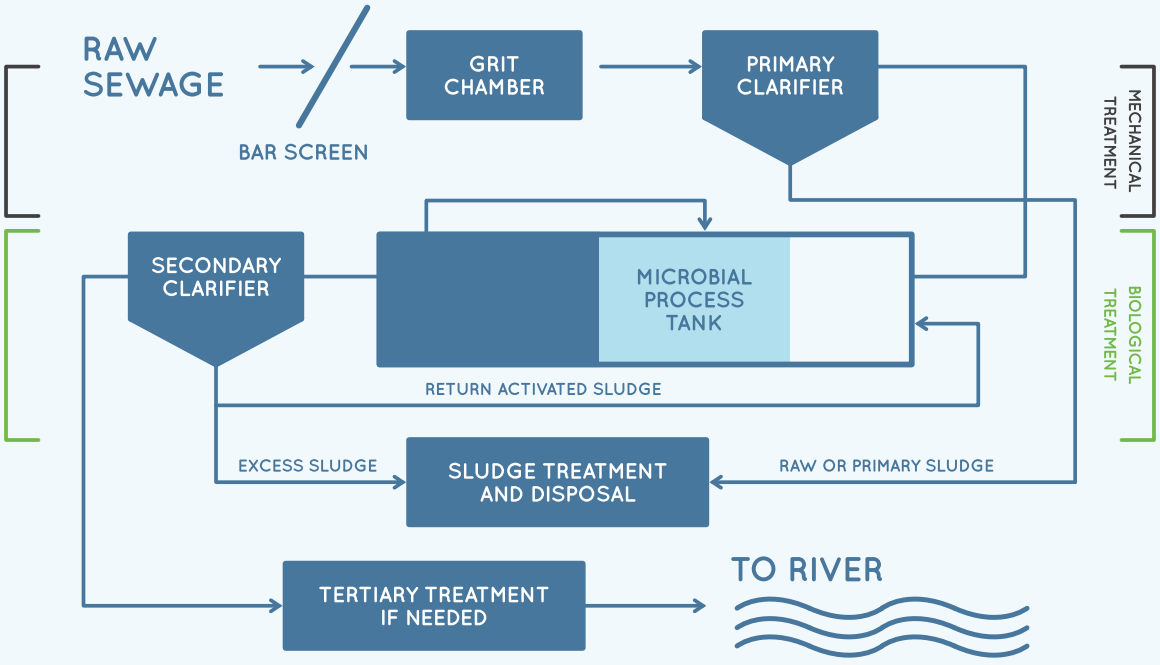

FIG.1. CONVENTIONAL WASTEWATER TREATMENT PLAN

SUBJECT: WATER MANAGEMENT

Case study:

WWTP in Klaipeda

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Water management in Germany

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WWTP in Warsaw

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WWTP in Denmark (Marselisborg)

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WWTP in Sweden – in Henriksdal

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WWTP in Lithuania

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WWTP in Berlin

RETRIEVED 20.06.2020 FROM LINK

References:

[1] Loucks D.P., van Beek E. (2017) Water Resources Planning and Management: An Overview. In: Water Resource Systems Planning and Management. Springer, Cham
RETRIEVED 20.06.2020

[2] W. J. Cosgrove, D. P. Loucks, Water management: Current and future challenges and research directions,
RETRIEVED 20.06.2020

[3] S. Zektser, .H.A. Loaiciga, J. T. Wolf , Environmental impactsof groundwater overdraft: selected case studiesin the southwestern United States Environmental Geology (2005) 47:396–404
RETRIEVED 20.06.2020

[4] Thriving Wetlands 8 February 2020
RETRIEVED 20.06.2020

[5] Meteorological Droughts in Europe, 2016
RETRIEVED 20.06.2020

[6] Water management in Europe faces rising challenges as ecosystems weaken, 2017
RETRIEVED 20.06.2020

[7] Urban waste water treatment in Europe, 15 Dec 2017,
RETRIEVED 20.06.2020

[8] WWTP in Sweden – in Henriksdal
RETRIEVED 20.06.2020

EXERCISE (1)

WHAT IS THE INFLUENCE OF WASTEWATER ON THE AQUATIC LIFE?

Background for the teacher:

All dirty water from household, hospitals, schools, industries, restaurants, commercial establishments, farms, that goes down into the sewage collection system is municipal wastewater. This includes also storm water and urban runoff. Household wastewater comes mainly from ordinary living processes: bathing, toilet flushing, laundry, dishwashing etc. This is consisted of water (99.9%) together with relatively small concentrations of suspended and dissolved organic matter and solids. Domestic wastewater is usually characterized by a grey color, musty odor and has a solids content of about 0.1%.

Water is becoming an increasingly limited resource in many regions of the world due to which engineering are being forced to think about other sources of water that might be used inexpensively and efficiently. Sewage water is the richest source of micro- and macronutrients and this aims for the better growth of plants. It can be used as domestic and industrial water. However, sewage should be treated prior to its reuse in order to reduce the risks of harmful effects on human and animal health.

EXERCISE (1)

Time: 20 min

	TASK EXPERIENCE	IMPLEMENTATION
1	EXERCISE TITLE:	WHAT IS THE INFLUENCE OF WASTEWATER ON THE AQUATIC LIFE?
2	TARGET OF THE EXERCISE:	Students identify the types of pollutants in wastewater Students know properties of pollutants and its behavior in waterbodies. Students recognize the negative effect pollutants on the aquatic plants / life
3	DETAILED DESCRIPTION OF THE EXERCISE:	Divide students into small groups. Give them previously prepared synthetic sewage in PET bottles. The sewage is transferred to bottles with plants by careful pouring by students. Students observe and write down what happened. • What are negative effects of wastewater towards aquatic plants? • What happen, when contaminants settle down on the plants?

		• What contaminants cut off the light and oxygen to plants? • What other negative effects are possible e.g. caused by dissolved contaminates (pesticides, drugs etc.)? Allow students 10 minutes of working time. When all groups are finished work, have each group share their results and conclusions.
4	MATERIALS NEEDED:	1,5L SYNTHETIC WASTEWATER, 10L BOTTLE WITH AQUATIC PLANTS
5	EFFECTS:	Students know the relationship between properties of pollutants and their behavior in waterbodies. They know that pollutants with a density less than the density of water floated, while pollutants with higher density than density of water settled out. Students identify the negative effects of dissolved contaminants in water. They are able to recognize the negative effect of sedimentation and flotation of contaminants. They understand the need of wastewater treatment and reuse effluents e.g. in industry.

EXERCISE (1)

KNOWLEDGEBASE

Source of knowledge + links

SUBJECT / LINK / SOURCE	
General information about the subject	
WATER STATISTICS IN EU	Water statistics in EU, Statistics Explained, November 2019 RETRIEVED 20.06.2020
GUIDELINES FOR THE BEST TECHNICAL SOLUTIONS AND PRACTICES FOR THE WASTEWATER TREATMENT IN SCATTERED DWELLING AREAS	Water emissions and their reduction in village communities – villages in Baltic Sea Region as pilots, Interreg, 2016-2019 RETRIEVED 20.06.2020

EXERCISE (2)

HOW DO YOU SEPARATE GRIT, SUSPENDED SOLIDS FROM WATER?

Background for the teacher:

The primary wastewater treatment is mechanical removal of solids such as tiny textile scraps, gravel, cinder, sand, seeds, eggshells, large and tiny food particles and others. These solid contaminants are quite easily separate from the wastewater. Sedimentation is used for grit (e.g. gravel, cinder, sand, seeds, large organic particles) and suspended solids (e.g. tiny food particles) separation, respectively in grit chamber and preliminary clarifier. Sedimentation is the tendency for particles suspended in water to settle out. The rate of falling down particles in clarifier depends on their shape and density. The sand with the spherical shape, high density and small surface area settles down rapidly in the grit chamber, while suspended solids with greater surface area and low density settle out in a primary clarifier in 2 hour. The clarifiers gravitationally separate the stream into settled solids, floating oil/fats and clarified water stream. There is a primary clarifier and grit chamber in each wastewater treatment plant.

EXERCISE (2)

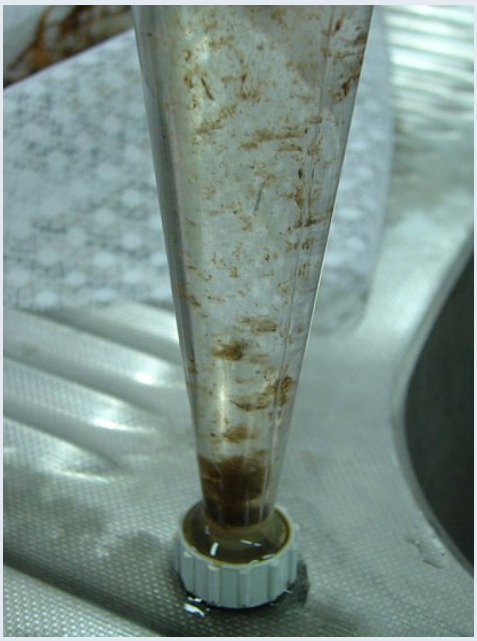
Time: 20 min

	TASK EXPERIENCE	IMPLEMENTATION
1	EXERCISE TITLE:	HOW DO YOU SEPARATE GRIT / SUSPENDED SOLIDS FROM WATER?
2	TARGET OF THE EXERCISE:	Students know the difference between grit and suspended solids sedimentation. Students know the term *"sedimentation"*. They know how primary clarifiers and grit chambers work.
3	DETAILED DESCRIPTION OF THE EXERCISE:	Explain students that sedimentation is one of the processes in wastewater treatment. Organize the students into groups of four or five. Instruct students how to perform the experiment or give away instructions. Allow students en minutes of working time. Students write down the observations and conclusions. When groups are finished, have each group share their results. Teacher writes down students' observations and conclusions on the board. Work in groups: give students previously prepared mixtures. Ask students to mix sewage in PET-bottle, and fill rapidly Imhoff cones.

		Students measure time of sedimentation in each cone using mobile phone timer. They write down observation: In which vessel solids are falling faster? (with sand, coffee ground and tea). Why are these solids falling faster? (small surface area of sand/ground coffee, while flocs are characterized by high surface area) (FIG. 2 Sedimentation of sand and sludge).
4	MATERIALS NEEDED:	TWO IMHOFF CONES OR PET BOTTLES (1.5L) WITH A LIDS AND CUT-OUT BOTTOMS, TWO PET BOTTLES (1.5L) WITH THE LIDS, SAND, COARSELY GROUND COFFEE, GRANULATED TEA, GLASS OR WOODEN STIRRING STICK, FE2SO4 SALT OR TOILET PAPER. Prepare mixtures in PET-bottles with the lids: (a) coffee grounds, tee grounds, sand in 1L water, (b) solution of iron salt in 1 L water or water with very tiny toilet paper scraps. Stir the mixtures. The amount of solids should allow to observe its falling. The flocks in iron salt solution should be well formed.
5	EFFECTS:	1) Students understand the relationship between properties of solids and their behavior in water. 2) They know that sand with low surface area rapidly settles down, while sludge flocks with high surface area need a longer time to settle down. 3) They are able to recognize the pollutants which can be easily removed from water by sedimentation. 4) They understand the solids behavior in water environment and that sedimentation is necessary to secure the operation of mechanical devices in the further part of wastewater treatment

Sedimentation of sand (a) and sludge (b)

a) sand



b) sludge

FIG.2. SEDIMENTATION OF SAND ND SLUDGE

PHOTO AUTHOR: EWA SIEDLECKA

EXERCISE (2) | MATERIALS FOR STUDENTS

EXERCISE (2) | MATERIALS FOR TEACHER

EXERCISE (2)

KNOWLEDGEBASE

Source of knowledge + links

SUBJECT / LINK / SOURCE	
General information about the subject	
SEDIMENTATION PROCESSES	Sedimentation processes , IWA RETRIEVED 20.06.2020
WASTEWATER PLANT CLARIFIER 3D MODEL ANIMATION	Wastewater Plant Clarifier 3D Model Animation, 22 Sept 2016 RETRIEVED 20.06.2020
GENERAL INFORMATION WASTE WATER: SEWAGE TREATMENT PLANT	General Information Waste Water: Sewage Treatment Plant, Germany RETRIEVED 20.06.2020
UWWTD TREATMENT PLANTS - TREATMENT MAP	UWWTD Treatment Plants - Treatment map, Germany RETRIEVED 20.06.2020

EXERCISE (2)

LITHUANIA A LEADING EU NATION IN WASTEWATER MANAGEMENT	Lithuania a leading EU nation in wastewater management, Created: 2013.10.01 RETRIEVED 20.06.2020
UMEÅ WASTEWATER TREATMENT	Umeå Wastewater Treatment Plant, North Sweden CleanTech RETRIEVED 20.06.2020

EXERCISE (3)

HOW DOES ACTIVATED CARBON CLEAN WATER?

Background for the teacher:

High-pure water must meet certain quality requirements to ensure taste and safety for users. Activated carbon can purify water removing chlorine and other badly smelling contaminates, which cause disgusting taste and are toxic for our health including micropollutants such as pharmaceuticals or pigments. It can be used for drinking water and industrial water purification. Activated carbon is a material with a large number of fine pores of various shapes formed during the activation process, and constitutes a huge surface area for adsorption. Adsorption is the steady or firm attachment of atoms, ions or molecules from a gas, liquid or dissolved solid to a surface. This process creates on the surface of the activated carbon a film of the contaminates. The surface area of activated carbon is 500-3000 m2/g. The larger surface area, the better adsorption effect. Granular activated carbon has numerous applications in industrial processes such as: drinking water filtration, groundwater remediation, volatile organic compounds recovery, distilled alcoholic beverage purification and others.

EXERCISE (3)

Time: 20 min

	TASK EXPERIENCE	IMPLEMENTATION
1	EXERCISE TITLE:	HOW DOES ACTIVATED CARBON CLEAN WATER?
2	TARGET OF THE EXERCISE:	Students understand the concept of adsorption. Students understand the need of application of adsorption process to industrial and drinking water purification. Students know the effect of contaminants' properties on the effective adsorption on activated carbon.
3	DETAILED DESCRIPTION OF THE EXERCISE:	Divide the students into small groups. Students fill a measuring cylinder or other vessel with water (1L each). Mixing with glass stick, students add up food coloring. Then students fill one activated carbon (AC) cartridge jug with the food coloring solution. They observe if leachate from cartridge is colorless (food coloring as an organic matter adsorbs on the AC surface). Allow students 7-10 minutes of working time. When groups finish, have each group share their results. Discuss with the students the organic matter adsorption on AC. Explain why AC removes organic matter.

		Explain that adsorption also participated in self-purification process of waterbodies.
4	MATERIALS NEEDED:	A VESSEL OR MEASURING CYLINDER WITH VOLUME OF 1.5L, A FOOD COLORING, AN ACTIVATED CARBON FILTER CARTRIDGE WITH BEAKER, OR FILTER JUG WITH ACTIVATED CARBON (AC) CARTRIDGE
5	EFFECTS:	Students learn about the adsorption process and its application in water treatment. Students identify compounds eliminated by adsorption. They understand the mechanism of organic matter adsorption and role of adsorption in waterbodies self-purification. They know that medicines, pesticides, cancerogenic compounds and other organic substances can be removed by AC adsorption.

EXERCISE (3)

KNOWLEDGEBASE

Source of knowledge + links

SUBJECT / LINK / SOURCE	
General information about the subject	
ACTIVATED CARBON MARKET	Activated Carbon, Lenntech RETRIEVED 20.06.2020

EXERCISE (4)

HOW DOES MEMBRANE BIOREACTOR WORK?

Background for the teacher:

This exercise focuses on the innovative membrane technology connected with biological process used for municipal and industrial wastewater treatment. Membrane bioreactor (MBR) is a combination of a membrane filtration process with a biological wastewater treatment based on the "activated sludge" process." Activated sludge" is a group of different microorganisms e.g. bacteria and protozoa organized in sludge flocs. These organisms feed on dissolved and suspended pollutants in wastewater such as protein, sugars and fats (from our kitchens, toilets and showers) and metabolize them in presence of oxygen to mineral products. The operating conditions in MBR also increase the efficiency of medicines removal. Membranes used in MBR for filtration have a pore size of 40 nanometers (smaller than bacteria size). Everything with the size bigger than 40 nm is kept on the outside of the membrane and doesn't end up in the outgoing water. Therefore microplastics and other particulate pollutants are separated and not released from this cleansing process, producing disinfected clear water as a product.

EXERCISE (4)

Time: 30min

	TASK EXPERIENCE	IMPLEMENTATION
1	EXERCISE TITLE:	HOW MEMBRANE BIOREACTOR (MBR) IS BUILD AND HOW DOES IT WORK?
2	TARGET OF THE EXERCISE:	Students know construction of membrane bioreactor. Students understand how membrane bioreactor works. Students understand the need for biological wastewater treatment stage.
3	DETAILED DESCRIPTION OF THE EXERCISE:	Teacher explains how to work biological wastewater treatment in MBR system Than teacher shows the pictures of some items: tank, pump, activated sludge microorganisms, filtration membrane, aeration system, and asks students to design their own MBR from these elements. Students divide into small groups think about the role of each element in MBR construction and draw their project on the sheet of paper. Allow students 10 minutes of working time. When task is finished, have each group present their project. Teacher discusses pros and cons of projects with the students.

		Support questions: • Is it a good localization of inlet and outlet of water? • What is a flow direction of water in membrane? • What is role of micro-organisms? • Where is the best place for aeration system? • What is role of aeration system in MBR?
4	MATERIALS NEEDED:	FIG.3. SIMPLE SCHEMATIC DESCRIBING THE MBR PROCESS PICTURES OF TANK, PUMP, FILTRATION MEMBRANE, AERATION SYSTEM, AND ACTIVATED SLUDGE. MATERIAL FOR TEACHER: SCHEMATIC DIAGRAM OF A FIELD - SCALE MBR SYSTEM Chae et al., Full-Scale Implementation of a Vertical Membrane Bioreactor for Simultaneous Removal of Organic Matter and Nutrients from Municipal Wastewater, Water 2015, 7(3), 1164-1172 RETRIEVED 20.06.2020
5	EFFECTS:	1. Students understand the role and necessity of biological wastewater treatment. They know the organic matter removal process in wastewater treatment and waterbodies. 2. Students design the simple set-up for water treatment. They learn the basic principles of the construction and operation of MBR and become familiar with advanced biological treatment process.

EXERCISE (4)

KNOWLEDGEBASE

Source of knowledge + links

SUBJECT / LINK / SOURCE	
General information about the subject	
HOW DO ZEEWEED HOLLOW FIBER MEMBRANES WORK?	How do ZeeWeed Hollow Fiber Membranes Work? Suez, 31 Jan 2018 RETRIEVED 20.06.2020
IN PUBLICATION: FIGURE 1. SCHEMATIC DIAGRAM OF A FIELD-SCALE MBR SYSTEM.	Chae et al., Full-Scale Implementation of a Vertical Membrane Bioreactor for Simultaneous Removal of Organic Matter and Nutrients from Municipal Wastewater, Water 2015, 7(3), 1164-1172 RETRIEVED 20.06.2020
SIMPLE SCHEMATIC DESCRIBING THE MBR PROCESS	Simple schematic describing the MBR process - MBRs, Membrane solutions RETRIEVED 20.06.2020

The MBR Process

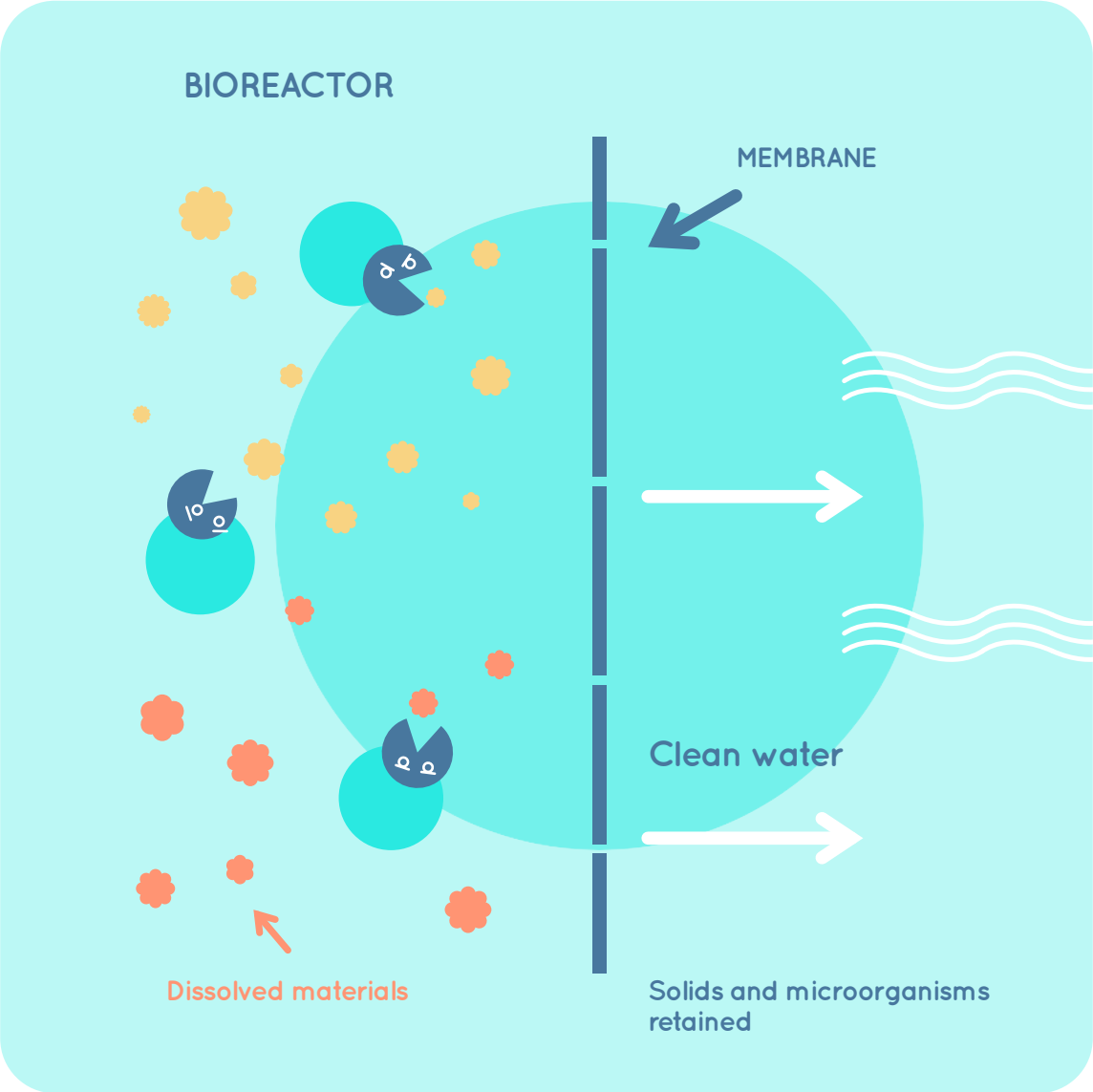


FIG.3. SIMPLE SCHEMATIC DESCRIBING THE MBR PROCESS

EXERCISE (5)

HOW TO ELIMINATE POLLUTANTS FROM WASTEWATER?

FOR GREEN TECH FUTURE!

Background for the teacher:

Water is an essential resource for humans, not only as a drinking water, but also for different industrial processes and production of goods. Our activity have played a major role in the damage caused to the environment. Factories' wastewater are a major contributing factor to water pollution. This is why we have to treat wastewater so that it can be reused and safely returned to the environment.
Wastewater treatment consists of a physical, chemical and biological processes that significantly reduce pollutants from water. In the wastewater treatment plant (WWTP), purification processes are performed (like those that occur naturally in the rivers and seas) in an artificially concentrated and automated way.

Wastewater treatment is a process that consists of 4 stages (FIG.1):

1. primary treatment called mechanical, serves to eliminate floating and suspended solids, sand, fats and oils,
2. secondary treatment (biological treatment) focused on eliminating organic materials,
3. tertiary treatment used for phosphorus elimination
4. post-treatment used for elimination of pathogens, micropolutants (e.g. ozonation, filtration with activated carbon etc.)

Generally, primary and secondary treatment is enough to obtain effluent, which can be discharged to environment safely. Municipal wastewater treatment plants in Baltic Sea region are mainly based on mechanical-biological treatment, although post-treatment is highly recommended where water needs to be reused for watering gardens or farming. Such water treated can be used without causing any risk to human health. Currently there is a serious problem with medicines and microplastics in wastewater, and post-treatment could be applied as a solution.

EXERCISE (5)

Time: 15min

	TASK EXPERIENCE	IMPLEMENTATION
1	EXERCISE TITLE:	HOW TO ELIMINATE POLLUTANTS FROM WASTEWATER?
2	TARGET OF THE EXERCISE:	Students know the role of physical and biological treatment in dissolved and suspended organics removal form wastewater.
3	DETAILED DESCRIPTION OF THE EXERCISE:	Based on the FIG. 3, teacher discusses primary, secondary and tertiary wastewater treatment. Then, asks students to present key information about the biological treatment / tertiary treatment within 60 seconds (elevator pitch) to another student acting as an investor who intends to modernize the sewage treatment plant in your city. After summarizing, students should determine why the investor may consider this idea important.

	After presentations discuss with students: • Which countries use the most nonrenewable energy and why? • How the presence of natural resources effects diversity and development of the renewable energy sources used? Now students discuss in groups: • What arguments would you use to convince the government in given country to give up nonrenewable fuels. Each group has a 30 second to present its argumentation.	
4	MATERIALS NEEDED:	FIG. 1. CONVENTIONAL WASTEWATER TREATMENT PLANT
5	EFFECTS:	Students understand the necessity of secondary / tertiary wastewater treatment appliance. They know how wastewater treatment plant works. They learn how to select the most important information about waste-water treatment and how to present it in a synthetic way under time pressure / within limited time.

EXERCISE (5)

KNOWLEDGEBASE

Source of knowledge + links

SUBJECT / LINK / SOURCE	
General information about the subject	
WWTP IN BERLIN	Successful case of water treatment RETRIEVED 20.06.2020

Effects

Such phenomena as droughts, floods, melting glaciers, sea-level rise and storms leading to severe consequences. The World Economic Forum ranked water crisis as number one in its 2015 assessment of global risks, with potential to cause damaging economic and social impacts across entire countries and sectors. So we need to counteract and mitigate the effects of climate change by looking at protecting the water. Therefore innovative technologies and integrated solutions are needed for adaptation as well as mitigation of climate changes. Appropriate water management by well-educated people will allow to enhance water security.

Students know the relationship between properties of pollutants and their behavior in waterbodies. They know that pollutants with a lesser density than the density of water float, while pollutants with higher density than density of water settled out. They know that sand with small surface area and density higher than water rapidly settles down, while sludge flocks with the high surface area and higher density than water need longer time to settle down. They are able to recognize the pollutants which can be easily removed from water by sedimentation. They know that the grit is eliminated in grit chambers, while suspended solids in clarifiers in mechanical wastewater treatment. Solids elimination by sedimentation is necessary to secure the operation of mechanical devices in the further part of wastewater treatment. Students can also predict the solids behavior in environment. They identify the negative effects of dissolved/undissolved contaminants in water on aquatic life. They understand the need of wastewater treatment and reuse e.g. in industry.

Students learn about the adsorption process and its application in water treatment. They identify compounds eliminated by adsorption. They understand the mechanism of organic matter adsorption and role of adsorption in waterbodies' self-purification. They know that medicines, pesticides, carcinogenic compounds and other organic substances can be removed with this process.

Students understand the role and necessity of biological wastewater treatment. They know that organic matter elimination in bioreactor is similar as self-treatment process in bodies of water. They learn the basic principles of the construction and operation of membrane bioreactor and become familiar with the advanced biological treatment process. They learn to think creatively. They design the simple set-up for wastewater treatment.

Students understand the necessity of secondary/tertiary wastewater treatment implementation. They know how wastewater treatment plant works. They learn how to select the most important information and how to present it in a synthetic way.

Students develop critical thinking skills, which will empower them to become active members of their community.

Wastewater treatment employees are critical to public health. Together with engineers, laboratory technics, administrators and scientists they work toward the management, protection and conservation of treated and untreated wastewater, recognizing that it is a critical part of the ecosystem.

Main goal:

Classes focus on the wastewater treatment technology and water conservation. They will show how important action is modernization of wastewater treatment plants, because of new challenges, which are drugs and microplastics removal from wastewater. Untreated wastewater can contaminate the local environment and drinking water supply, thereby increasing the risk of diseases (including COVID-19) development. The sustain-able water management relies on the principle of circular recovery of water. This means that wastewater is no longer considered a pollutant but, instead, available resource that can be locally recovered. The wastewater treatment can be a source of utility or processes water, which can be used instead drinking water. Water is a valuable resource that should be saved.

Knowledge and skills:

THE STUDENT WILL FIND OUT:

- WHAT ARE THE WASTEWATER TREATMENT STAGES?
- WHAT IS THE CORRELATION BETWEEN POLLUTANTS PROPERTIES AND WASTEWATER TREATMENT PROCESSES?
- WHAT ARE THE CORE ELEMENTS OF MBR?
- HOW DOES WWTPS WORK?
- WHY IS WASTEWATER TREATMENT NECESSARY?

THE STUDENT WILL BE ABLE TO:

- GRASP THE ESSENTIAL PRINCIPLES OF MBR PROCESSES
- KNOW THE CORE PARTS OF MBR CONSTRUCTION
- USE THE BASIC TERMINOLOGY RELATED TO WASTEWATER TREATMENT
- KNOW THE TERMS: MINERALIZATION, SEDIMENTATION, FLOTATION
- INDICATE THE MOST IMPORTANT STAGES OF WASTEWATER TREATMENT
- UNDERSTAND THE NEED OF WASTEWATER TREATMENT AND WATER SAVING

SCENARIO

Time	Goals, Objectives, Skills achieved	Materials, Contents	Working methods
	Warm up activities		
2	<u>Greeting students</u> Teacher tells your students that you will be discussing wastewater treatment processes. Explains that wastewater is all the throw-away water from homes, schools, hospitals, farms, and industries, and that it is obligatory to treat it.	SHORT COMPUTER PRESENTATION	TEACHER TALK
	Development and practice		
5	<u>Asks students:</u> "What are the pollutants in wastewater?" The teacher divides board into two columns, the first labeled <u>*solids*</u> (sand, grains, textiles,	BOARD, MARKERS, SHEETS OF PAPER, FLIP CHART	DISCUSSION, BRAINSTORM

Time	Goals, Objectives, Skills achieved	Materials, Contents	Working methods
5	microplastics) and the second labeled *dissolved* (detergents, sugar, urea, salts, orange juice, tea etc.). and the second labeled dissolved (detergents, sugar, urea, salts, orange juice, tea etc.). Students write down the pollutants in appropriate columns. The teacher asks students, which group of the following conta-minants is easiest to remove from waste-water? How do they remove different types of contaminants from wastewater? The teacher writes down their suggestions on the board. Explains students the terms: sedimentation, filtration, mineralization, flotation.	BOARD, MARKERS, SHEETS OF PAPER, FLIP CHART	DISCUSSION, BRAINSTORM
5	The teacher tells students, that in all large cities and towns in Poland, Germany, Denmark, Sweden and Lithuania, the municipal wastewater treatment plants (WWTP) consist of similar treatment steps. In generally, the main steps are mechanical and biological treatment. (Scheme 1.)	SCHEME 1.	TEACHER TALK

Time	Goals, Objectives, Skills achieved	Materials, Contents	Working methods
5	Watching the film about the upgrade of Henriksdal wastewater treatment plant in Sweden; Henriksdal wastewater treatment plant, Suez RETRIEVED 20.06.2020	COMPUTER, ACCESS TO THE INTERNET	WATCHING THE FILM
1	The teacher explains to the students the principal of membrane reactor working (FIG. 3) OR Simple schematic describing the MBR process - MBRs, Membrane solutions RETRIEVED 20.06.2020	COMPUTER, ACCESS TO THE INTERNET, SCHEME 2	TEACHER TALK
20	The teacher divides the students into small groups. Distributes the sheets of paper and color markers. Asks students to design your own membrane bioreactor (MBR). Provides questions to guide their work, such as: • Where is inlet and outlet in bioreactor? • Where is membrane and aerating system located? Allow students 10 minutes of working time.	PAPER, COLOR MARKERS	BRAINSTORM, WORK IN GROUPS

Time	Goals, Objectives, Skills achieved	Materials, Contents	Working methods
20	Once students have drawn the MBR, the teacher brings the class together and asks leader of group to present their project. Choose the best project by class voting. The class discusses the pros and cons of the best MBR project. (Exercise 4) or (Exercise 2) or (Exercise 5)	PAPER, COLOR MARKERS	BRAINSTORM, WORK IN GROUPS
Wrap up			
7	The teacher asks students to present key information about the biological treatment within 60 seconds to another student acting as an investor who intends to modernize the sewage treatment plant in your city. After summarizing, students should determine why the investor may consider this idea important.	SHEETS OF PAPER	ELEVATOR PITCH

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