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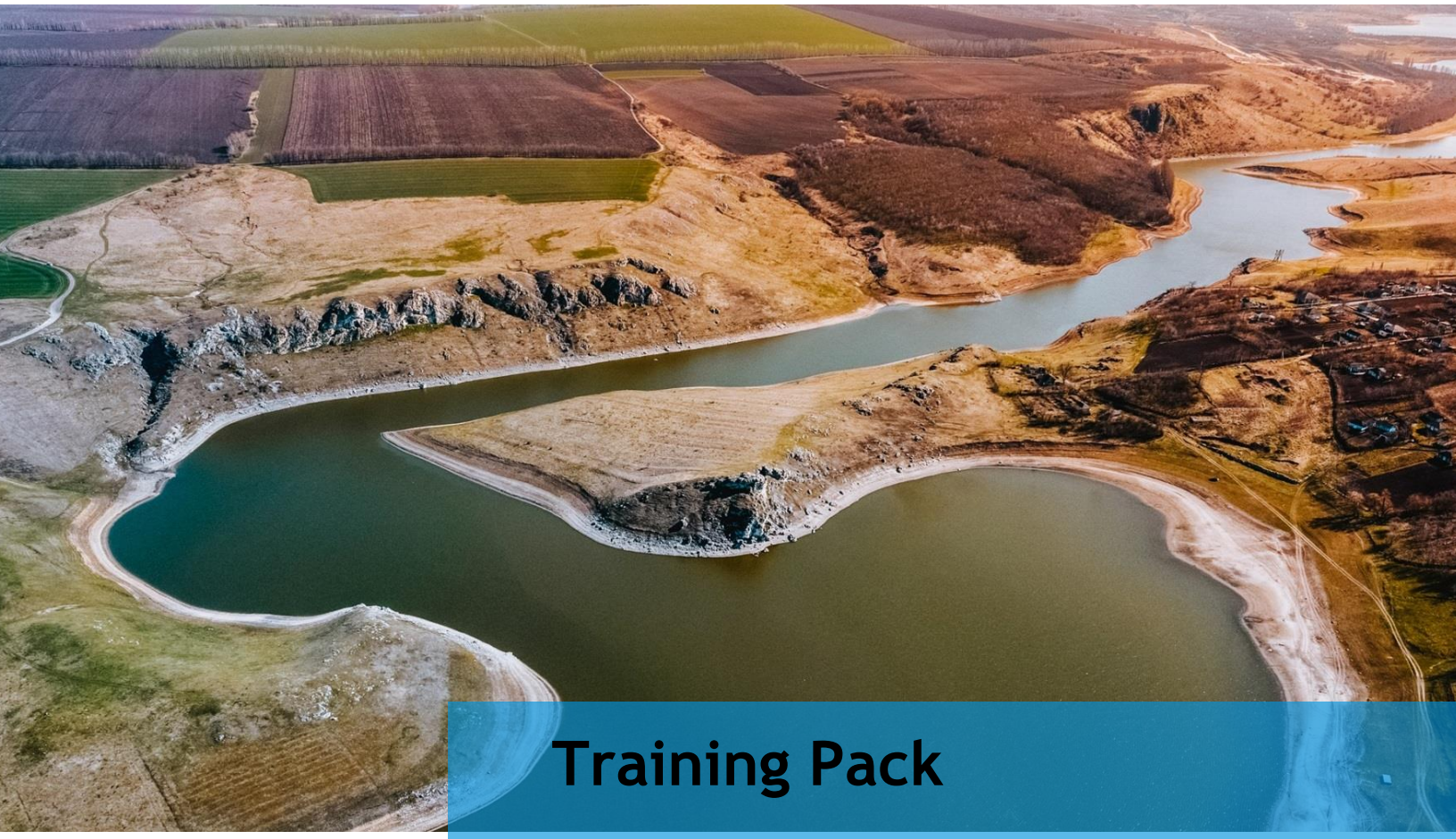
CRoCuS
Cleaner Rivers - Cleaner Seas

Black Sea CROSS BORDER COOPERATION

Common borders. Common solutions.



Training Pack

on the main sources of pollution of rivers and the best available solutions for reducing river littering

CROSS BORDER COOPERATION

2021

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Published by CRoCuS Project

TRAINING PACK
ON THE MAIN SOURCES OF POLLUTION OF RIVERS AND THE BEST AVAILABLE SOLUTIONS FOR REDUCING RIVER LITTERING

Cover photo: Pruth River, Varatic village, Republic of Moldova
Photographer: Alaiba Mihaela

The Title of the Programme
Joint Operational Programme Black Sea Basin 2014-2020
www.blacksea-cbc.net

The Editor of the Material
Earth Forever Association and WiSDOM Association

Date of Publishing: June 2021

Joint Operational Programme Black Sea Basin 2014-2020 is co-financed by the European Union through the European Neighbourhood Instrument and by the participating countries: Armenia, Bulgaria, Georgia, Greece, Republic of Moldova, Romania, Turkey and Ukraine.

This publication was produced with the financial assistance of the European Union. Its contents are the sole responsibility of CRoCuS Project and do not necessarily reflect the views of the European Union.

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Introduction

This Training pack is a major delivery of the project Cleaner rivers - cleaner seas, CRoCuS, a joint effort of Earth Forever Foundation (Bulgaria), WiSDOM (Moldova), Ecotox (Moldova), Mama-86-Nova Kakhovka (Ukraine) and Oancea Townhall (Romania) implemented with the financial support of Joint Operational Programme Black Sea Basin 2014-2020.

The goal of this publication is to increase the awareness and engagement of local authorities, environmental and health monitoring authorities, business, citizens and youth for sustainable management of waste for the protection and restoration of Prut, Dniepr and Tundja rivers and the whole Black Sea region.

The proposed litter and wastewater management approaches in this Training pack are based on critical assessment of the effects runoff waters and human activities, including industry, agriculture and urban spread, have on water quality and aquatic ecosystems.

Specific emphasis in the publication is put on the impact of recreational activities on rivers and nearby areas that pose higher risk of deterioration of water quality, landscapes and protected areas; justified proposals are made for improved management and development.

Another important direction to which this Training pack points is the issue impact of success or failure of plastic and organic wastes management on the environment and society as a whole on the planet Earth. Accordingly, the publication deals on all aspects of waste management policies and concepts, supporting them with introduction of the extant European Union (EU) waste management legislation. Since wastes can affect negatives the soil, landscapes, water and atmosphere, this document has not relented in highlighting this added importance by going further to apprise the reader of the needs for sustainable waste management, that embraces plastic recycling and re-use, as well as composting and re-use of biological wastes. Significant effort was made to present best practices of various types and scales for sustainable and safe waste treatment, handling and re-use. These include, wastewater treatment and reuse, processing and safe reuse of biological wastes, reuse of waste plastics, old tyres, shipping containers, etc. Accent was placed on the importance of both sustainable state policy to adequate waste policy but also the significance of individual lifestyle, responsible consumer choices and behaviour.

With respect to protecting the aquatic ecosystems and environment, this Training pack has gone further to deliver on various issues and methodologies to monitor and protect the air, water and land ecosystems while meeting the requirements of EU water and environmental legislation. The experience to overcome specific obstacles was shared for new member states like Bulgaria and Romania, as well as for candidate countries like Moldova and Ukraine.

In addition to its comprehensive content, the Training pack goes a step further in offering some quasi-didactic illustrations, targeting schools, NGOs, youth and citizens. The illustrations centre on how to conduct indoor and outdoor activities on river protection. These are found in the Annexes to this pack. The reader can learn from materials dealing on the following: organisation of cleanup activities; actions to combat erosion of river banks, model lesson plans and activities related to cleanup campaigns, field trips, as well as others.

Overall, this publication will add to awareness-raising, development and successful implementation of best practices and partnerships among civil society activists, local governments, schools and small businesses situated in the rural areas of the Black Sea region. It would contribute to the efforts to prevent, reduce, recycle and reuse wastewater and solid household waste; prevent and reduce the negative impact of human activities on soil and water bodies, on nature and protected areas, on land and aquatic ecosystems.

1. Impact of runoff quality and recreational activities on aquatic ecosystems

1.1. Impact of runoff quality on aquatic ecosystems

Atmospheric precipitation is water released from clouds, in the form of drizzling, rain, sleet, snow, ice pellets, graupel and hail. That part of the precipitation, snow melt and irrigation water that appears in uncontrolled (not regulated by a dam upstream) surface streams, rivers, drains or sewers form the runoff (Figure 1). According to USGS runoff may be classified according to speed of appearance after rainfall or melting snow as direct runoff or base runoff, and according to source as surface runoff, storm interflow, or groundwater runoff.

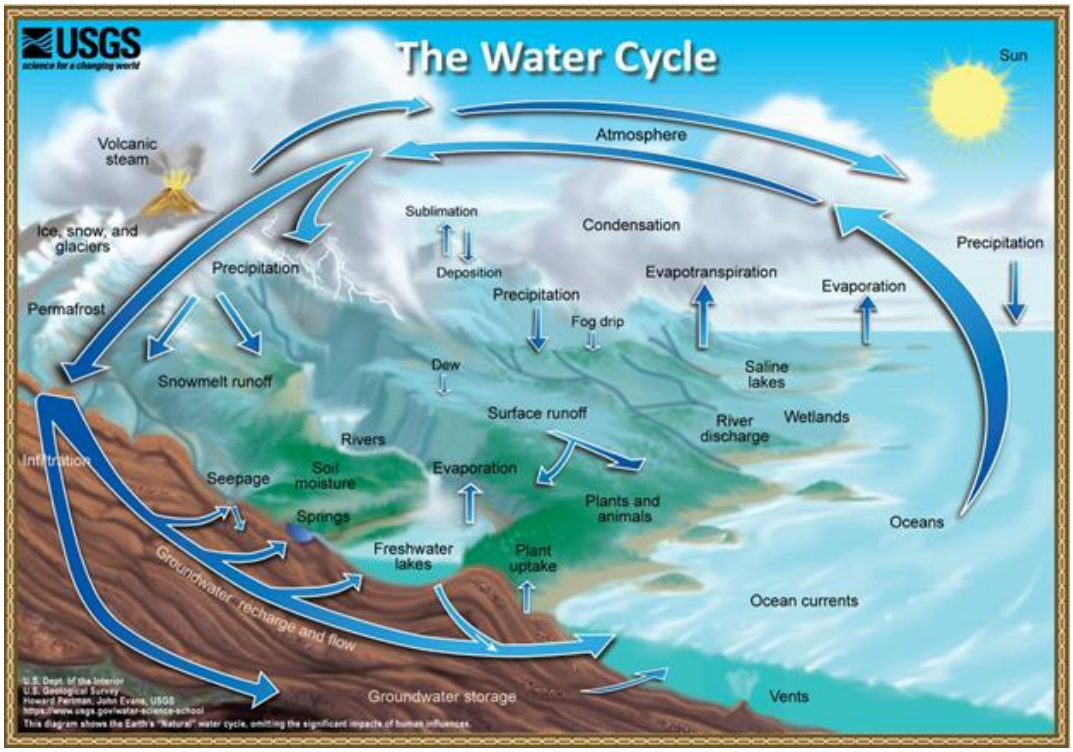

Figure 1. The natural water cycle[1]

The Sun is the "engine" of the natural water cycle. Solar radiation heats up the water in the Ocean and on the surface of the Earth; water evaporates and reaches the air in the form of vapour. Ascending air currents carry vapour into the atmosphere where, at lower temperature, vapour condenses to form the clouds. Mixing with global air currents, clouds eventually fall in the form of precipitation. Most of the precipitation falls back into the Ocean, or on the ground, where, due to gravity, continues to flow on the surface of the soil and rocks, as surface runoff. Part of this surface runoff enters the rivers to flow back into the Ocean. On the other hand, some of the runoff drains through permeable rocks under the surface of the Earth to form the groundwater bodies. Some of the groundwater finds cracks and flows up to the surface in the form of freshwater or mineralized springs. Another part of precipitation penetrates into the soil and is assimilated by plant roots to return into the atmosphere by evapotranspiration. Another part of the atmospheric water, filtered into the ground, reaches greater depths to form and refresh deep aquifers.

[1] *https://www.usgs.gov/media/images/natural-water-cycle-0, March 2021*

The natural factors of rainwater runoff are: rainfall intensity, rainfall duration, water infiltration into the ground, rainwater runoff on slopes and through the network of river basins. Human activities contribute to these types of runoff in various ways: construction of dams across riverbeds and wetlands; reduction of the size of forests in catchment areas, damaging the strips of trees and shrubs in the protected areas along running water bodies and wetlands, as well as along highways and railways; plowing the banks and destroying existing river protection areas; unauthorized landfills on the banks of small and large rivers; use of fertilizers, herbicides and pesticides in agriculture, etc.

The surface water runoff from the melting snow also influences the river runoff regime and could be the primary supply source for rivers with a vast percentage of mountainous relief in their catchments. This phase of the hydrological regime is called *a spring flood* or *big water and, d*epending on the altitude of the catchment area, would be better expressed in spring or early summer. It is characterized by long leakage time, peak flows, large or very short volumes and short starts, accumulation of pollution in snowpack and release of such accumulations during short melting periods, major contributions of snowmelt to runoff especially during events of rain-on-snow.

High spring water can flood the meadow and, later in the year, flood the terraces along the rivers. The phenomenon occurs in spring for small rivers and in spring - early summer for larger rivers with a high percentage of catchments with high altitude. The main factors affecting formation of large water stocks comprise: the snow water reserves and the character of their distribution within the hydrographic network; the intensity and duration of snow melting; the degree of soil water stocks in autumn; as well as the degree of soil freezing in winter. During this period water speed increases in the riverbed, the content of the mountain suspensions decreases, the salinity of the waters from the rivers without dams on the riverbed decreases. In spring, soils are still frozen and the snow water is cleaner, compared to the growing season. Many hydropower dams regulate spring floods, in accordance with hydropower needs. Thus, this activity supplements natural or climatic factors.

The runoff of surface water from melting snow plays a very big role by which high spring waters increase the self-cleaning processes of rivers and reduce the processes of their secondary pollution. These are also decisive for fish breeding and the development of planktonic and benthic hydrobionts (bacteria, algae, aquatic invertebrates). Surface water from melting snow differs greatly from the composition and properties of surface water after heavy rains. The runoff of surface water from melting snow also enriches the hydrological regime of wetlands, as well as increases the flow of groundwater (aquifer).

Generally, the atmospheric water, in most cases, contains very few chemicals - up to 10 mg/l. Thus, the content of mineral and organic substances in precipitation is insignificant - up to 1.2 g/m^2 per year[2].

At the same time, it may happen that atmospheric water accumulates various air pollutants originating from a number of human and natural activities, thus dissolving various chemicals released by thermal power plants, nuclear power plants, industrial areas, urban areas, agriculture, as well as those released due to eutrophication, volcanic activity, etc. Due to such processes, elevated concentrations of cadmium, lead, ammonium, nitrates, sulphates, phosphorus, etc. occur in rainwater; ash particles, silicates and other solid materials occur in snowflakes. Thus, atmospheric water turns into a component of the global circuit of pollutants and plays a key role in the global transportation of chemicals and, undoubtedly, significantly influences the distribution and migration of chemicals in aquatic ecosystems.

The chemical composition of atmospheric precipitation is formed by both global and local factors. For example, combustion power plants produce much higher levels of pollution with metals, organic substances and ash, compared to air quality of locations farther away from them[3,4]. In the first 6 years after the Chernobyl disaster, the concentrations of several metals, especially in the atmospheric

[2] *Лозовик, П.А., Бородулина, Г.С., 2009. Соединения азота в поверхностных и подземных водах Карелии. Водные ресурсы, 36(6), с.694-704*
[3] *Zubcov E., Toderash I., Ichim M. Dynamics of vanadium in the Cuciurgan cooling reservoir, 1998, p.138-140*
[4] *Zubcov E., Toderash I., Zubcov N., Biletchi L. Distribution, migration and the role of trace elements in surface waters. 2016 p. 78-107 (in Romanian)*

precipitation in Moldova, exceeded the multiannual averages many hundredfolds. This had a tremendous effect on the dynamics of lead in surface waters. In March 1984, brown snow fell on most parts of Moldova; and the metal content in the snow rose tenfold higher than the average values.

That is why, a major focus of current EU policy is to reduce the emissions of acidifying pollutants, particulate matter and ozone precursors from large combustion plants. Directive 2010/75/EU (Industrial Emission Directive, IED) entered fully into force in 2016. The IED sets minimum requirements for emissions of sulphur dioxide (SO2), nitrogen oxides (NOx) and dust (PM10) from plants greater than 50 MWth of installed capacity[5].

The increased rate and scale of urbanisation in the world, as well as in the Black Sea area, raise concerns about the volume and quality of urban runoff. Numerous scientists and practitioners look at it as a pollutant adversely affecting the water quality and significantly declining the biological integrity and physical habitat of receiving streams. Increased human population density is responsible for proportionately higher levels of car emissions, car maintenance wastes, municipal sewage, pesticides, household hazardous wastes, pet wastes, and trash which can either be washed or directly dumped into municipal storm-sewer systems leading to the rivers and the Ocean. A number of studies demonstrated a direct correlation between the degree of imperviousness of the urban areas. The "% impervious coverage" is believed to be a reliable indicator and predictor of the water quality degradation.

Dangerous urban runoff is clearly linked to human health threat both for urban citizens and visitors, as well as for the population sunbathing, fishing and swimming in water bodies like rivers, lakes, reservoirs, seas and oceans. Coastal beach waters occasionally contain high concentrations of health-threatening substances due to accidental leakages from industry and agriculture, or sewerage systems (pathogenic bacteria and viruses). Such flows often result in the posting or closure of local beaches. Pollutants – such as DDT, PCBs, heavy metals, etc., transported by urban runoff to receiving water bodies can also enter the food chain, where they can bioaccumulate and biomagnify significantly influencing ecosystems and further use of water resources.

Today, the issue of preventing environmental pollution of river basins with waste and contaminated runoff has become one of the most significant problems worldwide. Industrial development and the rapid growth of cities lead to an increase in air and water pollution, resulting from household waste. However, there is a fairly large category of wastewater in urban areas, which, so far, in most cases, does not even have rainwater and wastewater treatment systems; at the same time, has a significant impact on the condition, as well as hydrochemical properties of water bodies. This category of waters includes spring melt waters and, particularly, abundant rainfall and rain-on-snow. Unfortunately, the problem of protecting water bodies from surface pollution has not yet found an acceptable solution. De facto, the municipal localities neither have river water collection systems after heavy rains, nor cope with the volume of water after heavy rains and rain-on-snow events.

Another major threat for aquatic ecosystems is the excess of nutrients. Compared to the other European seas, the nutrient input to the Black Sea is significant. The input of total N by rivers reduced compared to 1970 and in 2000 was estimated to 640 000 tons and total P – to 90 000 tons, though DIN input of rivers increased in the South Black Sea region by approximately 30 % in this period. Phosphate input also increased due to discharge of raw or insufficiently treated wastewater. About 80% of dissolved inorganic nitrogen, 70% of dissolved organic nitrogen and 50% of particulate nitrogen is brought to the sea by the rivers[6].

The EEA integrated assessment showed that 60% of the assessment points in the Black Sea are eutrophied by nutrients supplied by the Danube and Dnieper – the 2nd and 3rd largest European rivers. As a result, the phytoplankton biomass is increasing and red tides are frequent in the region. It is well known that the Black Sea is permanently stratified by a halocline at the depth of 100-150 m, causing

[5] *https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32010L0075, April 2021*
[6] *Strokal M., C. Kroeze, Nitrogen and phosphorus inputs to the Black Sea in 1970-2050. Reg Environ Change (2013) 13:179-192*

anoxia below that depth. In the coastal zone, severe seasonal summer-time hypoxia happens at 5-30 m depth near the Danube and Dniester discharge area to cover up to 14 000 sq. km in 2000[7].

The following example is very relevant for the Black Sea area. A sample of surface and melting waters from the radius and suburbs of Chisinau contains some significant concentrations of organic pollutants, as follows: biochemical oxygen demand, BOD (20-150 mg O_2/l); chemical oxygen demand, COD (70-400 mg O_2/l); ammonium ions (10-50 mg N/l); total phosphorus (1-5 mg/l); suspensions (120-460 mg/l); and mineralization was <380 mg/l. Rainwater in Chisinau municipality, in the period ranging from 1980 to 1990, contained significantly higher concentrations of metals, as shown here: (Cu-60 µg/l, Zn-200 µg/l, Ni-30 µg/l, Pb-12 µg/l, Cr-6µg/l), V-5 µg/ l). These findings compare with significantly reduced concentrations of the same metals in recent times, as shown here: Cu ≤ 20 µg/l, Zn ≤ 50 µg/l, Ni ≤ 10 µg/l, Pb ≤ 6 µg/l, Cr ≤ 2µg/l, V ≤ 3 µg/l. However, the Mn concentration showed an increase to 200 µg/l. The copper content is high in leaks from vineyards - up to 300 µg/l in solution and 450 µg/l - in suspensions. Here, as well, COD reaches 600 mg O_2/l, which indicates the existence of substances hardly degradable (possibly coming from different pesticides, herbicides or their isomers). High mineral matter concentrations, 1600 mg/l, occur in corn and sunflower fields. On the other hand, organic matter concentrations occur in vineyards and orchards, which show these: Cu concentrations (95 µg/l) and Zn (180 µg/l), nitrates reach 20 mg N/l, mineral phosphorus - up to 2 mg P/l[8].

Several methods exist to reduce water body pollution from river basin runoff. It is established that forested areas practically reduce up to 80% of surface runoff, increase the level of groundwater, as well as the share of groundwater in river and lake water volumes. In protected areas, the existence of strips of trees, shrubs and grasses from the class of cereals and fabaceae, reduces the pollution of water bodies by 60-70%, where metals, organic substances and suspensions form the bulk of the pollutants[9].

Most rainwater collection and treatment technologies primarily provide techniques for sedimentation of the suspensions in these waters. It is known that mountain soils and rocks are the filters that save water bodies. Knowledge of the properties and potential for absorption of mountain rocks have served as the basis for the development, in recent years, of new technologies for stormwater treatment, using rocks as sorbents. Thus, the use of various sorbents of natural origin in the biological treatment phase is the most successful and cheapest system for treating surface water formed, as a result of spring melting and heavy rains in spring-summer-autumn.

It is now clear that sedimentation cannot solve the problem of pollution, especially from pesticides, herbicides, nitrogen compounds, phosphorus, detergents and other organic substances dissolved in rainwater. Expanding and supporting organic farming, as well as reducing household waste, would be the way to solve this problem.

To better control the risk of contaminated runoff, it is necessary to change the conventional management practices to nature-based approach by preserving and restoring the natural hydrologic cycle, filtration and infiltration can greatly reduce the volume/peak rate, velocity, and pollutant loads of urban runoff.

[7] *Korpinen, S., Klančnik, K., Peterlin, M., Nurmi, et.al. 2019, Multiple pressures and their combined effects in Europe's seas. ETC/ICM Technical Report 4/2019: European Topic Centre on Inland, Coastal and Marine waters, 164 pp.*
[8] *Zubcov, Elena. Biogeochemical migration patterns and the role of trace elements in freshwater ecosystems of Moldova/ The dissertation for the habilitation degree in Biological Sciences, Chisinau, Institute of Zoology,1999*
[9] *Zubcov, Elena. Biogeochemical migration patterns and the role of trace elements in freshwater ecosystems of Moldova/ The dissertation for the habilitation degree in Biological Sciences, Chisinau, Institute of Zoology,1999*

1.2. Impact of recreational activities on rivers

Rivers and river banks are preferred locations for relaxation, fun, picnics, sports, as well as various types of specific recreational activities, such as boating, swimming, sunbathing and fishing that have positive effects on human health and well-being. While benefiting from these "ecosystem services", visitors also may cause some negative effects on landscape, nature and aquatic ecosystems.

A spring-summer-autumn for a family or a group of friends is incomplete without a picnic in the woods or by a river. What could be better than a meal in the woods, by a lake or a river in the countryside? Dining outdoors with relatives, friends, classmates or colleagues is unforgettable pastime for everyone.

Unfortunately, often going out for some relaxation, visitors got disappointed as traces of previous visitors abound. This situation thus calls for prior cleanup of the place before using it for ones' dreamed picnic. To be environmentally responsible and kind to the next visitors, it is, therefore, important to clean up every mess before leaving the grounds where ones had their picnic and enjoyable activities. Before leaving the picnic spot to go home, it is necessary to bury the organic waste in the soil (for composting). If we anyway make open fire for the picnic, the best would be to burn the used paper, napkins and bones - ash is a useful soil ingredient. Plastic and glass containers have to be collected to be deposited back home in the usual trash bins for household wastes - best in the separate waste collection containers.

How do we organize a picnic with a minimal impact on nature and the environment? Here are some tips:

- Use reusable dishes: To avoid plastic littering at picnic locations, provide packs of reusable plates, cutlery sets and drinking glasses. For regular or repeated picnics, acquire a set of picnic tables and dishes that are reusable.
- Opt for local and seasonal products: It is good to give preference to local and seasonal products. This provides support for local producers, protects the environment, by reducing transportation costs, which consume huge amount of resources and emit hazardous emissions into the atmosphere. Furthermore, it is advisable to pack purchased supermarket food items into your own reusable containers and bags. Moreover, substitute carbonated drinks for homemade lemonades and store in reusable jugs. Water would be better stored or transported in glass or metal bottles.
- Compost food scraps: Instead of throwing away food scraps, use them to make compost when you return home or even there on the spot burying them in the wild. From vegetable peels to fruit scraps and tea bags, gather them together in a shallow pit or a heap and cover them with soil.

Leaving the landscape preserved and clean of food left-overs and trash, ones show their respect to Mother Nature and kindness to the next visitors in the woods and shores. Disposable cutlery thrown around would go directly into the waters of rivers to reach the lakes and the sea, so one carefully collects them all and disposes them in the trash bins back at home. The consequence of littering will have negative effects on water quality and biodiversity, as well as aquatic and terrestrial ecosystems in general.

Features of Impact of recreational activities and stormwater discharges on the rivers

Recreation facilities usually arise around water bodies that permit camping, cafes, restaurants, sports facilities and other types of leisure activities.

Typical impact of recreational activities on nature and ecosystems includes soil erosion and compaction, damage to vegetation, disturbance to wildlife, water pollution, increased fire frequency, vandalism and noise.

Most of the short-term recreation facilities are located either directly on the river banks or near them. Recreational activities can, in consequence, impact water resources, both directly and indirectly. Direct impacts result when recreational activities, such as swimming or boating, occur directly in the

water body. Indirect impacts result when land-based recreation activities, such as camping or hiking, occur close to the river banks. The most popular types of recreational activities include swimming, fishing, sailing, row boating, motor boating, water sports, camping, as well as tourism.

Motor boating creates various physical and chemical disturbances on the rivers, thus resulting in significant impacts. Physical impacts from motor boating include: increased water turbulence, cutting action from propellers, direct contact and disturbance. Motor boats, especially those with outboard engines, create turbulence, which can cause erosion of the shoreline. Although most of these impacts are created primarily by motorboats, turbulence can result, also, from use of rafts, canoes, and rowboats. Chemical impacts include: pollution from outboard motors — particularly motors of two-stroke design, and sewage discharged directly from boats into water. Discharge from motors contributes much of the waste generated from recreational activities. The discharge typically contains raw fuel, nonvolatile oil, volatile oil, lead, and phenols, which negatively affect plant and animal species within riparian environments.

Camping sites along the river banks are also associated with both physical and chemical negative impacts. Physical impacts to water quality from camping can include many different indicators, such as increased soil compaction, runoff, higher erosion rates, lower soil moisture, reduced flow of air, water and nutrients through the soil, higher pH, a smaller number of roots in the soil, as well as a loss of vegetative cover. A decline in vegetation near the shoreline leads to a reduction in soil microbial activity and increases erosion of the shoreline. Even non-intensive recreational use of campsites may have rapid and considerable impacts.

The impact of recreational transport on the natural environment is manifested through emissions of harmful gases from motorised vehicles, increased noise levels, as well as through the construction of new roads and parking lots. Emissions pollute the air (carbon dioxide, heavy metals, chlorine, fluorine, mercury, as well as arsenic, are detectable in the atmosphere), leading to the extinction of rare plant species, various microorganisms, and gradually accumulating in the river water. In many cultures, a vast number of entertainment and catering events during holidays occur along the riverbanks. These include beaches, cafes, sports grounds with parking, as well as recreation areas. Such intensively used infrastructure destroys natural ecosystems. Quite often, untreated wastewater from hotels, cafes, restaurants, recreational houses, huts is discharged into the river, causing significant damage to aquatic flora and fauna and to those animals, which use water as natural habitats (beavers, wild geese, ducks). Tourists and visitors often bring various types of trash which is often dumped in parking and recreational areas, or even directly into the rivers and lakes, thus harming nature and the environment, as well as worsening the sanitary and epidemiological condition of natural areas. Constructing new tourist facilities carries its own inherent problems, that include: tree-felling, displacing the fauna, disorganising soil structure, destruction of some small-size fauna and flora, as well as a consequential rise in household wastes. One of the main problems is the siltation of the rivers. The cause of siltation is the contamination of the banks with debris, discharge of untreated wastewater, as well as lack of bank protection.

Various efficient measures might be taken to limit the negative impact of recreational activities on the rivers and other water bodies.

The two most efficient measures would be to restrict building of campsite infrastructure by size and number, so tourist spots do not keep expanding out of areas with high intensity of recreational use and occupy new land into the wilderness; and to limit the installation of fire-grates for barbecues only in closest proximity to already existing well-planned recreational infrastructure. These two measures should be effective because they offer best desired infrastructure for recreational use in established, legitimate campsites, control of pollution, improve fire risk safety, restrict flow of hikers to remain in the most sensitive areas and encourage them to move to more stable locations to reduce erosion, sediment loading along the river and in the riparian areas.

Management measures to address the potential for increased biological and chemical contamination from camping and hiking could include establishment of proper facilities and raising the awareness of visitors about proper waste disposal; identification and rehabilitation of the most contaminated areas; providing of effective management systems for the protection and use of water resources, including

pollution control; conduction of laboratory study of sludge and determining the possibilities of using this sludge in agriculture, as means to rehabilitate small rivers, springs, as well as coastal areas; prohibiting the discharge of raw and insufficiently treated wastewater into water bodies, in order to improve the sanitary and hygienic conditions, as well as the operation of drainage systems; improving the management of funding targeted on nature and environment; strict enforcement of the environmental legislation by responsible institutions and the citizens; campaigns for cleaning up the river banks; immediate banning of car washing in the river, logging, making open fire along the river banks; increasing penalties for polluting the banks and rivers; understanding the value of nature as a significant part of a person's culture and wellness.

To minimise the environmental degradation associated with tourism and recreation may require: appropriate land-use zoning; regulation and surveillance of access and activities; direct physical protection of particular areas; and education both on-site and elsewhere. In addition, it is important to provide incentives to encourage low-impact types of recreation, such as contemplative, naturalist and wilderness travel activities; and discourage high-impact types such as sporting and social activities, use of motorised vehicles, and accommodation involving building and engineering construction.

Scientists identified that certain types of water recreation (e.g., hiking and birdwatching) are consistently predictive of greater concern about poor water quality. More frequent participation in these types of recreation may lead to increased receptivity to public policies aimed at addressing water quality problems.

2. Assessing contamination and monitoring river health

2.1. Assessing the contribution from unsustainable sanitation to river littering and impacts on river ecosystems

In the rural areas of Moldova, Ukraine, Romania, Bulgaria, as well as other countries in Eastern Europe, the wastewater is discharged as either raw or insufficiently treated, owing to the mass use of unsuitable treatment facilities, such as cesspools or uninsulated septic tanks (Figure 2). Thus, the wastewater pollutes the surface water bodies. Furthermore, this kind of wastewater could pollute the groundwater bodies as well. In rural areas, with the usual characteristic of poorer population and lower population density, centralized technical solutions may be costly and unaffordable for the population. Nevertheless, the centralized systems sometimes malfunction, causing overflow and leakage of wastewater (*Figure 3*).

Figure 2. A typical septic tank from a rural area of Moldova

Figure 3. Overflow of wastewater from the centralized sewerage system (a village near Chisinau)

In rural Moldova, wastewater treatment is very poorly developed. The National Bureau of Statistics (NBS) indicates that less than 2% of the rural population had access to the sewerage network in 2007; the OECD/EUWI indicating the following estimations:

- Rural population connected to wastewater collection system: 5%;
- Percent of rural wastewater treated: 0%;
- Use of simple pit latrines: 95%[10].

Nowadays, some progress was made in rural areas, regarding sanitation coverage. However, not so much was achieved, in the area of wastewater treatment. Even though not all of the pit latrines pollute the groundwater, as some of them use concrete pits, the users still need to empty them, which in rural areas means discharge into ravines, with the consequential organic and nitrate pollution of these rivers.

The result of some surveys carried out by Ecotox and WiSDOM associations between 2016 and 2018 in Central and Southern Moldova, indicated quite high coverage of flush sanitation. However, the

[10] *OECD, 2013. Business models for rural sanitation in Moldova, EAP Task Force https://www.oecd.org/environment/outreach/Business%20models%20for%20rural%20sanitation%20in%20Moldova_ENG%20web.pdf, April 2021*

wastewater treatment continued to be a problematic issue, from an environmental and human health point of view.

In Orhei district, Piatra and Jelobok villages, 80% of 46 interviewed people indicated that they use two sanitation systems – a flush toilet, connected to a cesspool (Figure 4) and an outside pit latrine. The accumulated wastewater from the cesspool, usually made of old tyres (Figure 5), infiltrates into the soil and could pollute the groundwater. Those who indicated that they use flush toilets mentioned that they never cleaned these soakaway pits or cleaned them very rarely (once in 4-5 years), the sludge being discharged into ravines or on the landfill, from where it can reach the surface waters.

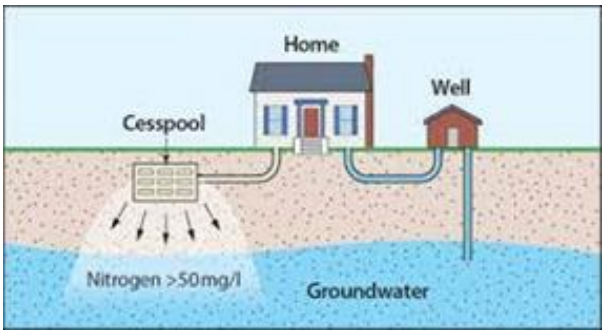

Figure 4. A schematic example of a cesspool.
Source: groundstone.ca

Figure 5. A DIY cesspool made of tyres.
Source: decoexpo.com

Out of 101 people in Slobozia Mare and Cahul, interviewed in 2016, 63% indicated that they use both a pit latrine and a flush toilet connected to a cesspool or a septic tank. Following detailed interviews, we understood that the septic tanks were uninsulated, with concrete walls but an open bottom. Thus, the wastewater usually leached into the soil. The probability of high degree nitrate and nitrite pollution of shallow wells cannot be dismissed here. Out of 15 analyzed well water samples, all exceeded the maximum allowable level for nitrates and in 4 samples, the nitrate concentration was ten times higher than the maximum allowable concentration. In response to question regarding cleaning the septic tank of the sludge fraction, 24% indicated that they never clean it (probably this also includes the owners of newly built septic tanks), 18% - they clean it once a year, 13% - once every half year and 8% - once every three months.

Some old sewerage village systems (Figure 6), in Moldova, were designed to collect only greywater from source but lacked treatment facilities. The result was direct discharge of this raw greywater into ravines or rivers. However, none of these classic systems functions at the moment.

Only 8% of the villages in Ukraine have sewer systems. However, 26% have flush toilets[11]. Only around one-third of the wastewater collected is effectively treated. Thus, a large volume of untreated wastewater is directly discharged into the environment, with potential to pollute rivers[12].

The situation with wastewater treatment was somewhat improved in rural areas of Romania and Bulgaria, after they became members of the European Union (EU).

Figure 6. A manhole with a local sewerage system for greywater of a school in a rural area. The greywater pipe ends in a ravine, which can be transported to the river by the stormwaters.
A photo from the village of South of Moldova.

[11] *World Bank Group, Danube Water Program, 2018. A review of rural water and sanitation in seven countries of the Daube region*
[12] *https://sos.danubis.org/eng/country-notes/ukraine/, April 2021*

Therefore, in Romania 48% of the rural population has access to flush toilets and 17 % - to sewer systems; this still leaves a high proportion of untreated wastewater continually discharged into the environment. Even though two-thirds of the Bulgarian population has access to a wastewater network, only 57 percent of this proportion is connected to a wastewater treatment plant[13].

Despite enormous investment in infrastructure (3.1 bln EUR, with 85% supported by the EU Funds), the overall situation in Bulgaria indicates only close to 26% functional wastewater facilities, with 20.4% of this water as input for secondary treatment while and 6.7% of the wastewater load collected undergoes more stringent treatment[14]. The EU Commission started a penalty procedure against the country in July 2017 after the final derogation expired in 2015. According to the National Water and Sewerage Strategy[15], there is a need to invest about 12 bln EUR more until 2038 to reach compliance.

Organic pollution from wastewater discharge can greatly affect river ecosystems. Untreated wastewater contains pathogens that cause a variety of diseases, including diarrhea. Accumulation of organic pollutants in rivers stimulates microbial growth and leads to oxygen depletion, while high nutrient loads can cause eutrophication and excessive algal growth and disturb the entire river ecosystem. Organic pollution can influence spawning and feeding efficiencies of fish thus, reducing the species diversity and abundance.

For the breakdown of organic pollutants from the wastewater, bacteria which live in water uses oxygen, meaning that polluted river water often suffers a severe decrease in the level of dissolved oxygen. Such conditions have a negative impact on susceptible species, such as common mayfly species (Figure 7), which are less able to tolerate rising water temperatures in polluted rivers with low oxygen levels.

Figure 7. Two aquatic insects - the mayflies Heptagenia coerulans and Palingenia longicauda, which are sensitive to organic pollution, the last one being a critically endangered species. Photo: Oxana Munjiu

Wastewater may also contain oil and grease, which are more difficult to break down and usually settle on the surface of the water. This blocks the light the photosynthetic aquatic plants need. It can also suffocate fish and get caught in birds' feathers. When untreated wastewater flows into the river, it can also elevate the temperature of the water, further disrupting the ecosystem. Fish are cold-blooded animals; so, they rely on the water to regulate their own body temperature. If the water is becoming too warm, the fish need to increase respiration, feeding and movement. Additionally, the temperature of the water also affects the amount of oxygen in it, which is also an important element for fish.

[13] *World Bank Group, 2018*
[14] *https://ec.europa.eu/environment/eir/pdf/report_bg_en.pdf, April 2021*
[15] *https://www.mrrb.bg/static/media/ups/articles/attachments/b9603ed612b5911606816d30f897dd80.pdf, April 2021*

Illegally dumped plastic waste in one way or another - with the runoff from intensive precipitation, erosion or directly dumped at the river bank, finally reaches the streams and rivers (Figure 8 and Figure 9) deteriorating the water quality and endangering human life and aquatic ecosystems.

Figure 8. The Tundza River banks, Zumnitsa, plastic pollution due to illegal dumping by households. Photo: Earth Forever

Figure 9. The Iskar River, plastic pollution due to illegal dumping. Photo: GreenPeace

It is estimated that 1.15 to 2.41 million tonnes of plastic are entering the ocean each year from rivers. More than half of this plastic is less dense than the water, meaning that it will not sink once it encounters the sea[16]. Once these plastics enter the gyre, they are unlikely to leave the area until they degrade into smaller microplastics under the effects of sun, waves and marine life.

In the autumn of 2019, the first islands from trash were identified in the Black Sea by a group of Russian scientists from A.N. Severtsov Institute of Ecology and Evolution of the Russian Academy of Sciences who came to the sea to count the dolphin population (Figure 10). The Danube River is the main source of pollution of the Black Sea. According to Ziare.com the Danube River deposits 4.2 tonnes of plastics each day into the Black Sea.

Figure 10. Plastic islands float in the Black Sea. Photo: bnr.bg

The Great Pacific Garbage Patch - threefold the size of France, is a terrifying reminder of the pollution footprint of humanity (Figure 11). This floating garbage island is the biggest one out of five that cover the Ocean and though its location and shape are constantly changing due to seasonal and interannual variabilities of winds and currents, it is considered to be generally located somewhere halfway between Hawaii and the West Coast of America.

[16] *Laurent C.M. Lebreton, et.al., River plastic emissions to the world's oceans, Nature Communications 8, no. 15611, June 2017*

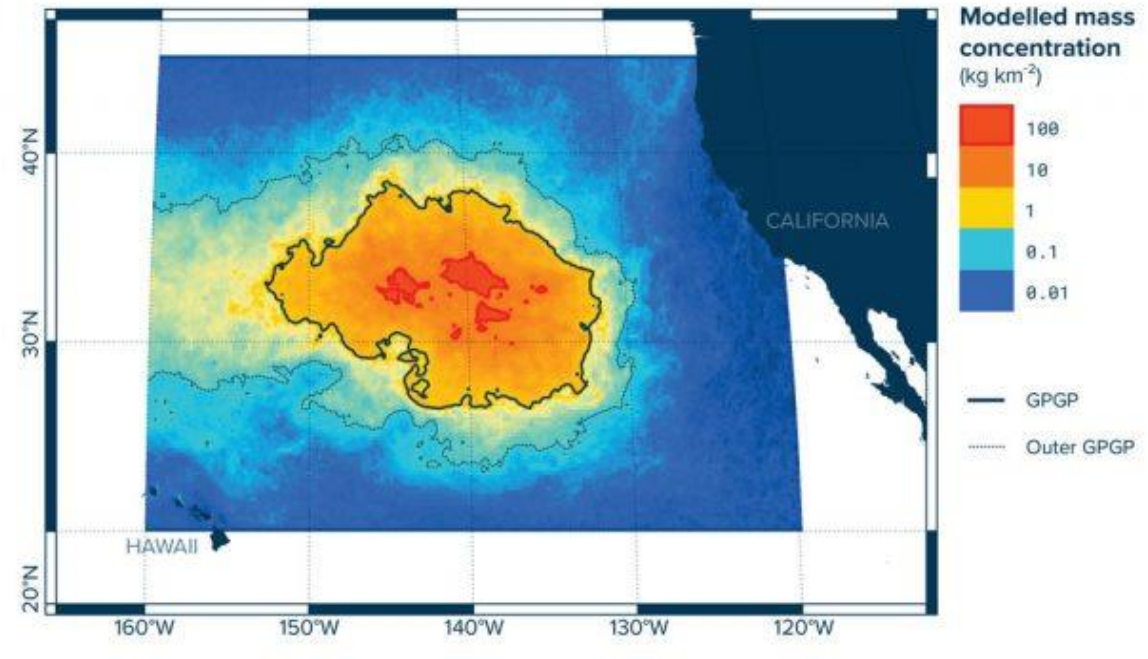

Figure 11. The Great Pacific Garbage Patch, modeled mass concentration by size classes. Source: theoceancleanup.com

The plastic waste starts its journey to the Ocean from the shores of beaches and eventually makes its way past the waves sucked out by the ocean currents. The plastic islands are brought together by currents that drift the plastic into a circular vortex in which they are retained under the sun and waves slowly being turned into micro plastic, but surely do not vanish. As more and more plastics are discarded into the environment, microplastic concentration in the Great Pacific Garbage Patch will only continue to increase.

The mass of the plastic in this Patch was estimated to be approximately 80 000 tonnes equivalent to that of 500 Jumbo jets. A total of 1.8 trillion plastic pieces were estimated to be floating in the patch – a plastic count that is equivalent to 250 pieces of debris for every human in the world[17].

2.2. *Monitoring and protection of rivers*

For the protection and sustainable use of aquatic ecosystems, it is necessary to monitor the ecological status of these ecosystems and their river basins. Monitoring is a system for evaluating the physical, chemical and biological parameters of water, according to natural and anthropogenic conditions. Surface water quality monitoring is carried out, using the procedures and technical measures sampling; analysis and synthesis to evaluate quality parameters; as well as status and trends in surface water quality. Bulgaria and Romania as EU-member states, as well as Moldova and Ukraine as candidate countries apply the European Union Directive 2000/60/CE in the regulation and the requirements on the systematic monitoring and registration status of surface water and groundwater. The procedures and measures used for sampling, chemical analysis methods, as well as field and on-line measurements, are validated and documented, in accordance with internationally accepted standards. The first stage of monitoring is the formation or elaboration of a programme or a coherent and comprehensive assessment tool of the state of aquatic resources. This facilitates the forecasting, elaboration and approval of management plans of aquatic organisms, as well as the analysis of progress in their implementation. The programme includes 3 types of monitoring: surveillance (supervision), operational, investigative.

[17] *https://theoceancleanup.com/great-pacific-garbage-patch/, April 2021*

The basic components of the programmes are the following:

- Network of water bodies for monitoring (name and GIS coordinates);
- Parameters and methods for monitoring hydrological, physico-chemical, biological parameters and the frequency of their monitoring (Table 1 and Table 2); and
- National or international quality assessment system.

Table 1. *Parameters and methods for monitoring of physico-chemical and biological parameters*

GROUP OF INDICATORS		Surface water quality indicator	Acronym	CAS number	Methods used
	The gas regime	Carbon dioxide	CO_2	Titration	SM SR EN 13577:2011. Determination of carbon dioxide content
General parameter	Nutrients-eutrophication	Nitrogen from nitrates	$N\text{-}NO_3^-$	Spectrophotometry	SM SR ISO 7890-3:2006. Water quality. Determination of nitrate content
	Heavy metals	Cadmium	Cd	Country specific	SM SR EN ISO 5961:2012. Water quality. Determination of Cd content by atomic absorption spectrometry, SM SR EN ISO 8288:2006

Table 2. *Frequency of sampling for physico-chemical and hydrobiological parameters in the mandatory monitoring points of aquatic ecosystems*

	Rivers [once in the mentioned interval]	Lakes and reservoirs [once in the mentioned interval]
Physico-chemical quality parameters		
Thermal and gaseous regime	1 month	1 month
Conductivity	1 month	1 month
Biological quality parameters		
Bacterioplankton	3 times during the vegetation period, April - September (it would be good under the ice in winter)	3 times during the vegetation period, April - September

For the quality assessment Bulgaria and Romania as EU-member states, as well as Moldova, apply Directive 2000/60/EC and Directive 2008/105/EC in regulating environmental quality requirements for surface waters. In 2019, Ukraine harmonized its legislation with Directive 2000/60/EC. The provisions in these current EU regulatory instruments lay down environmental quality standards for water, amend and repeal Council Directives 82/176/EEC, 83/513/EEC, 84/156/EEC, 84/491/EEC, 86/280/EEC, as well as amend Directive 2000/60/EC, as published in the Official Journal of the European Union L 348.

The regulation is a necessary working tool for water management and environmental protection authorities, as well as those involved in qualitative assessment of water resources. These activities help establish values of temperature, acidity/alkalinity, dissolved oxygen, chemical and microbiological parameters.

The results classify surface waters into 5 quality classes, as shown below: I-Very good, II-Good, III-Moderately polluted, IV-Polluted, V-Heavily polluted or dirty.

The classification of surface waters is made in accordance with the environmental quality requirements for surface waters, with reference to physico-chemical, hydrobiological, microbiological, virological and helminthological parameters (Table 3).

Table 3. *Classification of environmental quality of surface waters*

Parameter (group)	Acronym	Unit	Quality class I	Quality class II	Quality class III	Quality class IV	Quality class V
Dissolved oxygen	O_2	[%saturation]	>90% (*or NB*)	≥80%	≥60%	≥40%	<40%
Dissolved oxygen	O_2	mg/l, vara	>8	7	5.5	4.0	<4
Nitrate	NO_3^-	[mg N/l]	0,5(*or NB*)	1	4	10	>10
Mineralization	Min_{tot}	[mg/l]	<500(*or NB*)	700	1000	2000	>2000
Copper suspension	Cu_s	[µg/l]	<15(*or NB*)	20	30	100	>100
Copper dissolved	Cu_{diss}	[µg/l]	<5(*or NB*)	8	15	30	>30
Endosulfan	-	[µg/l]	0.005	0.0075	0.009	0.01	>0.01
Phytoplankton biomass	-	[mg/l]	<0.5	1.5	2.5	5.0	10
Phytoplankton	-	Saprobic index	1,5	2,0	3,0	3,5	4,0
Escherichia coli	-	[cfu/100 ml]	<500	500	1,000	>1,000	>1,000
Intestinal enterococci	-	[cfu/100 ml]	<200	200	400	>400	>400
TOTAL: 96 parameters							

At all stages of monitoring, a system is created for recording materials from various forms of registers (a hard copy), computer databases, as well as GIS systems.

If it is a local assessment system to ensure the participation of NGOs and involvement of the local community and children, an awareness programme is developed as well. Children or citizens interested in first monitoring stage, using this programme, organize a trip along the river, where they do the following: geographical description and mapping of the river basin, filming and description of the banks, identifying the state of the vegetation, identifying sources of pollution, as well as noting some hydrological materials of the rivers (length, width, depth, water speed, as well as others).

During the second stage of monitoring, water quality is investigated in accordance with organoleptic indicators. Any knowledge of the properties of water begins with the definition of organoleptic indicators, i.e., those for which the senses are used: sight, smell, taste. Organoleptic properties include such characteristics as: colour, transparency, odour, taste and subsequent taste, foam and the amount of suspended solids. Organoleptic evaluation brings a lot of direct and indirect information about water quality and the state of the water body. These investigations can be done quickly and without the use of expensive devices. Particular attention is paid to phenomena that are unusual for a lake, a pond that often indicates its pollution: the death of fish and other aquatic organisms and plants, the release of gas bubbles from bottom sediments, the appearance of increased turbidity,

foreign colours, odour, "water chills", stains of oil substances on the surface of the water, as well as others.

Smell is a property of water to cause irritation specific to the nasal mucosa in humans; and is measured in degrees. The smell of water is caused by volatile odorous substances that enter the water thus, giving rise to the following activities: life processes of aquatic organisms; biochemical decomposition of organic substances; chemical interaction of components contained in water; as well as the influence of industrial, agricultural and domestic wastewater. To determine the intensity and nature of the odour, pour 100 ml of test water into a flask with a capacity of 250-350 ml and close with a stopper. Spin the contents of the flask several times, open the flask and, carefully, inhale the surface air. Then, determine the nature and intensity of the odour (the water temperature should be about 20°C). If the odour is faint, then the water in the flask should be heated to a temperature of 50-60°C. Examples of suitable odours and water quality - smell of freshness, include: fresh, cut, fine grass; wet wood sawdust; tree bark; rotten soil, freshly ploughed soil; cucumber, floral; black mud; faecal; mould; rotten, hatched eggs; oil, chlorine, phenolic, alcohol. The odour value is measured in points from 1 to 5 (1-odorless, 2-very light, weakly detected, 3-visible, 4-attracts attention, 5-very strong).

Colour is an indicator of water quality. The following determinants refer to water quality: intensity of water colour, due to the content of coloured compounds; platinum-cobalt scaling, in degrees; as well as comparing the test water colour with predetermined standards. The colour of natural waters is mainly due to the presence of humic substances and ferric (Fe, III) compounds. The amount of these substances depends on the geological conditions, aquifers, soil structure and composition, the presence of swamps and peat bogs in the river basin, as well as others. Wastewater from some factories (including wineries) can also produce a fairly intense water staining. Usually, the northern rivers that flow through swampy places have a yellow-reddish and, even, brown colour; while the rivers in the South of Europe, most often, have a slightly bluish-green colour or are colourless.

The transparency (or transmission of light) of natural waters is due to their colour and turbidity, i.e., the content of various coloured and suspended organic and mineral substances in them. The water, depending on the degree of transparency, is conventionally subdivided into transparent, slightly opalescent, opalescent, slightly cloudy, cloudy and very cloudy. Water is not potable, if the transparency is less than 30 cm.

Suspended solids present in natural waters comprise particles of clay, sand, mud, suspended organic and inorganic substances, plankton as well as various microorganisms. During the spring floods, one can often see more turbid water, compared to normal periods. This is due to both the higher speed of the water, which erodes the banks, removes soil particles from the floodplain, as well as the flow of suspended solids that come into the water with the melted snow.

Turbidity. To determine turbidity, a clear, colourless thin glass tube or vessel, containing a water sample, is placed before a light source. The sample is viewed in a way that the gaze is directed perpendicularly to the direction of the light rays. Then, the turbidity of the test sample is determined, according to the following scale: 1-transparent, 2-slightly cloudy; 3-cloudy; 4-very cloudy.

The water temperature in a river or lake is the result of several simultaneous processes, such as solar radiation, evaporation, heat exchange with the atmosphere, heat transfer through currents, turbulent mixing of waters, as well as others. Water temperature is one of the most important factors that is reflected in the physical, chemical, biochemical and biological parameters that occur in aquatic ecosystems.

The third stage of monitoring the condition of water bodies is the determination of water quality, using hitech equipment, as shown among some equipment and accessories of the Hydrobiocenosis and Ecotoxicology Research Center of the Institute of Zoology, Moldova (Figure 12).

There are various kinds of equipment for *in situ* analysis of water pH value or its acidity, dissolved oxygen, water conductivity, some nutrients (ammonium nitrogen, nitrate, as well as nitrite). Planktonic and benthic hydrobionts populations (bacteria, microalgae, invertebrates), as well as the direct state of the ichthyofauna are equally important. When we reach the end of field research, we feel a certain regret. It is important to set up the groundwork for the success of further research, whether it is a new stage in one's work or the beginning of the work of others. The results may be necessary for decision-makers: local government employees and government agencies, the management of a national park or nature reserve nearby, the governance of businesses.

Figure 12. Equipment and accessories for determination of water quality

Therefore, it is necessary to prepare a document that fully reflects the basic information one received during the research period. If one can do something to improve the state of the aquatic ecosystems being investigated, note it, describe what changes have taken place. In conclusion, one should summarize the paper and draw general conclusions about the state of the water body and the research conducted.

CRoCuS Project Partners Ecotox and WiSDOM from Moldova also produced and disseminate some guides developed for NGOs, student schools and specialists in the field of water monitoring in Romanian, Russian and English:

- Zubckov, Elena, Nadejda Andreev, Nina Bagrin. *Ghid de gestionare durabilă a deșeurilor organice în scopul prevenirii poluării apelor*, Chisinau, 2021, 49 p.
- *Hydrochemical and Hidrobiological sampling guidance*, Chisinau, 2015
- *Guidance on the monitoring of water quality and assessment of the ecological status of aquatic ecosystems*, Chisinau, 2020
- *Мониторинг малых рек и водоемов. Практическое руководство неправительственных экологических организаций, учителей и школьников*, 2010, 95 с.

3. Waste management concepts and policies

3.1. Waste management concepts

Waste management is a simplified conceptual framework that acts as a guide to the most desirable waste management options. Waste management includes the collection, transportation, valorization and disposal of these waste. More broadly, it includes any activity involved in the organization of waste management from production to final treatment.

The main principles of waste management are:

- Waste hierarchy, referring to the "3Rs rule" Reduce, Reuse and Recycle, waste prevention and minimisation being the most desirable goal.
- Extended producer responsibility, adding all the environmental costs to the market price of a product, including end-of-life disposal.
- The polluter pays principle, requiring that a waste generator pays for the appropriate disposal of the waste.

The concept of Zero waste is based on the aphorism "less is more, zero is even better": The best waste is that which is never produced. The zero-waste movement is known as the "movement of the 5Rs," defined by Bea Johnson in 2013 in "Zero Waste Home: The Ultimate Guide to Simplifying Your Life by Reducing Your Waste."

The followers of Zero waste concept add 2 more Rs to the classic waste management concept:

- Refuse to bring home what you don't need. Every time we accept a freebie or knickknack that we don't need, we create demand for more to be produced. In her book, Johnson provides the example: every time we take the "free" soap and shampoo samples from hotel bathrooms, they have to be replaced with new, fully-filled bottles.
- Rot: use composting to decompose organic matter.

The basis of the sustainable management concept is to prioritize waste management options to maximize their sustainability, as follows:

- Reduction: Reduction of waste generation. Some waste can be completely avoided, while in other cases, the quantities can be minimized. Particular priority must be given to minimizing hazardous components in waste as well as certain hazardous materials that should be completely removed from the waste stream.
- Re-use: Putting the objects back into use so that they do not enter the waste stream.
- Recycling: Separation of materials for reprocessing before reuse (an example being the reuse of waste paper for the manufacture of recycled paper).
- Recovery: obtaining the value of waste by converting it into something different. The two main examples are the conversion of organic waste to compost and the recovery of energy from waste.
- Disposal of waste is the least attractive option for waste management. The priority for waste disposal is to ensure that it is done to a high standard to limit the impact on the environment.

Sustainable waste management is a key concept of the circular economy and offers many opportunities:

- Economic: Waste management involves collecting, sorting, treating, recycling, and when properly facilitated providing a source of energy and resources. Therefore, it has a huge economic potential that needs to be leveraged by public and private entities.

- Social: Besides creating jobs, improved waste management leads to a better quality of life for local populations, by improving hygiene conditions and reducing health risks related to illegal dumping and inadequate garbage collection.
- Environmental: The main advantage of sustainable waste management is to lessen the impact on the environment, by improving air and water quality and contributing to the reduction of greenhouse gas emissions. Besides, reducing food waste also helps reduce the heavy environmental cost of producing more.

Sustainable waste management highlights also the personal responsibility of citizens as consumers to control and minimize the waste:

- Consumers are advised to design and purchase products from reused, recycled or sustainably-harvested renewable, non-toxic materials to be durable, repairable, reusable, fully recyclable or compostable, and easily disassembled. It is crucial that consumers are well informed to allow for informed decision-making and stay aware of and discourage systems that drive needless consumption.
- The awareness of consumers is raised on their responsibility to minimize the waste production by planning carefully their consumption and purchase of perishables to minimize discards due to spoilage and nonconsumption; to facilitate the minimization of ecological footprint required for product, product use, and service provision while consuming seasonal and locally produced products and materials; to minimize quantity and toxicity of materials use; to choose products that are made from materials that can be easily and continuously recycled.
- The choice to reuse is also linked to the personal responsibility of the consumer to maximize reuse of materials and products; to maintain, repair or refurbish to retain value, usefulness and function of stuff; to remanufacture with disassembled parts, dismantle and conserve “spare” parts for repairing and maintaining products still in use; to repurpose products for alternative uses.
- Recycling and composting might be very efficient in households and communities by supporting and expanding systems to keep materials in their original product loop and to protect the full usefulness of the materials; by composting as close to the generator as possible; by supporting resilient local markets and uses for collected materials wherever possible.
- As responsible citizens in a democratic society it is everyone’s responsibility not to support policies and systems that encourage destructive disposal of organics and/or the destruction of recyclables; not allowance of toxic residuals into consumer products or building materials; to campaign for strict enforcement of water management legislation and to support the implementation of best practices for sustainable waste management.

The EU's approach to waste management is based on three major principles:

- Prevention of waste generation - a factor considered to be extremely important in any waste management strategy, directly related to both the improvement of production methods and the determination of consumers to change their demand for products (orientation towards green products) and to address a lifestyle that generates small amounts of waste.
- Recycling and reuse - if waste is generated, encouraging a high level of recovery of component materials, preferably through material recycling. In this sense, several waste streams are identified for which material recycling is a priority: packaging waste, end-of-life vehicles, battery waste, waste electrical and electronic equipment.
- Improving the final disposal of waste and monitoring - if waste cannot be recovered, it must be disposed of under safe conditions for the environment and human health, with a follow up monitoring program.

3.2. EU waste management legislation and policy

In 2020, the European Commission adopted the Circular Economy Action Plan[18] - one of the main blocks of the European Green Deal and Europe's new agenda for sustainable growth. The plan focuses on the following: electronics and ICT; batteries and vehicles; packaging; plastics; textiles; construction and buildings; food; water and nutrients, while aiming to make sustainable products the norm in the EU; to empower consumers and public buyers; ensure less waste; as well as to make circularity work for people, regions and cities. It introduces legislative and non-legislative measures to strengthen competitiveness, while protecting the environment, as well as giving new rights to consumers.

With measures along the entire life cycle of the products, the Action Plan announces initiatives along the entire life cycle of products, targeting, for example, their design, promoting circular economy processes, fostering sustainable consumption, and aiming to ensure that the resources used are kept in the EU economy, for as long as possible.

The Circular Economy Package[19] includes four directives that were adopted by the European Parliament on 18 April 2018 and entered into force on 5 July 2020:

- The Waste Framework Directive (2008/98/EC);
- The Landfilling Directive (1999/31/EC);
- The Packaging Waste Directive (94/62/EC); and
- The Directives on end-of-life vehicles (2000/53/EC), on batteries and accumulators and waste batteries and accumulators (2006/66/EC), and on waste electrical and electronic equipment (2012/19/EU).

The overall goal of the directives is to improve EU waste management, in order to protect, preserve, and improve the quality of the environment, as well as to encourage the prudent and rational use of natural resources. More specifically, the directives aim to implement the concept of "waste hierarchy", which sets a priority order for all waste management legislation and policy, which should make any disposal of waste, a solution the last resort:

- Prevention;
- Preparing for reuse;
- Recycling;
- Other recovery, *e.g.*, energy recovery; and
- Disposal.

Amended Waste Framework Directive (2018/851/EU)[20] requires Member States to improve their waste management systems to the management of sustainable material; to improve the efficiency of resource use; as well as to ensure that waste is valued as a resource. Among other areas of focus, the amendments address the following:

- Measures to prevent waste generation, *inter alia*, obliging Member States to facilitate innovative production, business, and consumption models that reduce the presence of hazardous substances in materials and products, encourage the increase of the lifespan of products, and promote re-use.
- The handling of municipal wastes.

[18] *https://eur-lex.europa.eu/resource.html?uri=cellar:8a8ef5e8-99a0-11e5-b3b7-01aa75ed71a1.0012.02/DOC_1&format=PDF, 28.01.2021*
[19] *https://www.europarl.europa.eu/RegData/etudes/BRIE/2018/614766/EPRS_BRI(2018)614766_EN.pdf, 28.01.2021*
[20] *https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:32018L0851&from=EN, 28.01.2021*

- Incentives for the application of the waste hierarchy, such as landfill and incineration charges or pay-as-you-throw schemes.
- Measures to encourage the development, production, marketing and consumption of recycling-prone products suitable for multiple use and, on attaining waste status, become suitable for re-use and recycling.
- Measures to promote the re-use of products constituting the main sources of critical raw materials to prevent those materials from becoming waste.
- Minimum operating requirements for extended producer responsibility schemes.
- The promotion of sustainability in production and consumption in Member States, including communication and educational initiatives, as well as measures to promote prevention and reduction of food waste.
- Member States' obligation to set up separate collections for paper, metal, plastic, and glass waste.

Member States must implement measures whereby unprocessed municipal waste is:

- better prepared for re-use after its collection; and
- recycled.

This must be done to a minimum of 55% by weight by 2025, 60% by 2030, and 65% by 2035. The directive acknowledges that large differences exist among Member States with respect to their waste management performance and, therefore, allows low-performing Member States to postpone these targets by up to five years.

Amended Landfilling Directive (2018/850/EU)[21] requires Member States to significantly reduce waste disposal by landfilling. This will prevent detrimental consequences for human health and the environment, and ensure that economically valuable waste materials are recovered through proper waste management and in line with the waste hierarchy. Member States will be required to ensure that, as of 2030, waste suitable for recycling or other recovery, in particular contained in municipal waste, will not be permitted to be disposed of to landfill. Use of landfills should remain exceptional rather than the norm. Furthermore, the Member States will take the necessary measures to ensure that by 2035, the amount of municipal waste disposed of in landfills is reduced to 10% or less of the total amount of municipal waste generated. Acknowledging that such reductions will require major changes in waste management in many Member States, these measures likely will facilitate further progress and investment in the collection, sorting, and recycling of waste. Member States that used landfills to dispose of more than 60% of their municipal waste in 2013 will be allowed to postpone the respective deadlines by five years.

Amended Packaging Directive (2018/852/EU)[22] aims to increase packaging waste recycling. In particular, Member States implement measures, in order to prevent the generation of packaging waste and to minimise the environmental impact of packaging. Economic instruments and other measures should be used to provide incentives for implementing the waste hierarchy. The measures have to encourage an increase in the share of reusable packaging placed on the market and of systems to reuse packaging in an environmentally-sound manner. This includes using deposit-return schemes, setting qualitative or quantitative targets, using economic incentives, and setting up a minimum percentage of reusable packaging placed on the market every year for each packaging stream. By the end of 2024, extended producer responsibility schemes will be established for all packaging.

By the end of 2025 (and 2030), at least 65% (2030: 70%) by weight of all packaging waste must be recycled, and the following minimum targets for specific materials contained in packaging waste must be met: 50% (55%) of plastic, 25% (30%) of wood, 70% (80%) of ferrous materials, 50% (60%) of

[21] *https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:32018L0850&from=EN, 28.01.2021*
[22] *https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:32018L0852&from=EN, 28.01.2021*

aluminium, 70% (75%) of glass, and 75% (85%) of paper and cardboard. Some Member States may postpone these target deadlines by up to five years, under certain conditions.

Directive 2018/849/EU[23] amended the previous directives on end-of-life vehicles, on batteries and accumulators and waste batteries and accumulators, and on waste electrical and electronic equipment. It primarily establishes monitoring and reporting requirements for Member States regarding the reuse and recovery goals for end-of-life vehicles and collection targets for waste batteries, accumulators and electrical and electronic equipment. Member States will take the necessary measures to apply the waste hierarchy to all wastes that the respective directives cover. In the context of the EU commitment to a transition towards a circular economy, a review process will consider the feasibility of setting targets for specific materials contained in the relevant waste streams.

In 2019, another Directive was added to the sustainable waste management legislative package of the EU – Directive 2019/904/EU on the reduction of the impact of certain plastic products on the environment[24].

The Single-use Plastics Directive aims to prevent and reduce the impact of certain plastic products on the environment; in particular, the aquatic environment and on human health, promote the transition to a circular economy with innovative and sustainable business models, products and materials, while contributing to the efficient functioning of the internal market scope: single-use plastic products and products made of oxo-degradable plastic,70% covered, of all marine litter: top 10 SUP (43%) + fishing gear (27%).

The Directive sets ambitious targets, as follows:

- quantitative reduction in consumption by 2026, compared to 2022, for items like food containers, cups for beverages, including covers and lids; increased availability of alternatives, e.g., re-usable; items not provided free of charge, as well as others;
- ban of plastic products with readily available alternatives (single and multi-use) like cotton bud sticks, cutlery, plates, straws, beverage stirrers, sticks for balloons and all products made of oxo-degradable plastic; cups, food and beverage containers made of expanded polystyrene, as well as to put restrictions on plastic content, not the whole product by 3 July 2021;
- by 3 July 2024, all single-use beverage containers and bottles, up to 3 litres with caps and lids made of plastic, may be placed on the market only if the caps and lids remain attached to the containers during the products' intended use stage;
- binding target of, at least, 25% of recycled plastic for PET beverage bottles to be enforced from 2025 onwards, calculated as an average for the Member State, not per producer. By 2030, the target of, at least, 30% of recycled content for all single use plastic bottles should be achieved;
- by 3 July 2021, tobacco products with filters, cups for beverages, wet wipes and sanitary towels will require a clear and harmonized labelling on the product or on packaging. For cups, the label will be on the product itself. The label will indicate the presence of plastics in the product, how waste should be disposed, as well as the resulting negative environmental impact;
- by the end of 2024, extended producer responsibility will be introduced for food and beverage containers, bottles, cups, packets and wrappers, light weight carrier bags and tobacco products with filters; so, producers will help cover the costs of waste prevention (awareness raising), waste management (collection and treatment costs of on-the-go waste in public areas); litter clean-up and data gathering. For wet wipes and balloons, only the waste prevention and litter clean-up costs are to be covered;

[23] *https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:32018L0849&from=EN, 28.01.2021*
[24] *https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:32019L0904&from=EN, 28.01.2021*

- the separate collection target for plastic beverage bottles to be achieved through EPR or through deposit refund schemes (by 2025 – 77% and by 2029 – 90%). Enforced measures should support high quality recyclables and uptake of secondary raw materials, as well as support plastic packaging recycling target of 55% by 2030;
- awareness-raising measures such as: providing information to consumers on availability of reusable alternatives, reuse systems and waste management options; impact of littering; impact on sewer network of inappropriate waste disposal to achieve reduction in littering of single-use plastic products covered, as well as fishing gear.

The Circular Economy Package supports also the efforts for better biowaste management in Europe and for placing recycled bio-waste materials on the European market as products. With the adoption of the amended Waste Framework Directive (2018/851/EU), Landfilling Directive (2018/850/EU), Directive on waste (2018/851/EU)[25], as well as Fertilizer Regulation (2019/1009/EU)[26], the legislative framework for achieving these objectives have been set. The main elements with relevance for improving biowaste management in Europe are introducing separate collection of bio-waste by 2023 in all member states, excluding mechanical biological treatment of municipal waste from recycling by 2027; and limiting the landfilling of municipal solid waste to 10% by 2035. With the revision of the EU Fertilizer Regulation, including harmonized European-wide end-of-waste criteria for compost and digestate, organic fertilizing products from recycled materials (compost and digestate) can be freely traded on the European fertilizer market.

Only about 40% (equivalent to 47,5 million tons per annum [M tpa])[27] of the biological waste in Europe is effectively recycled into high-quality compost and digestate. As up to 50% of municipal solid waste is organic, the bio-waste fraction plays an important role in recycling and the nascent circular economy. Implementation of separate collection of bio-waste in all EU member states, as laid down in the Waste Framework Directive, is a key for diverting organic waste from landfills and to guarantee that high-quality secondary raw materials (composts and digestate) are consistently manufactured, so that they can be placed on the European fertilizer market.

To achieve the overall recycling target of 65% of municipal waste by 2035, it is crucial that recycling of bio-waste has to take place.

[25] *https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:32018L0851&from=EN, 28.01.2021*
[26] *https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:32019R1009&from=EN, 28.01.2021*
[27] *https://www.compostnetwork.info/wordpress/wp-content/uploads/190823_ECN-Compost-Production-in-Europe_final_layout-ECN.pdf, 28.01.2021*

4. Sustainable waste management solutions

4.1. Nature-based solutions

NbS (nature-based solutions) is a novel concept applied by various originations, incl. the European Commission, UN, as well as others.

NbS is an umbrella term for ecosystem-related approaches (Figure 13) that are determined by site-specific natural and cultural contexts that include traditional, local and scientific knowledge to embrace nature conservation norms (and principles). NbS can be implemented alone or in an integrated manner with other solutions to address societal challenges (e.g., technological and engineering solutions) to produce societal benefits in a fair and equitable way, in a manner that promotes transparency and broad participation. NbS are an integral part of the overall design of policies, and measures or actions, to address a specific challenge at a landscape scale to maintain biological and cultural diversity and the ability of ecosystems to evolve over time.[28]

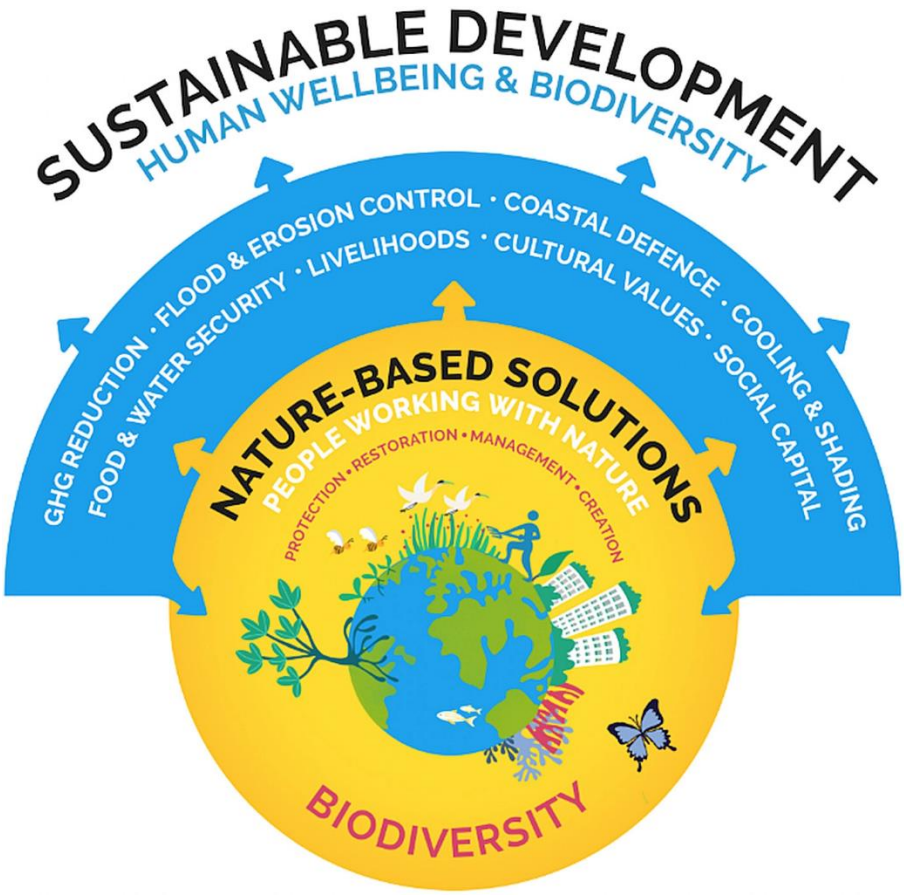

Figure 13. NbS is an umbrella term for ecosystem-related approaches[29]

Under the increasing stress of an unprecedented number of global population and ever-growing economy, neither built infrastructure nor natural ecosystems are able, separately, to provide water security and resilience. NbS have a multi-functional role with growing potential to address social, environmental and economic dimensions of global challenges. A number of strategic EU and UN

[28] *Cohen-Shacham, E., Walters, G., Janzen, C. and Maginnis, S. (eds.) (2016). Nature-based Solutions to address global societal challenges. Gland, Switzerland*

[29] *Seddon N., Smith A., Smith P., Key I., Chausson A., Girardin C., House J., Svirvastava S., Turner B. Getting the message right on nature-based solutions to climate change, Global Change Biology, Wiley Online Library, https://doi.org/10.1111/gcb.15513, 1 Feb 2021*

programmes (e.g., Horizon 2020, Agenda 2030, etc.) identify NbS as critical for coastal resilience, multifunctional water and watershed management, ecosystem restoration, adaptation and mitigation of climate change.

The fundamental role of ecosystems to support human wellbeing is a cornerstone of indigenous peoples' belief and traditional knowledge systems. The arborloo toilet (Figure 14) is a clear illustration of this.

An arborloo is a dry composting toilet. It works by alternating the position of the slab and superstructure above a shallow pit, while it is full. The pit should remain well above the water table so as to not contaminate groundwater. Faeces, urine, paper, leaves, other materials for wiping, as well as potentially anal wash water go into the pit. After each use, a cup of the excavated soil should be added to help control smell and flies. When the pit is nearly full, the outhouse and slab are moved to a newly-dug pit and the old pit is covered with some of the earth from the new pit and left to compost. A fruit tree or other useful vegetation is planted in the old pit.

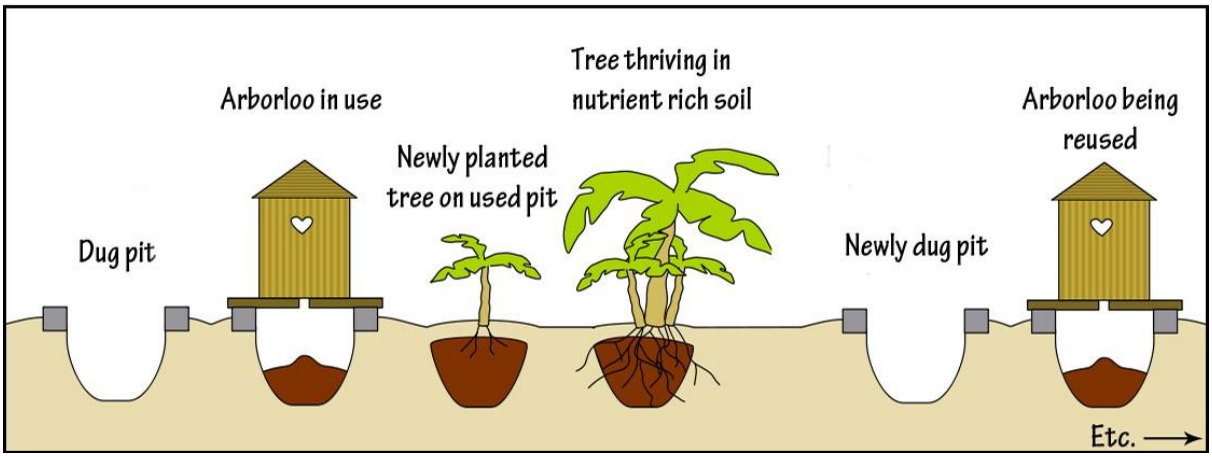

Figure 14. Arborloo[30]

Ecological sanitation (EcoSan) is not a specific technology but it is rather a way of thinking, based on three fundamental principles: preventing pollution rather than attempting to control it, after we pollute; sanitizing the urine and the faeces; as well as using the safe products for agricultural purposes. This approach can be characterized as 'sanitize-and-recycle'[31]. Ecological sanitation implies separating waste streams, saving water and energy, nutrient recycling, cost efficiency, and the integration of technology to environmental, organisational and social conditions[32]. Ecosan offers a flexible framework, where centralized elements can be combined with decentralized ones, waterborne with dry sanitation, high-tech with low-tech, as well as others. By considering a much larger range of options, optimal and economic solutions can be developed for each particular situation. This is based on thorough scientific research and evidence for safety WHO adopted Guidelines for the Safe Use of Wastewater, Excreta and Greywater - Volume IV: Excreta and greywater use in agriculture.[33]

CRoCuS project partners are the pioneers who promote ecological sanitation in Bulgaria (Earth Forever), Moldova (WiSDOM and Ecotox) and Ukraine (Mama-86-Nova Kakhovka). Urine-diverting dry toilets (UDDTs), planted filters, vermifiltration, as well as constructed wetlands, are among the technologies of ecological sanitation promoted in rural areas. In Moldova, several UDDTs were built at school and household levels. The main challenges faced with this type of sanitation is the maintenance,

[30] *https://www.wikiwand.com/en/Arborloo, 29 Mar 2021*
[31] *Winblad U & Simpson-Hébert M (editors): Ecological sanitation - revised and enlarged edition. SEI, Stockholm, Sweden, 2004*
[32] *Jenssen P.D., etc. Ecological sanitation and reuse of waste water, ECosa, a Thinkpiece on ecological sanitation, The Agricultural University of Norway, March 30, 2004*
[33] *WHO Guidelines for the Safe Use of Wastewater, Excreta and Greywater - Volume IV: Excreta and greywater use in agriculture. World Health Organization (WHO), Geneva, Switzerland, WHO (2006)*

as well as, willingness to apply the products to the soil. It is important to promote the closed-loop approach, putting a value on the compost and urine as fertilizers, as well as on good management for reducing the potential malfunctioning of the system. One system which could also be promoted in rural areas is the vermifiltration system, which represents a climate-friendly sanitation system, allowing for treatment and recycling of wastewater, with the help of earthworms.

The vermifiltration system comprises 4 main components that include a septic tank with two compartments, an equalisation tank (equaliser), a distribution reservoir with associated distribution pipe system and a vermifiltre (Figure 15). In the septic tank, the solids are settled and anaerobically digested in the first chamber, which reduces the volume. The liquid stream flows through the baffle wall into the second chamber, where additional sedimentation takes place. Excess liquid, now in a relatively clear state, is then drained through an outlet pipe into the equalisation tank. This tank acts as a buffer to provide a steady flow in order to prevent overpeacking, which could force solids and fresh organic material to be pumped into the vermifiltre. Flow equalisation also controls the flow at each stage of the treatment system, allowing physical, biological and chemical processes to take place in a timely manner. A submersible pump with a level sensor has been installed in this system. This sensor measures the level of wastewater in the equalising tank and triggers the pumping process.

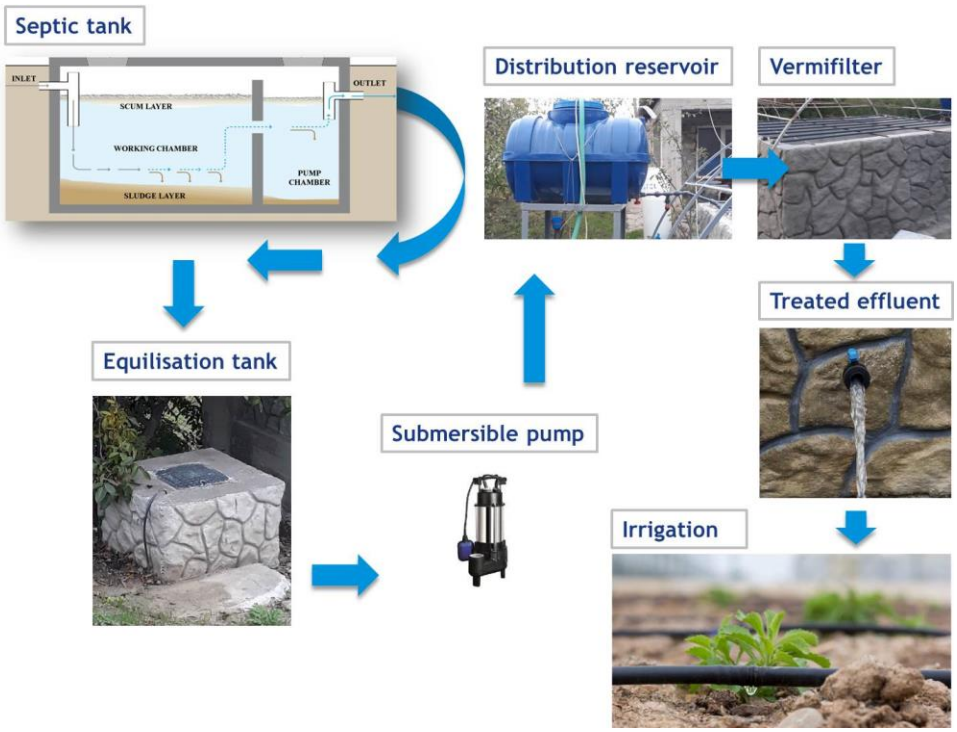

Figure 15. A schematic view of a demonstration vermifiltre built by WiSDOM association in a rural area of Moldova, at household level

The plastic distribution reservoir acts as the storage of the pumped water. Being located above the vermifiltre, the wastewater flows by gravity in a system of perforated pipes and further distributed over the entire surface of the vermifiltre. In the vermifiltre the top layer is the substrate for earthworms - a layer of crushed paper, covered with a layer of soil mixed with organic waste, where the compost earthworms *Eisenia foetida* are placed. Beneath the earthworm substrate, a layer of biochar is placed, which absorbs pollutants that have not been decomposed by earthworms. Under the biochar layer there are two layers of gravel of sizes 2-10 and 20-40 mm. At the bottom of the vermifiltre there is a system of perforated pipes that collect the treated effluent and brings it to a drip irrigation system. In order to avoid freezing of the vermifiltre during the cold period and to allow the earthworms to be active, the vermifiltre is provided with a polyethylene foil cover.

Terra Preta Sanitation (SPS) is another nature-based sanitation practice, originating from Amazonian aboriginal communities between 450 BCE and 950 CE. It is reported to regenerate anthropogenic soils at the enormous rate of 1 centimeter per year[34]. TPS applies the ancient knowledge for safe and beneficial human waste treatment by using lacto fermentation as the first stage of waste treatment, coupling it with vermicomposting to obtain a nutrient-rich "compost" and safe soil amendment with analogous properties to the Terra Preta soils[35]. Broad application of TPS has the potential to reduce a number of risks shared by billions of people on Earth.

Applications of charcoal to the soil provides other benefits such as: increase in productivity (from 0 to 300%); decrease in the methane and nitrous oxide emissions (estimated at up to 50%), decrease in the need for fertiliser (estimated at 10%); and decrease in the leaching of nutrients. Besides the economic benefits, the environmental benefits should also be taken into account, especially with regard to global climate change (C sequestration) and, in this context, the environmental benefits will be enhanced by reducing the emissions of other greenhouse effect gases (CH_4, N_2O and NO_x)[36]. Humus-rich Terra Preta soils can absorb enormous amounts of water and address the risk of water scarcity in Black Sea Region, due to climate change.

Resources-oriented systems, like Terra Preta Sanitation, are based on separate collection and treatment of blackwater (Figure 16). Reuse of nutrients requires low dilution or loop systems, saving a large proportion of the household water. The remaining wastewater, the greywater, can be treated for local or on-site reuse easily[37]. Terra Preta approach can successfully be used for ecosystem management and restoration (Figure 17).

Figure 16. Terra Preta sanitation[38]

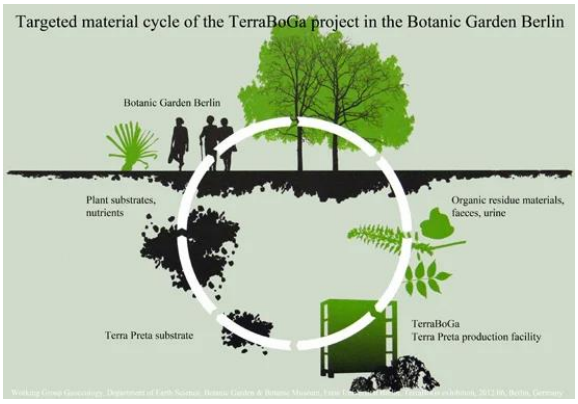

Figure 17. Terra Preta cycle[39]

Studies on future climatic trends for Europe suggest that temperatures may increase between 1ºC to 3.5ºC by 2100[40]. This would reflect increased water stress for agriculture, freshwater ecosystems,

[34] *Day, D., Carbon negative energy to reverse global warming. Eprida, 2004*
[35] *Andreev N., et.al. A concept for a sustainable sanitation chain based on the semi centralised production of Terra Preta for Moldova, 4th International Dry Toilet Conference, 2012*
[36] *Novotny, E.H., et.al. Lessons from the Terra Preta de Índios of the Amazon region for the utilisation of charcoal for soil amendment. J. Braz. Chem. Soc. vol.20 no.6, on-line version ISSN 1678-4790. São Paulo, 2009*
[37] *Oterpohle, R., et.al. Terra preta sanitation 1 – background, principles and innovations, DBU, June 2015*
[38] *Andreev, N., Ronteltap, M., Lens, P.N.L., Bulat, L., Zubcov, E. Lacto-fermented mix of faeces and bio-waste supplemented by biochar improves the growth and yield of corn (Zea mays L.). Agriculture, Ecosystems & Environment, Volume 232, 16 September 2016, Pages 263-272*
[39] *Schuetze, Thorsten; Vicente Santiago-Fandiño, Terra Preta Sanitation: A Key Component for Sustainability in the Urban Environment, Sustainability 2014, 6(11), 7725-7750, https://www.mdpi.com/2071-1050/6/11/7725, 12 Mar 2021*
[40] *Irish Water, Assessment of the Potential for Reuse of Treated Wastewater from Proposed Regional Wastewater Treatment Plant, December 2017*

drinking water supply, as well as others, due to prolonged droughts, especially in southern parts of the continent.

In the current context and proven tendencies, wise management and reuse of water turns into a major approach for sustainable landscape and ecosystem management and for survival of humanity. While EU legislation continues to be an obstacle for broad water reuse, it is a common practice around the world. Landscape irrigation is widely used in the USA, Australia, Singapore, Mediterranean countries and the Middle East. In Europe, golf course irrigation is the most popular reuse application. Groundwater recharge to aquifers not used for potable water has been practiced for many years. A number of European countries use treated wastewater for irrigation: Spain (70% of treated wastewater), France, Italy, as well as others[41].

Agricultural use of reclaimed water has a long history and is the most widespread reuse application in more than 50 countries across the globe. WHO guidelines for irrigation with reclaimed water[42], is a science-based standard that has been successfully applied to irrigation reuse applications throughout the world; and it is expected that the new revision of the EU Urban Wastewater Directive (91/271/EEC) will open broadly the door for this practice.

Total water abstraction in the European Union amounts to about 247 000 million m^3/year - 17% is used for public water supply and is strongly influenced by population growth and the way of life. The European Union's population is set to grow just slightly up until 2025, due to immigration, before starting to drop: 458 million in 2005, 469.5 million in 2025 (+ 2%), then 468.7 million in 2030 (+ 1,1%)[43].

Changes in lifestyle of Europeans contribute to the rise in resource use. A 2-person household uses 300 litres of water per day, 2 single households use 210 litres each[44]. Domestic water use is affected by climate change. A correlation between temperature and domestic water in several studies for the EU and US, showed that when daily temperatures are above 25°C, per-capita water use increases by 11 litres per 1°C (roughly 2% of current daily per capita use)[45].

As regards public water supply, the reduction of leakage in water supply networks, water saving devices, as well as more efficient household appliances, have the potential for up to 50% water savings from 150 litres/person/day (average in the EU), to a low 80 litres/person/day[46].

Water savings and reuse address water scarcity and droughts, deliver financial and economic benefits in the following ways: delayed or avoided procurement of additional water supply infrastructures; reduction in sewage and wastewater treatment capacity or reduced water bills; reduced stress in river basins; reduced fertiliser use, soil erosion and leaching; reduced energy consumption, electricity bills and thus CO_2 emissions contributing to climate change strategies and policy actions[47].

4.2. Recycling of plastics

The need for plastic began to rise in the 1950s, leading, ten years later, to its increased production. So much was this that its consumption worldwide became comparable to that of non-ferrous metals. Relatedly, recycling of plastics has grown steadily, as it is widely used in many countries.

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[41] *Irish Water, Assessment of the Potential for Reuse of Treated Wastewater from Proposed Regional Wastewater Treatment Plant, December 2017*

[42] *WHO Guidelines for the Safe Use of Wastewater, Excreta and Greywater - Volume IV: Excreta and greywater use in agriculture. World Health Organization (WHO), Geneva, Switzerland, WHO (2006)*

[43] *European Commission (2005): Communication from the Commission - Green Paper "Confronting demographic change: a new solidarity between the generations", COM(2005) 94 final*

[44] *European Commission (2005): Commission staff working Document, Annex to the communication from the Council and the European Parliament on Thematic Strategy on the Urban Environment Impact Assessment, {COM(2005) 718 final}*

[45] *Intergovernmental Panel on Climate Change (IPCC) (2007): Fourth Assessment Report. WGII - Climate Change Impacts, Adaptation and Vulnerability*

[46] *Ecologic, Institute for International and European Environmental Policy, EU Water saving potential (Part 1 - Report), ENV.D.2/ETU/2007/0001r, 19. July 2007*

[47] *Ecologic, Institute for International and European Environmental Policy, EU Water saving potential (Part 1 - Report), ENV.D.2/ETU/2007/0001r, 19 Jul 2007*

However, there are still technical, economic and structural problems to be overcome but the possibilities of surmounting these are vast. In some sectors, for example, bias against secondary materials remains a major obstacle to plastic recycling. In any case, this attitude is changing rapidly, amid environmental protection and other influences.

The proliferation of polyethylene terephthalate (PET)-based plastics in beverage storage poses a great challenge to the recovery of plastic packaging. Otherwise, the advantage of recycling PET packaging is enormous, given the large number of used bottles that can be acquired at acceptable cost. Thus, the collection of plastic materials from solid household waste can be done by two methods:

- Sorting by consumers, though more difficult, due to the large number of types of plastic. For a successful sorting, the plastic must be marked with various colours or numbers;
- Sorting different types of plastic at processing stations (Figure 18 and Figure 19).

Given the facts above, it is inferred that plastic waste management is one of the most pressing environmental issues in nowadays. Thus, it turns out that recycling emerges as one of the biggest processors of plastic wastes. Accordingly, modern technologies have aided in this recycling process in providing a variety of useful products, like: pipes, barrels, toys, furniture, blankets, clothing, footwear, as well as others. Mechanical recycling stands out as the dominant recycling process, in the case of mixed plastic waste. This process involves sorting and preliminary identification; shredding and then separation; washing; drying; as well as granulation. Preliminary sorting (Step 2 from Figure 18) involves the raw separation of waste, according to different properties, like: colour, size, shape, as well as type of plastic[48].

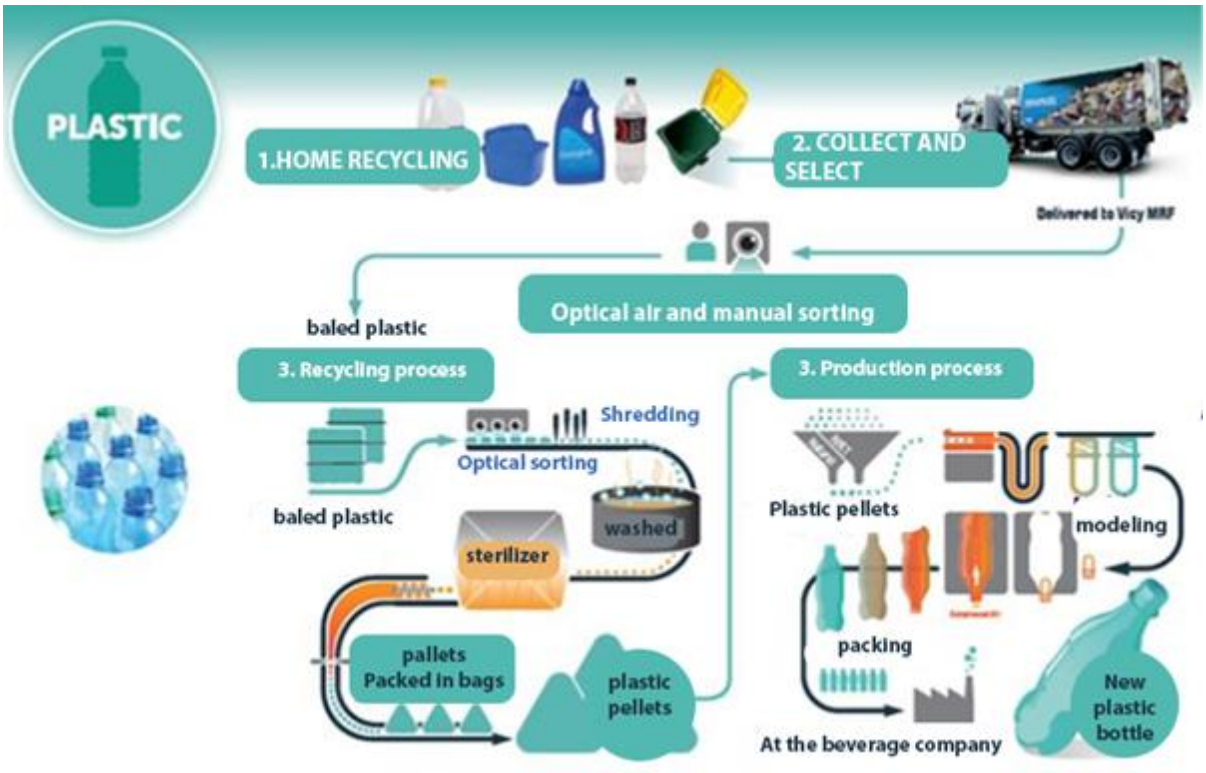


Figure 18. The cycle of recycling and recovery of plastic.

Source: www.containerdepositsystems.com.au

[48] *Handbook on waste management, https://wmp.ge/wmp2/wp-content/uploads/2019/11/BSB-457_3R_RO.pdf, March 2021*

Figure 19. Life cycle of a plastic bottle.

Source: www.plasticseurope.org

4.2.1. Reasons for recycling

- Plastic degradation lasts over 500 years.
- Plastic is made of oil, gasoline and coal. There are currently about 40 types of plastic, each one with a different chemical composition and properties.
- Plastic is made of non-renewable natural resources that cannot be replaced when exhausted.
- Products made from recycled plastic have a lower manufacturing cost than those made from raw materials.
- Recycling a plastic bottle saves enough energy to operate a 60 W light bulb for 6 hours.
- Recycling partially eliminates pollution and conserves natural resources. Detailed analyses have shown that these environmental benefits of recycling are much more effective than any other environmental protection action.
- Recycling conserves energy. Much less energy is needed to turn recycled materials into new products, compared to starting production with raw materials. By recycling a tonne of materials in a regular recycling programme, you save at least US $187 by saving on electricity, oil, gas and coal, even if we take into account the consumption, due to the collection and transportation of materials.
- Recycling eliminates the costs of storing or incinerating of wastes. Recycling costs are partially amortized by avoiding storage or incineration costs and by selling the resulting materials. Storage prices vary widely by area, and the market for recycled materials is booming.

- Properly-designed and fully-implemented recycling programmes can be fully competitive with waste storage or incineration. Numerous recycling efficiency techniques are currently available, some of which are being tested and implemented.
- Recycling creates new jobs and increases the competitiveness of the industry. Recycling provides the industry with cheaper resources, long-term economic benefits that translate into value for consumers who spend less on products and packaging.

Therefore, the effects of recycling on industrial development are significant.

4.2.2. 3R principle for plastic

In the 1960s, the intensive use of plastic began. Historically, the production of plastic and plastic packaging materials began due to the introduction of cheap oil, chemicals and new technologies. Over the last 60 years, the role and importance of plastic in the economy grew steadily. Thus, global plastic production increased 30 times, since the 1960s and, in 2015, amounted to 322 million tonnes. It is expected to double, again, in the next 20 years. Plastic is useful in a diverse field. Thus, the 150 types of plastic, with 30% comprising different polymer blends, find uses in the following: light and innovative materials in cars and airplanes; high-tech insulation - in energy; biodegradable plastic, as well as in 3D printing. Polymers with some determined characteristics contain some toxic additives that call for care and caution in any type of handling. Therefore, plastic recycling is a very complex process due to its diversity and variety of composition. Packaging materials are very common in the use of plastic and they serve different purposes: protection and storage of food; their packaging and distribution. Today, 41% of global plastic production is used as packaging materials, and 47% of this amount is used for food packaging. Plastic is mainly used for the packaging of soft drinks, vegetables and oils, cosmetics and perfumery and other products.

The two-litre plastic bottles were first marketed in 1978. Until 1981, the world market was dominated by products put in reusable glass bottles (alcoholic, low-alcohol, non-alcoholic and other soft drinks), while, since 1981, the glass has been gradually replaced by disposable plastic tableware.

4.2.3. Plastic codes

In 1988, the Plastic Industry Company (SIP) defined the types and codes of plastic (Figure 20 and Figure 21). The aim was to help identify, separate and recycle household packaging. SIP codes are widely used for marking packaging materials. This practice is mandatory in many countries.

Figure 20. Plastic codes.

Source: azecs.az

Figure 21. Description of plastics by codes. Source: greensxm.com

4.3. Composting of biological waste

Composting is an accelerated biological process, where microorganisms produce heat, carbon dioxide and water; and dead organic matter is converted to a homogeneous humus-like material, called compost. The heat generated in this biological process destroys pathogens and seeds, thus, making the compost useful in agriculture. Several months later, the matter decomposes, becomes hygienically safe and produces no objectionable odour. The compost turns out the best natural fertilizer.

Compost has the following advantages:

- a good fertilizer in agriculture and horticulture;
- allows optimal use of nutrients;
- improves soil structure with its attendant porosity;
- increases the water retention capacity in the soil; and
- provides a large-scale protection system against artificial fertilizers.

Composting is similar to the natural decomposition of organic matter to its basic components. Small-scale composting is done in the family yard, while the larger-scale type involves community lands. Materials for small-scale composting involve the following: organic waste from kitchen (vegetable and fruit peel, coffee grounds, filter paper, food scraps, bones and eggshells); animal waste (manure, rabbit or other pet waste, poultry manure, straw used in hamsters or other small animals), feathers and hair; as well as garden debris (grass, dried leaves, twigs and bark, weeds, material after the hedge has been cut).

Composting is easy to be organized especially on a household level in small composting sites. First of all, lay a loose layer of crushed dry organic material of about 20 cm, comprising of branches and hedges, straw or plant stalks. This will eliminate the excess water and, at the same time, allow ventilation. Second, layers of fresh foliage, mowed grass, kitchen debris and animal waste, with intermediate layers of soil, are placed one over the other. The base layer must always be covered. Continue adding layers, up to a height of 1.5 m. The top of the pile can be covered with a protective layer of grass, reed, old bags, foliage or straw and, finally, with a layer of black garden soil, for faster compost ripening. The pile must be watered, at intervals, to avoid drying.

Composting could be fun and achieve excellent results if the composting site is well equipped and properly managed. The CRoCuS project aims to supply proper equipment and to train the project partners to practice efficient composting producing a high-quality final product (Figure 22).

Figure 22. Composting equipment for efficient composting practice.

Source: homesteading.com; Ecotox

It is important to remember that composting depends on the active life and good health of soil generating bacteria and primitive animals - like worms. Lack of water blocks the activity of microorganisms and, implicitly, the decomposition process. On the other hand, too much water kills these microorganisms (which need only a little water and a lot of air). Accordingly, during the rains, the compost pile should be covered and, in drought periods, should be watered. Microorganisms can multiply, due to insufficient ventilation or moisture; and this creates an unpleasant odour. To prevent this, the composter storage bins must have vents for air or for water to leak. Another factor that contributes to decomposition is heat, the optimum temperature being at least 40-60°C. Manure from poultry and domestic rabbits, as well as straw or sawdust from hamsters or other such animals, may be used also, provided that they are well mixed with other compost materials. Exotic fruit peels, paper and cardboard, are less suitable for composting; exotic fruits contain many chemicals that delay spoilage. Cardboards have less composting value. Due to the chemicals contained in the paints, printed paper with one or more colours is not recommended for composting. It is strictly forbidden to introduce into the pile of compost, glass, any kind of metal or plastic, as well as any kind of waxed paper, waste oils and paints, vacuum cleaner dust or wood or coal ash.

Figure 23. Composter for household organic waste. Photos: Earth Forever

The compost pile should be placed in the shade, to avoid drying it out. Thus, under a canopy or in a covered and ventilated box would equally serve. The box should not exceed 1.5 m in height and 2 m width. The length depends on the available space and the amount of household biodegradable materials. For compost in smaller households, especially designed baskets or crates made of wire mesh, disused motor vehicle tyres, trash cans, wooden crates or bricks, can be used.

Project partners Ecotox (Moldova), WiSDOM (Moldova) and Earth Forever (Bulgaria) are experienced in raising awareness about the use of composting; building of composting sites and training local people to practice efficient composting (Figure 23).

One of the major impacts of the CRoCuS project is to supply project rural communities with composting equipment (Figure 24), to build composting sites and to train project beneficiaries to compost efficiently their organic waste, especially branches and leafs collected in public areas (streets, parks, etc.).

Figure 24. Branch chopper acquired by project partner Mama-86-Nova Kakhovka, Ukraine. Photo: Mama-86-NK

5. Best practices of waste management

5.1. Wastewater treatment and sustainable sanitation

CRoCuS project partners are the pioneers who promote sustainable sanitation in Bulgaria (Earth Forever), Moldova (WiSDOM and Ecotox) and Ukraine (Mama-86-Nova Kakhovka). Urine-diverting dry toilets (Figure 25), planted filters (Figure 26), constructed wetlands (Figure 27) are among the technologies that would fit into the concept of sustainable sanitation.

Figure 25. Urine-diverting dry toilet. Photos: Earth Forever

Figure 26. Planted soil filter

Photo: Earth Forever

Figure 27. Constructed wetland

Photo: Earth Forever

Figure 28. AGRO treatment facility.
Source: pi-trade.com

Sustainable sanitation does not focus on specific technologies, it is rather a concept that protects and promotes human health and environment, preserves natural resources by efficient treatment and safe re-use. The results are technically and institutionally appropriate, economically viable and socially acceptable.

CRoCuS project aims to contribute to the promotion of ecological sanitation by introducing a model wastewater treatment facility for the Mayoralty in Yulievo, municipality of Maglihz, Bulgaria. AGRO is an aerobic facility that operates without use of electricity (Figure 28). It provides for sedimentation and biological treatment of domestic wastewater, with the opportunity for reuse for ground irrigation *in situ*, for landscape maintenance of the backyard of the administrative building. AGRO possesses European certificate DIN EN 12566-3+A2:2013. AGRO replaces the existing septic pit that does not comply with EU legislation.

5.2. *Re-use of biological waste*

Figure 29. Useless branches chopped to be used as mulch.
Photo: Earth Forever

One very elegant way to re-use biological waste is to apply it as mulch. Mulch is easy to produce by chopping various types of dry and fresh organic material: useless branches, straw, rice husk, grass, etc. (Figure 29). Mulching builds a reliable obstacle against unwanted vegetation (weeds), reduces evaporation from the soil, in long-term it improves the soil structure and increases its fertility. Mulching is good for beautiful landscapes with flowers and decorative bushes and trees in urban parks (Figure 30). With the support of mulching, one might significantly reduce the need of digging, weeding and irrigation in your home garden and venerable garden.

Figure 30. Effect of mulching of urban park areas

The CRoCuS project is providing specialized equipment of high quality to support the introduction of efficient mulching and composting practices in the project communities (Figure 31) in Bulgaria, Moldova, Romania and Ukraine.

Figure 31. Chopper for branches and leaf blower provided by CRoCuS to project rural communities.

Photos: Earth Forever

5.3. Utilization and re-use of waste plastics

CRoCuS project has as one of its major objectives better management of plastic waste. Project partners are installing presses for plastic bottles and cans in many schools, community centers, public areas in all project rural areas in Bulgaria, Moldova, Romania and Ukraine to raise the awareness of the local people on the importance of personal effort to reduce significantly the volume of plastic waste (Figure 32).

Figure 32. Plastic bottles installed for reducing with 80% of the volume of waste plastic bottles and cans

Japan is an example of best national management practices for plastic waste recycling. Inspired by its 'mottainai' (もったいない) traditional philosophy (translated as “don’t waste anything worthy” or “what a waste”), Japan recycles an impressive 84 percent of the plastic collected (and 85% of the plastic bottles). The country reaches this percentage through diversified recycling mechanisms: among others, more than 37% of the plastic waste is incinerated to generate energy; about 23% is either reprocessed into new products or chemically recycled being broken down into its primary components and recombined to create new products; 16% is non-utilized dumped or burned without energy recovery[49].

There are good reasons behind Japan's motivation to address its plastic waste problem seriously. Known for its addiction to plastics, the country is the world’s second-biggest producer of plastic waste per capita (after the US). Domestic plastics products consumption reached 10,290 kt. With the introduction of fees for plastic bags from July 1, 2020 the first visible step towards raising public awareness of the problem was made.

Supermarkets in Japan have PET bottle shredders providing shopping tokens in exchange for plastic (Figure 33). PET resin is then used to make everything from clothes and carpets, to new bottles.

[49] https://www.pwmi.or.jp/ei/plastic_recycling_2019.pdf, April 2021

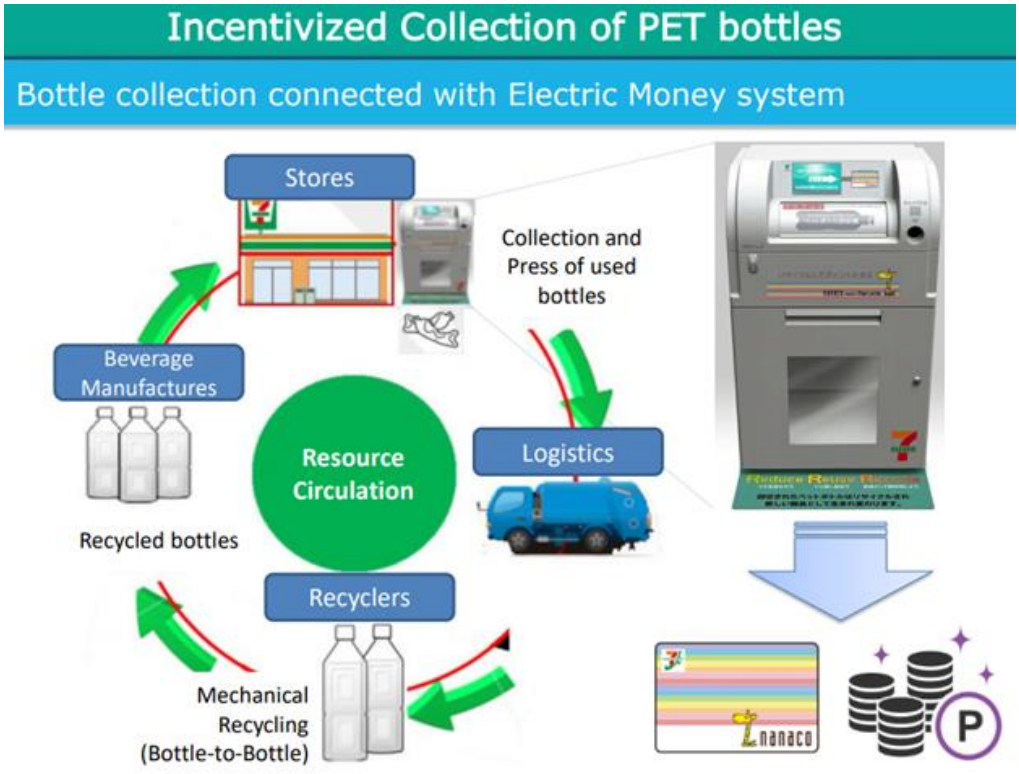


Figure 33. Japan incentivizes plastic recycling

Source: Recycling Promotion Division Environmental Regeneration & Resource Circulation Bureau Ministry of the Environment, Japan

Japanese widely use apps that feature "dictionaries" to help people sort their waste, as well as alarms to remind people what to put out for collection on a given day.

Kamikatsu is a small town in Japan that became a zero-waste municipality. The sorting of the garbage in Kamikatsu is segregated into over 45 separate categories. The town has no trash collecting containers. Residents transport their household waste themselves to a local facility.

Another fast-growing fashion is the construction of roads utilizing plastic wastes. A one-kilometre stretch of such road uses the equivalent of about 684 000 plastic bottles or 1.8 m single-use plastic bags.[50]

Due to specific geosystems in the Netherlands, the sinking roads are a big problem. It is because the ground is so wet that roads get soaked and often have to be replaced after just three to four years. Rotterdam was the first city that has shown interest in 100% sustainable recycled plastic roads (Figure 34). The Dutch City Council sees this idea, in a friendly environmentally path, as the future of humanity.

Figure 34. Plastic road.

Source: sciencealert.com

According to VolkerWessels construction company, plastic offers lots of advantages both in the process of construction and in the maintenance period. Plastic is impermeable to water, as well as much lighter than asphalt. Plastic roads could be designed with integrated storm drains that accumulate water during heavy precipitation to release it

[50] *https://www.bbc.com/news/uk-scotland-south-scotland-47454719, 5 Mar, 2019*

later in a controlled way. The hollow space within the blocks allows easy insertion of cables and hoses whenever necessary.

Prefabricated plastic roads are quick to build. Their life span is 50-100 years without maintenance compared to conventional roads that need to be replaced three times over every fifty years, on average. The plastic road has great endurance and can withstand extreme temperatures from -40°to 80°C.

Plastic roads are getting very popular in various parts of Europe (Figure 35 and Figure 36) and the world (Figure 37)

Figure 35. Plastic road in Aberdeenshire, Scotland. Source: earthdecks.net

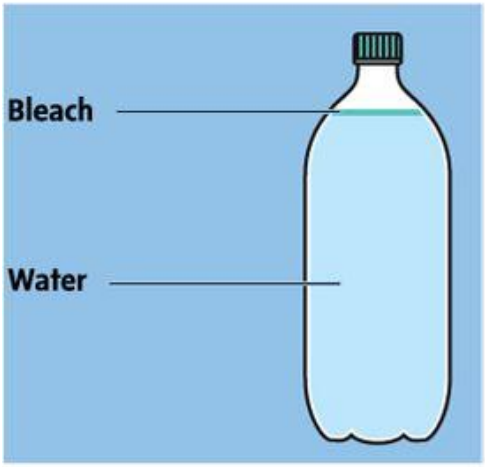
Figure 36. Plastic road in Durham, England. Source: durhammagazine.co.uk

Figure 37. Plastic road in Chennai, India. Source: skyfilabs.com

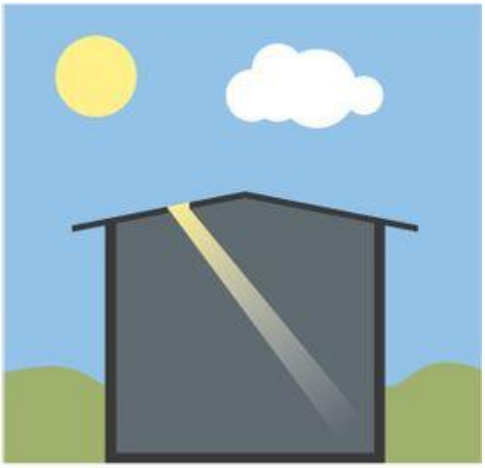
Another best practice of plastic bottle reuse that gains fast popularity is the "Moser lamp" (Figure 38). It all started in 2002 when Alfredo Moser from Uberaba, Brazil was figuring out a way to illuminate his workshop during one of the frequent power cuts. The "Moser lamp" is an easy to apply low-cost technology to turn a plastic bottle full of water into a source of free solar lighting indoor (Figure 39), as well as street lighting (Figure 40).

Figure 38. Alfredo Moser and his solar plastic bottle lamp. Source: permaculturenews.org

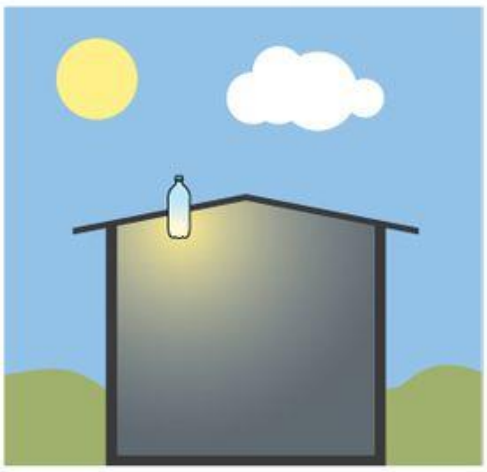
Using solar bottle bulbs is an innovative way to light up homes in parts of the world where there is no electricity.



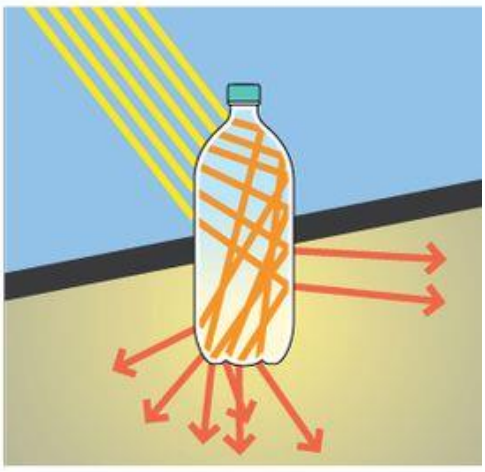
The water light bulb is simple and cheap. A 2-litre bottle is filled with clean water, plus about 10 millilitres of bleach in order to inhibit algae growth over time.



The advantage to using solar water bulbs over simply cutting holes in the roof is that sunlight shining down a hole works like a spotlight, lighting only a small area within the room.



Putting a water-filled bottle in the hole collects more light because light rays travelling through denser-than-air material such as water change direction.



Light reflected this way will bounce back and forth as it travels through the water bottle, and will spread out to light the room more evenly.

Figure 39. Instruction for making a "Moser lamp".

Source: physicscentral.com

Figure 40. Outdoor solar plastic bottle lighting, Haiti. Source: literoflight

Yet another easy to implement example for re-use of plastic bottles filled with sand, gravel or soil as garden edges of raised beds (Figure 41).

Figure 41. Reuse of plastic bottles for garden edge, private house in village Tohatin.

Photo: Nadejda Andreev

5.4. Utilization of waste tyres

Re-used waste tyres are another product that inspires numerous indoor and outdoor projects. Tyres are designed to be strong and durable, Worn or used tyres that have served their original purpose still have structural durability that can be utilized.

Starting with an enormous variety of outdoor and indoor applications for playgrounds (Figure 42), open park furniture (Figure 43), landscape management (Figure 44), interior furniture (Figure 45), construction of buildings (Figure 46).

Figure 42. Playgrounds. Source: hative.com

Figure 43. Park furniture. Source: fabartdey.com, thegardeningcook.com

Figure 44. Landscape management. Source: hative.com, fabartdiy.com

Figure 45. Indoor furniture. Source: renoguide.com.au

Figure 46. Re-use of old tyres in construction. Source: homedit.com

5.5. Utilisation of waste shipping containers in construction

The cost of a shipping container home can be significantly less than a traditional home (Figure 47). Such buildings can be used as homes and offices in urban areas, fields, forest and beaches. It is possible to install standard electricity and plumbing if only all the permits will be issued. An alternative is going off-grid and truly living in wilderness.

Shipping container houses could serve as a cheap emergency shelter but can also turn into a comfortable solid construction in urban areas used as a residential family house or for business purposes.

Figure 47. Utilization of shipping containers for the construction of buildings. Source: taylordesign.com

5.6. *Re-use of waste glass*

Another waste material that ignites the imagination of many persons is glass, especially glass bottles (Figure 48 and Figure 49). Glass bottles are used for various inspiring outdoor and indoor projects all over the world.

Figure 48. Inspiring waste glass bottle projects. Source: thegardenglove.com, krepcio.com, cordwoodconstruction.com

Figure 49. Richard Pim and his 'Blotto Grotto' constructed from 5,000 wine bottles.

Source: dailymail.co.uk

5.7. Sustainable lifestyle as a personal contribution in reducing and recycling of waste

Each of us is responsible for the current state of the environment in a positive or negative way depending on his/her style of living and the way s/he operates his/her business activities. Individual efforts can greatly contribute towards advancing the Agenda 2030 and achieving the Sustainable Development Goals. It is important to realize that environmental degradation is not only limited solely to the policies, strategies and standards designed and followed by large companies, in one way or another each of us contribute with our grain of sand.

Although they seem small in scale and a kind of insignificant, our cumulative individual everyday actions can contribute significantly to sustainability. The individual commitment and awareness of each of us brings the society closer to the ultimate goal of sustainable development.

Sustainable lifestyle requires everyday effort to reduce the amount of Earth's resources consumed by all and each of us. Living on our common Earthship with limited resources, each of us should try to have as little of an impact on the Earth as possible, while also trying to replace the resources one has to use to meet his/her needs.

Annually billions of plastic bags are used, which require several million barrels of oil to be manufactured. You can make a difference starting by using recycled paper bags or your own cloth bags for shopping (Figure 50).

Figure 50. Using a textile bag shows personal responsibility. Photos: Alina Andreev and Kevin Mantay

You can also start pretreating your organic waste at the collection stage. You can collect your family food scraps separately in a bucket with a lid. After each new addition of the food leftovers, a small amount of wheat bran is added (about 1/3 of tea glass). Sprinkle it with a solution of sauerkraut or whey. This way, the waste ferments under low oxygen conditions, the smell of the organic waste is reduced and the composting process speeds up. Fermented waste will be covered by white mold on the top (Figure 51). Chop and add twigs, weeds or scraps of paper. Shredding increases the area on which microorganisms have to work and ensures a more even distribution of moisture between materials.

Figure 51. Fermented waste covered by white mold indicates favorable conditions. Photo: Nadejda Andreev

Last but not least, an average person uses 167 disposable water bottles a year. By simply switching to a reusable water bottle, you could save 167 plastic bottles from becoming garbage, as many ones are not recycled and finish in a dumpsite and even reach the middle of the Pacific Ocean.

It is your personal obligation to start separately collecting and disposing your household waste - plastics, glass, metal, hazardous waste (batteries, pharmaceuticals, household and garden chemicals, luminescent lamps, etc.) and thus protecting the environment.

Conclusion

Our everyday life of producing waste (littering) places enormous pressure on the river ecosystems and biodiversity. Natural events such as storms, heavy rainfalls that were intensified during the last decades, exacerbate this impact by transporting these significant quantities of litter from the land to the rivers and finally to marine environment. The floating litter and that located on the river banks affect negatively the aquatic ecosystems by decreasing overall biodiversity and visual quality. A significant amount of the floating litter in the Prut, Dnieper and Tundza rivers is composed of plastic waste with plastic bottles and bags being predominant types of plastic packaging.

The partners involved in the development of the training pack are 4 NGOs from Bulgaria, Moldova and Ukraine, and a local authority from Romania with a great experience in awareness raise, assessment and management of solid waste and river ecosystems. Earth Forever foundation has gained a rich experience in implementing various international and local project in rural communities, for advocating for better water, sanitation and waste management services, with a rich experience on mobilizing stakeholders will share knowledge and experience for other partners on the efficient enforcement of EU waste legislation and implementation actions. WiSDOM association has also experience in the implementation of different demonstration actions in rural areas, for sustainable waste management, treatment and reuse of wastewater/excreta. Ecotox association has valuable experience in the application of scientific results in the field of ecological sanitation, water and health and environmental education. Mama-86-Nova Kakhovka has experience in public awareness raising on environmental issues, sustainable development, greening economy and lifestyle/consumption, Integrated Water River Management (IWRM), water and health security, separate collection and recycling of waste, wastewater and human excreta. Oancea Townhall has experience in separate collection, reduction and recycling of biodegradable waste.

We believe that the information reflected in this Training pack will contribute to: a) reduction of the land-based littering and the volumes and sources of pollution, organizing various hands-on trainings and activities for teachers, NGOs and decision makers; b) raising awareness and educating the public to take action for reduction of river littering in Moldova, Bulgaria, Romania and Ukraine.

In summary, the information reflected in different modules of the Training pack revealed that there are many best practices of safe waste treatment, handling and re-use, which could be promoted both at local and regional level. The training modules are available in English, Romanian, Bulgarian and Ukrainian and can be printed by anyone interested either as a whole book or separately in accordance to the area of interest, provided the source is referred to correctly.

Photo: Ferdi Rizkiyanto

ANNEXES

1. Useful tips on organization of indoor and outdoor river protection activities for schools and NGOs

1.1 General tips

1.1.1 Choose the type of activity depending on the target audience

A hike along the river banks, a bike ride that follows the river, a community clean-up of an urban river or a school water audit/debate are more suitable for pupils of gymnasium and lyceum level. A short ecology walks or a classroom watershed or aquifer modelling hands-on activity is suitable for the pupils of the primary school. Such events as water festivals, celebration of the community river can bring together people of different ages.

1.1.2 Set both learning and educational goals for each activity

A trip with the pupils to the river would aim to various learning objectives such as information on the biology of most common water and riparian plants and animals, food chains in a specific river ecosystem, interaction between water and living creatures, while the educational objectives can be the understanding of the importance of observation in the cognition of nature, of pupils' own role in the protection of water ecosystems, creating a sense of pupil ownership and respect for a brighter freshwater future.

1.1.3 Encourage participants to be active observers and listeners

In some cases, for example, of a trip focused on ecological observation, there is the risk that the guide, a school teacher as a rule, may tend to give the full analysis of seen objects or landscape by him/herself and put the participants in the position of passive observers. By raising questions and encouraging discussions, the guide shall stimulate the participants to take active part in the observation and analysis of the objects; to “discover” objects, processes, links and interconnections. In this way participants will develop their power of observation, understanding, love for nature and imagination. During the informal discussion in the “heart of events”, pupils learn to study environmental objects and processes (a river bank, aquatic ecosystem in a paddle, the specific needs of a water plant, a staffed fish in the museum, irrigation runoff as source of contamination in the local river, etc.), summarise the information and make conclusions.

In a demonstration activity, such as monitoring the river water quality by using the macroinvertebrates, it is of high importance to let participants work independently. This type of activity shall be prepared well ahead of the field demonstration. The organisers shall prepare the materials for the identification of species in advance; prepare instructions for participants taking in mind their level of knowledge and providing basic information about the taxonomy of macroinvertebrates.

During independent work, the organiser shall monitor and support the participants who would work individually or in small groups. Independent work shall be followed by sharing of results and discussion on conclusions - a representative of each small group will present the group observations and findings and conclusions that they made.

The same approach is used in community-based monitoring of the expansion of alien (non-native) or invasive species.

1.1.4 Give some homework

Homework can be used as preparation for the ecological activity or as verification or enhancement of newly received information, acquired knowledge, developed skills, etc. For example, prior to a school indoor activity related to the management of waste, some pupils can be involved in an experiment, which aims to determine the volume of different types of household waste (biodegradable, non-biodegradable) generated and handled/reused by their families.

For an activity devoted to water consumption, students can be asked to identify a leakage of water (pipe, tap) and to assess the volume of lost water from this leakage.

A community questionnaire also can be disseminated and summarized in advance for the preparation of an ecological or environmental activity.

Watching some videos, reading papers, brochures and reports, surfing the net for statistical data, studying maps can be given as homework to gymnasium and lyceum students. Drawings, non-complicated observations or measurements can be used as homework for pupils of primary schools.

1.1.5 Invite a guest

Depending on the topic of activity, the invited guest could be a specialist in management of water resources (for example, a specialist from a wastewater treatment plant), a researcher in the field of water chemistry or biology, a film director of a documentary about local water resources, a lawyer specialised in the field of environment law, an ecological inspector, an experienced guide in canoeing & kayaking, etc.

A guest of a demonstration activity on a river water quality with a portable oxygen or pH meter would provoke the curiosity not only of students who are interested in biology, but also of those interested in chemistry or physics.

Inviting different guests is not only a way to build lasting memories and meet interesting people, it would also help the students in the selection of their future careers.

1.1.6 Disseminate materials

Any materials designed with a focus on an ecological issue are welcome: brochures, leaflets, banners, posters, book notes, T-shirts, bags, mouse pads, etc.

Taking into account their short usage life, they shall not be too expensive, but need to meet some elementary quality standards (for example, in the case of paper materials – readable text, eye attractive colour and design).

1.1.7 Turn the learning process into fun

To teach students about water — where water comes from, how to protect and save it, and why all these are important, can be enjoyable.

In the case of indoor activities with kids, interactive games and quizzes, virtual tours and magic shows can be used with a great long-lasting effect. For elder students, interactive maps and official databases can raise sincere interest. Drawing a map of your watershed, for example, using specialised software would attract the interest of the students who spend their time exploring IT opportunities.

Presentation of photos and videos produced by the students during the ecological activities would stimulate the participants to combine the observation of nature and inspiration to make art.

Usually, young people enjoy open-air activities. If youth does not feel connected to nature and environment, they will not have the desire to protect them. Participating in a tree planting campaign on a riverbank, a young person would learn about the need to enforce the river buffer area to reduce polluted runoff; in a boat trip combined with camping – to understand better the impact of human activity on river flow; in a visiting trip to a water supply municipality plant – the connection between the quality of drinking water and the raw wastewater discharged into the river.

1.2 Organizing clean-up activities

1.2.1 Pick a cleanup site

First of all, identify an area (a park, areas near the rivers or lakes, forest areas, etc.) which needs to be cleaned. Secondly, walk across the candidate area to estimate its accessibility and safety for a group cleanup effort. Assess the volume of waste and calculate approximately the means of transportation and materials you need to collect, segregate and remove the waste. Analyse potential

dangers: traffic, animals, including domestic animals like dogs, in the neighborhood, dangers around construction sites, if there is construction occurring near the cleanup site.

1.2.2 Approach collaborative partners

Groups experienced in conducting cleanups may be helpful as organizing partners. Try to engage local environmental and conservation groups (any nature reserve representatives if available in your area), coordinate the event with the local public authorities informing them about your intentions to organize community cleanup. In case there are no facilities for segregated waste collection in or nearby the cleanup area, try to bring your recyclable waste to the closest recycling centre. In order to minimize the transportation costs, reduce the volume of waste by pressing it.

1.2.3 Arrange for trash and recyclable waste removal

Coordinate your cleanup event in collaboration with a recycling or a waste management company in your area. Introduce your intentions and objectives to them emphasising that it would be a volunteer community service effort. Ask them to sponsor the effort by hauling away the garbage. Ask them to advise for safety measures and proper disposal of special/hazardous materials.

1.2.4 Gather the required materials

- Standard cleanup materials can be found in almost any supermarket. You would likely need:
- Garbage bags (make sure to have bags both for trash and for recyclable waste);
- Garden/construction/disposable gloves;
- Hand sanitizing materials;
- A loudspeaker could be useful, depending on the size of the cleanup area and number of participants;
- Appropriate work clothing and shoes (outfits you do not mind getting dirty);
- First aid kit/s, depending on the number of persons who are expected to take part in the event;
- Fire extinguisher/s, depending on the size of the cleanup area and the weather conditions.

1.2.5 Spread the word

- Promote the cleanup event among the community to inspire the population to join or to initiate a parallel project of their own at the same time! You can spread the word by: posting flyers in the community, local press, social media; presenting your intentions on the TV, radio, social media; organize or join an information event in your community center; present to the local school, etc.
- Getting media coverage about the results and impact of your event. Call or e-mail local media reporters in advance and let them know about the cleanup. Tell them about the event and your group's motivation and objectives. Draft a press release with the help of a communication specialist.
- Raise the awareness of the prospective participants to wear adequate clothing, hats and shoes/boots, as well as to bring tools and equipment that would be useful - rakes, buckets, gloves, trash bags, etc.

1.2.6 Finalize your preparations one day in advance

- Consult the weather forecast for the day of the event. If heavy rain or severe weather is forecasted, you better postpone your cleanup event.
- Be sure you are adequately informed about the water level and possible flooded areas.
- Charge your cell phone before leaving home! Volunteers, reporters, and vendors may need to reach you throughout the day.
- Charge the battery of your camera, or consider inviting a photographer, to document the event.
- Check for the nearest working 1st aid facility on the planned cleanup day.

1.2.7 Event set-up

- Arrive at the cleanup site at least an hour before the announced launching moment.
- Organize an area of operation with drinking water supply for participants, first aid kit/s and fire extinguisher, extra trash bags, hand sanitizing materials, etc. (preferably protected by direct sunshine).

1.2.8 Kick-off your cleanup event

- Provide brief welcome and logistic remarks to get your event off to a good start.
- Acknowledge participants for their responsible behaviour and encourage their enthusiasm.
- Introduce your partners for this cleanup campaign - NGOs, schools, business, etc.
- Introduce the representatives of local authorities and give them a chance to say few words.
- Say few inspiring words about the importance of keeping rivers and the environment clean nowadays and for the future, and the individual responsibility of everyone.
- Emphasize safety - cautiousness about nearby traffic, attention to animals, staying away from water, handling of hazardous waste (broken glass, aerosol cans, pharmaceuticals, batteries, chemicals, etc.), using gloves, sanitizing hands, first aid and fire extinguisher availability, etc.!
- Provide useful logistic info - who is responsible for what; who clean where; how to package trash and recyclables; where and how to store filled bags; what is the arrangement about bulky waste (tyres, pieces of furniture, etc.); availability of drinking water, additional bags, gloves, etc.; whom to address in case of health hazards, unexpected situations - names and phones put on paper in advance to be carried in pocket).
- Identify the cleanup supervisors (teachers or NGO activists) and provide their cell phone numbers for quick access.

1.2.9 Conclude

At the end of the cleanup be sure to:

- Separate all the trash from recyclable materials (steel, aluminum, plastics, glass, etc.). Pay attention to materials that might need special handling and disposal (broken glass, pharmaceuticals, batteries, hazards, etc.), as well as bulky waste (tyres, pieces of furniture, etc.).
- Organize the identified commercial waste disposal service or volunteers with pickup trucks to haul all the materials and dispose it according to its type and specific regulation for disposal.

1.2.10 Assess your positive impact

- Track how many bags or tonnes of waste you collect, as well as the size of the surface area you cleaned.
- Take pictures of the cleanup area before and after the activity, as well as pictures of the participants working, piles of filled bags, trucks transporting away the trash, etc.
- Give some awards to the most active volunteers - these could be bought later from money raised from selling the recycling materials that were collected.
- Send information about the results of the event together with photos of volunteers to the media. Post it to your partners immediately after the event and encourage them to create their own while sharing the information pack prepared by you. Post information on your website. Post news on social media! Share the information with as many organisations and persons as you can!

1.2.11 Thank the participants

- Follow up with your collaborative partners and volunteers after the event to express your appreciation again for turning the cleanup into a success.
- Discuss the impact (the quantity of waste removed/recycled, watch photos/videos) and offer certificates for participation/of appreciation.
- If you have any civic leaders, local public authorities or reporters who attended the cleanup event, send a formal appreciation note with photos of your event and statistics about your cleanup impact. This is a great gesture that might be helpful in engaging them into future events. It may also be helpful to initiate a discussion about political action and measures on river and stream protection (e.g., development of a local environmental strategy, water and sanitation safety plan and/or plan of measures)!

1.3 Organize actions for combating erosion of the river banks

- Survey the status of river banks to identify negatively impacted sites for demonstrating restoration actions.
- Develop a list of practical restoration/rehabilitation measures aiming to reduce the risk of soil erosion and landslides while at the same time addressing issues of watershed management, soil fertility and biodiversity conservation.
- Implement pilot actions such as reforestation; seeding of grass and herbs; installation of small-scale anti-erosion structures - e.g., live willow fences.
- Promote your actions to allow it to be replicated. Write short stories, make short videos (30-40 seconds) and promote them via Facebook and Instagram, get to know about what you have done so other communities use your ideas too.

2. Model lesson plans and activities to be implemented during the project Clean-up days, Demonstration activities and Eco picnics for schools, NGOs and local governments

Lesson plan 1

Class: VI-VIII

Discipline: Science/Biology

Lesson theme: What is a spring, a stream and a river?

Type of lesson: Lesson-learning

Required general, social and civic competences:

Before organizing the lesson, it is important to check how many students and teachers will participate; what are the general physical and geographical characteristics of the locality; search about the sources of pollution and localize the existing authorized and unauthorized garbage dumping sites, landfills; availability of recreation areas and/or sites; status of wastewater treatment.

- Students and teachers will be informed briefly about the EU BSB Program, the purpose and objectives of CRoCuS project and the project partners implementing it.

- Students will learn the main characteristics of a flowing water body and to distinguish among a spring, a creek, a stream and a river. They will learn their flowing water body originates; the factors that determine its ecological status. Simple methods to monitor the ecological status of a river will be introduced to students. Other terms that would be introduced and explained could include: river bed, river terrace, river basin, catchment area, aquatic ecosystem, common EU standard for water quality, transboundary catchment and river, etc.

- Students will understand the impact of human activity on the rivers, catchments and basins; the importance of the conservation of aquatic resources and possible measures for the immediate reduction of pollution and preservation of aquatic ecosystems specific for their community.

- Students will be prepared for a trip to assess the ecological status of the river in their community, including to identify the sources of pollution.

Specific skills:

- Students and teachers will obtain information about the CRoCuS project and the opportunities to participate in activities and events that are yet to be implemented, as well as information about the BSB Program and opportunities to develop and submit their own projects for funding.
- Students will be trained to apply simple monitoring instruments to access the ecological status of the river in their community.
- Raising their awareness and knowledge, participants will be inspired to reduce their personal foot-print as consumers, to become promoters for reducing the pollution in their community and be able to act as informed participants in decision-making opportunities on ecological and environmental issues in their area of residence, including the reduction of pollution from household waste and bad agricultural practices.

Resources:

Methodological: information with demonstration, frontal conversation, discussions

Lesson sequences	The content of the didactic activity	Methodological resources	Evaluation
I. Organizational moment	Inform students and teachers about the BSB Program and CRoCuS project; describe their goals and objectives; share opportunities for them to take part in actions and events. Provide specific information about various types of flowing water bodies; identify the most significant natural and anthropogenic factors (through the local aspect).	frontal conversation	
II. Homework check	Ask some questions on the homework to the students to assess the level and quality of preliminary preparation they have done, their interest and motivation.		
III. Catching the attention	Students are informed about the field trip that will follow to expand their knowledge and be able to test the water from their local river and assess its ecological status.	frontal conversation	
IV. State the theme and objectives pursued	Under the guidance of the teacher, the students organise 2 lists: Flowing water bodies acknowledging the difference among springs, creeks, streams and rivers, in their community. Sources of pollution in the community - from industry, agriculture, recreation, households, landfills, illegal dumping. The teacher divides students into small working groups (up to 5 in one group), each group focusing on a specific sub-theme to develop a list of short answers to the following questions: How recreational activities may impact your local river? How sewage may impact your local river? How agrochemicals may impact your local river? How industry may impact your local river? How landfills may impact your local river? Students are supported by the teacher by "question-answer" explanations, and short answers "yes" or "no".	frontal conversation didactic game	
V. Directing the learning	Each group prepares a very brief presentation of their findings for the other students. The teacher summarizes the findings as a foundation to introduce the concept of water quality monitoring and control. Some examples of simplified water quality monitoring are demonstrated: identification of water temperature, colour, smell, transparency, nitrates and nitrites, mineralization through conductivity, pH.	didactic game common investigation method	small group work evaluation

VI. Providing feedback	For the next lesson, ask the students to make a list of all items and materials dumped as waste from an average home and yard from their community that may turn into a source of pollution of water bodies and drinking water sources.		verbal appreciation
VII. Formative evaluation	The teacher will appreciate the students' presentations.		verbal appreciation

Additional information to the first lesson.

The main source of water supply of a river are its spring and tributaries.

The spring is the point where groundwater comes out to the surface of the earth and emerges, sometimes just as a trickle, only after an incident rain or snowmelt, giving rise to flowing water in the form of a creek or a stream, and constitutes the origin of the hydrographic network.

The springs form creeks and streams; streams turn into tributaries to form the rivers.

A river is a stream with a low flow, which usually can be crossed easily; its flow usually increases during heavy rainfall or intensive melting usually.

A river is a (permanent) natural flowing watercourse, formed through joining of several streams, which flows downhill naturally, under the effect of gravity, and which flows either into another river or stream (as its tributary), or into a lake, a sea or the ocean.

A natural course of permanent or intermittent (periodic) water is called a river. Its water moves gravitationally from the source to the river mouth due to the difference in altitude. The river is with a length of not less than 10 km and a surface of the receiving basin of at least 50 km2. It is fed by atmospheric precipitation and groundwater and flows through a riverbed.

A river is that part of the natural valley through which the water of a stream flows without flooding the meadow.

The river is a dynamic system that undergoes certain changes over time. The nature of the rivers can change depending on the area crossed. Many rivers which spring from the mountains have a fast flow. From springs downstream, rivers gradually change their flow characteristics, riverbed configuration and water quality. In Europe, the longest rivers are the Volga and the Danube. In the major riverbed there are many lakes and ponds that have a permanent or temporary connection with the river. At discharge, due to the interaction between the salty water of the sea or the ocean with the freshwater of the river, a delta or estuary with brackish water could be formed.

Lesson plan 2

Field trip *(2 lessons of 45 minutes)*

Class: VI-VIII

Discipline: Science/Biology

Lesson topic: What is the ecological status of our community river?

Lesson type: Field trip/observation

General, social and civic competences:

Before organizing a field trip and field assessment, especially on the river banks, it is important that all participants be informed about safety rules on the river banks, in winter (on ice), during heavy rains and landslides.

Students will:

- Get information about river monitoring of the ecological status of rivers and lakes according to the requirements of the Water Framework Directive of the EU.
- Understand the causes and effects of stormwater pollution in general and surface runoff directly in their community;
- Determine where the stormwater drains in their locality to share information with the people of the community.

Specific competences:

- Students will determine the main sources of pollution in their community.
- Through the synthesis of materials, visualization and observation, students will establish the streams through which stormwater flows into the river in their community.
- Students will be able to create awareness-raising materials (a presentation, a leaflet, a social media post, a poster, etc.) to effectively educate community members about water pollution.

Resources:

Methodological: awareness-raising field trip, group work, frontal conversation

Lesson sequences	The content of the didactic activity	Methodological resources	Evaluation
I. Organizational moment	Explain to students about the purpose of the field trip observations. Give the definition of ecological status according to WFD and emphasis on the goal for achieving a good ecological status of European rivers. Provide definition for monitoring of rivers and its importance for improved management of freshwater locally, in Europe and the world.	frontal conversation	
II. Homework check	The teacher names some students who are asked to present the homework (information about the rivers which flow through their area).		

III. Catching the attention	The teacher presents a quote as the motto of the lesson on a river, which will serve to introduce the next moment of the instructive-educational process: e.g. Water is life!	frontal conversation	
IV. State the theme and objectives pursued	Go on a field exploration trip along your local river. As you walk, observe and discuss the features of the river basin. Determine the visible places where water drains when it rains. Follow the path that the water will take. Where does the water go? Does it flow through a stream system, reaching a lake or a river? Observe the stormwater catchment basin (e.g., pond, stream, wetland, etc.) if possible. Is the stormwater catchment basin clear or turbid? Is it cold or warm? Do you notice living organisms in the water? Do nearby plants look healthy or is there just bare, eroded soil? Do you notice the decomposition of algae and animal waste? What would happen when it is a light rain with summer breeze or when it is a heavy rain with strong wind? Perform simplified water quality monitoring in the field: identification of water temperature, colour, smell, transparency, nitrates and nitrites, mineralization through conductivity, pH. According to the results, access the ecological status of your local river.	frontal conversation	
V.Directing learning	Back in class, ask students to share their observations and summarise their findings on the ecological status of your local river; discuss the cause and effect of urban runoff on the river quality; emphasise on some very peculiar polluting practices for your area and discuss measures to restrict their negative influence on human health and the environment.	the didactic game	group evaluation
VI. Providing feedback	For homework, ask students to walk through their own neighbourhood and record their observations. You may want to assign specific comments for students to report, for example: ◊ Where does the stormwater flow from your garden or yard? ◊ List three sources of pollutants that you have observed in your vicinity. ◊ Have you noticed any water quality controls (for example, signs that do not	the method of collective investigation critical thinking individual work	verbal appreciation

	throw waste in drains, grass waves in wetlands, ponds, on the banks of streams, small rivers, etc.)? Or ask the students to make a poster calling on the population not to dump wastewater and waste into the environment, because they end up in rivers.		
VII. Formative evaluation	Under the guidance of the teacher, students will present orally what they observed.		verbal appreciation

Additional information to the lesson.

It is crucial for the society to use wisely and preserve the rivers as the main and most accessible freshwater resources on the Earth. Freshwater is a finite resource as essential to agriculture and industry as it is to basic human existence.

Water quality monitoring is a fundamental tool in the management of freshwater resources.

Monitoring is the programmed process of sampling, measurement and subsequent recording or signaling, or both, of various water characteristics, often with the aim of assessing conformity to specified objectives.

Monitoring is the long-term, standardised measurement and observation of the aquatic environment in order to define status and trends.

The definition of ecological status looks at the abundance of aquatic flora and fish fauna, the availability of nutrients, and aspects like salinity, temperature and pollution by chemical pollutants. Morphological features, such as quantity, water flow, water depths and structures of the river beds, are also taken into account.

Ecological status identifies the quality of the structure and functioning of surface water ecosystems. It shows the influence of pressures (e.g., pollution and habitat degradation) on the identified quality elements.

Ecological status is determined for each of the surface water bodies of rivers, lakes, transitional waters and coastal waters, based on biological quality elements and supported by physico-chemical and hydromorphological quality elements. The overall ecological status classification for a water body is determined, according to the 'one out, all out' principle, by the element with the worst status out of all the biological and supporting quality elements. More dashboards are available below the main dashboard.

The definition of ecological status looks at the abundance of aquatic flora and fish fauna, the availability of nutrients, and aspects like salinity, temperature and pollution by chemical pollutants. Morphological features, such as quantity, water flow, water depths and structures of the river beds, are also taken into account.

The EU Water Framework Directive classification scheme for surface water ecological status includes five categories: high, good, moderate, poor and bad. 'High status' means no or very low human pressure. 'Good status' means a 'slight' deviation from this condition, 'moderate status' means 'moderate' deviation, and so on.

The same river can contain different water bodies, since the status of the water may change.

To define good chemical status, environmental quality standards have been established for 33 new and eight previously regulated chemical pollutants of high concern across the EU.

Europe's water is under pressure. Recent figures show that 20% of surface water is at serious risk from pollution; 60% of European cities over-exploit their groundwater resources; 50% of wetlands are endangered. Demand for water is growing all the time.

Lesson plan 3

Class: IX-X

Discipline: Science/Civil education

Lesson theme: **Use and protection of or community river**

Type of lesson: An integrated lesson

Time: 2 lessons, 45 minutes each

General, social and civic competences:

Before organizing the lesson, it is important to check how many students and teachers will participate; what are the general physical and geographical characteristics of the locality; search about the sources of pollution and localize the existing authorized and unauthorized garbage dumping sites, landfills; availability of recreation areas and/or sites; status of wastewater treatment.

Students will:

- Receive general information about the rational use and protection of water resources; environmental impact of various types of water use.
- Study the quality of water resources and the sources of water pollution, as well as the consequences of anthropogenic impact on the hydrosphere.
- Recognise the importance of the impact of human activity for degradation and/or preservation of water resources and aquatic ecosystems.

Specific skills:

- Students will raise their awareness about pollution of water from industry, agriculture, recreation and households.
- Students will survey the effect of wastewater treatment facilities in their area.
- Raising their awareness and knowledge, participants will be inspired to reduce their personal foot-print as consumers, to become promoters for reducing the pollution in their community and stand for efficient and affordable wastewater treatment for their community and in their households.

Methodological Resources: Frontal conversation, discussions, presentation.

Materials: Handouts, booklets, posters, laptop, multimedia projector, presentations, educational film.

Procedures	The content of the didactic activity	Methodological resources	Evaluation
I. Organizational moment	The teacher explains to the students the theme and objectives of the lesson. S/he emphasises on urban pollution that deteriorates the quality of water in natural freshwater bodies.	frontal conversation	
II. Actualization of basic knowledge	The teacher presents to the students specific information on e.g.: Main sources of pollution of freshwater bodies. Hazardous pollutants (e.g., salts of heavy metals, etc.) that might enter the freshwater flows and would accumulate in the local reservoir. Characteristics of wastewater. Wastewater treatment technologies - conventional and alternative.	frontal conversation	verbal appreciation
III. Catching the attention	"Water is uniquely vulnerable to pollution. Known as a "universal solvent," water is able to dissolve more substances than any other liquid on earth. It's the reason we have Kool-Aid and brilliant blue waterfalls. It's also why water is so easily polluted. Toxic substances from farms, towns, and factories readily dissolve into and mix with it, causing water pollution." Melisa Denchak	frontal conversation	
IV. State the theme and objectives pursued	Activity is done in small groups, e.g.: Local authorities Tourist business Farmers Fishermen Water engineers Water scientists Lawyers Water protection activists Consumers	creative small group work	
V. Directing the learning	Each group - according to their prescribed role, organises a discussion and prepares a brief presentation on the priority issues and urgent measures to be taken for the improvement of water quality of the community river. Each group presents to the other the process of work and the conclusions they agreed on.	didactic game; common investigation method presentation	group scoring

VI. Providing feedback	Students answer questions e.g.: Can you personally prevent the negative impact on the environment having a picnic or vacation on the river bank? How my personal lifestyle influences the intensity of water consumption and pollution of natural water/ Is my personal consumer foot-print sustainable enough to protect the interest of future generations?	discussion	verbal appreciation
VII. Summary. Formative evaluation	The teacher evaluates the students' presentations.		verbal appreciation

Additional information to the lesson.

Since many industrial methods use fresh water for various purposes, industrial facilities must dispose of the toxic runoff from these methods. The runoff frequently flows into other fresh water sources, such as rivers, lakes and groundwater wells, which local residents use for drinking and bathing.

Water pollutants from industrial sources may include[51]:

- Lead – This is a metallic element and can cause health and environmental problems. It is a non-biodegradable substance so it is hard to clean up once the environment is contaminated. Lead is harmful to the health of many animals, including humans, as it can inhibit the action of bodily enzymes.
- Mercury – This is a metallic element and can cause health and environmental problems. It is a non-biodegradable substance so it is hard to clean up once the environment is contaminated. Mercury is also harmful to animal health as it can cause illness through mercury poisoning.
- Nitrates – The increased use of fertilisers means that nitrates are more often being washed from the soil and into rivers and lakes. This can cause eutrophication, which can be very problematic to marine environments.
- Phosphates – The increased use of fertilisers means that phosphates are more often being washed from the soil and into rivers and lakes. This can cause eutrophication, which can be very problematic to marine environments.
- Sulphur – This is a non-metallic substance that is harmful for marine life.
- Oils – Oil does not dissolve in water, instead it forms a thick layer on the water surface. This can stop marine plants receiving enough light for photosynthesis. It is also harmful for fish and marine birds.
- Petrochemicals – This is formed from gas or petrol and can be toxic to marine life.

[51] https://epicwaterfilters.co.uk/pages/industrial-pollutants, June 2021

Agricultural impacts on water quality[52]

Agricultural activity	Impacts	
	Surface water	*Groundwater*
Tillage/ploughing	**Sediment/turbidity**: sediments carry phosphorus and pesticides adsorbed to sediment particles; **siltation** of river beds and loss of habitat, spawning ground, etc.	
Fertilizing	Runoff of nutrients, especially phosphorus, leading to eutrophication causing taste and odour in public water supply, excess algae growth leading to deoxygenation of water and fish kills.	Leaching of nitrate to groundwater; excessive levels are a threat to public health.
Manure spreading	Carried out as a fertilizer activity; spreading on frozen ground results in high levels of contamination of receiving waters by pathogens, metals, phosphorus and nitrogen leading to eutrophication and potential contamination.	Contamination of ground-water, especially by nitrogen
Pesticides	Runoff of pesticides leads to contamination of surface water and biota; dysfunction of ecological system in surface waters by loss of top predators due to growth inhibition and reproductive failure; public health impacts from eating contaminated fish. Pesticides are carried as dust by wind over very long distances and contaminate aquatic systems 1000s of miles away (e.g., tropical/subtropical pesticides found in Arctic mammals).	Some pesticides may leach into groundwater causing human health problems from contaminated wells.
Feedlots/animal corrals	Contamination of surface water with many pathogens (bacteria, viruses, etc.) leading to chronic public health problems. Also contamination by metals contained in urine and faeces.	Potential leaching of nitrogen, metals, etc. to groundwater.
Irrigation	Runoff of salts leading to salinization of surface waters; runoff of fertilizers and pesticides to surface waters with ecological damage, bioaccumulation in edible fish species, etc. High levels of trace elements such as selenium can occur with serious ecological damage and potential human health impacts.	Enrichment of groundwater with salts, nutrients (especially nitrate).

[52] *Ongley, Edwin D. Control of water pollution from agriculture - FAO irrigation and drainage paper 55, Food and Agriculture Organization of the United Nations. Rome, 1996*

Clear cutting	Erosion of land, leading to high levels of turbidity in rivers, siltation of bottom habitat, etc. Disruption and change of hydrologic regime, often with loss of perennial streams; causes public health problems due to loss of potable water.	Disruption of hydrologic regime, often with increased surface runoff and decreased groundwater recharge; affects surface water by decreasing flow in dry periods and concentrating nutrients and contaminants in surface water.
Silviculture	Broad range of effects: pesticide runoff and contamination of surface water and fish; erosion and sedimentation problems.	
Aquaculture	Release of pesticides, e.g., Tributyltin (TBT), and high levels of nutrients to surface water and groundwater through feed and faeces, leading to serious eutrophication.	

Before raw sewage can be safely released back into the environment, it needs to be treated correctly in a water treatment plant. In a water treatment plant, sewage goes through a number of chambers and chemical processes to reduce the amount and toxicity of the waste.

- The sewage first goes through a primary phase. This is where some of the suspended, solid particles and inorganic material is removed by the use of filters.
- The secondary phase of the treatment involves the reduction of organic, this is done with the use of biological filters and processes that naturally degrade the organic waste material.
- The final stage of treatment is the tertiary phase; this stage must be done before the water can be reused. Almost all solid particles are removed from the water and chemical additives are supplied to get rid of any left-over impurities.

The most popular types of recreational activities on the river banks and lakes include swimming, fishing, sailing, row boating, motor boating, water sports, camping, etc.

Lesson plan 4

Class: III-V

Discipline: Nature

Lesson theme: How to keep rivers and lakes clean

Type of lesson: Learning

General, social and civic competences: Sense of self-responsibility for the world around us

- Pupils will raise their awareness about the river water pollution and protection.
- Pupils will study the water resources of their country, sources of water pollution; consequences of anthropogenic impact on the hydrosphere; will build a sense of self-responsibility for the world around us.
- Pupils will be motivated to follow responsible behavior towards nature and the environment; will foster a sense of responsibility for the preservation of rivers and nature.

Specific skills:

- Pupils will be informed about the urgent problems of pollution in their community and region.
- Pupils will survey some environmental issues in their community.
- By studying the publication materials that will be disseminated among them by the teacher, the pupils will become promoters for reduction of pollution in their community.

Methodological Resources:

Frontal conversation, discussions, projects, didactic game, presentation, common investigation method.

Materials: drawings "influence of river littering on flora and fauna", handouts, posters, pictures, photos, geometric shapes (for dividing pupils into small groups).

Procedures	The content of the didactic activity	Methodological resources	Evaluation
I. Organizational moment	The teacher presents the theme and objectives of the lesson to the pupils.	frontal conversation	
II. Actualization of basic knowledge	The teacher asks the pupils: *What do you associate with the word river?* *What kinds of water pollutants do you know?* *What shall one do if there are problems with littered areas?*	discussion	verbal appreciation
III. Catching the attention	*How long does it take for the waste to decompose?*	frontal conversation	verbal appreciation

IV. State the theme and objectives pursued	This role game is done in small groups (G), e.g.: **G1: Explorers** **G2: Environmental activists** **G3: Artists** **G4: Wizards**	creative small group work	
V. Directing the learning	After a discussion, each group prepares brief presentation on their assigned group topic: **G 1: Where does river litter originate from?** **G 2: The best methods to prevent river littering.** **G 3: Illustrate good/bad behaviour of visitors along the rivers and lakes.** **G 4: Create a collage "Save the river!"**	didactic game; common investigation method; presentation	
VI. Providing feedback	Students answer the question: *What behavior would you follow having a picnic on the river bank with your family?*	discussion;	verbal appreciation
VII. Summary. Formative evaluation	The teacher makes the summary of the lesson		verbal appreciation

Additional information to the lesson

Sources of river water pollution:

Wastewater: Pollution of reservoirs with sewage with various harmful impurities of inorganic (acids, alkalis, mineral salts) and organic (oil and oil products, detergents, pesticides, etc.) composition. In addition, various microorganisms, fungal spores, helminth eggs, many of which are pathogenic for humans, animals and plants, enter the rivers with wastewater.

Farms: Pollution with large amounts of chemical fertilizers, pesticides, herbicides, insecticides and organic waste, which are washed out and get into surface and ground waters, as well as pollution from large livestock farms.

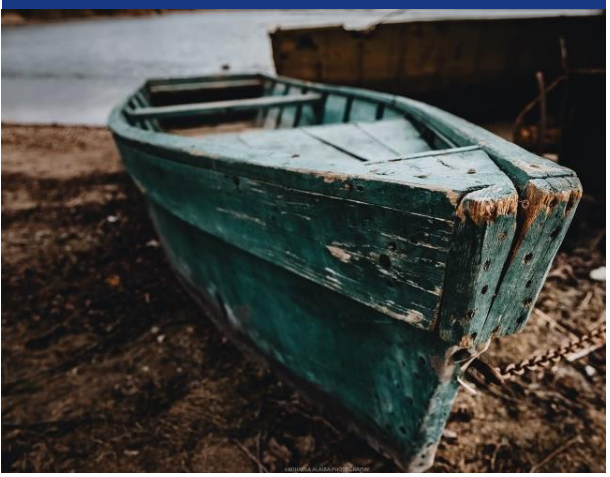
Industrial waste: The main water pollutants include chemicals and wastewater. Oil leaks prevent gas exchange between water and the atmosphere and reduces the oxygen content of water. Fuel oil clots settle to the bottom, kill microorganisms that are involved in the process of self-purification of water.

Solid waste: Water pollution occurs as a result of the accumulation of insoluble impurities in it - plastic bottles, bags, clay, silt, which is washed off with rainwater from plowed areas (fields). Siltation of rivers occurs as a result of plowing floodplains and cutting down forest belts. Particulates reduce the clarity of water, inhibit the development of aquatic plants, clog the gills of fish and other aquatic animals, impair the taste of water, and sometimes make it completely unusable.

Thermal pollution: It occurs as a result of the release of heated water from thermal power plants, nuclear power plants and other energy facilities into reservoirs. Warm water changes the thermal and biological regimes of water bodies and adversely affects their inhabitants. Water heated to the temperature of 26-30°C, suppresses fish and other inhabitants of reservoirs, and if the water temperature rises to 36°C, the fish dies.

Atmospheric pollution: The presence of ash, soot and various gases in the air, with precipitation fall into the rivers.

Source: thebalancesmb.com



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The Title of the Programme
Joint Operational Programme Black Sea Basin 2014-2020
www.blacksea-cbc.net

The Editor of the Material
Earth Forever Association and WiSDOM Association

Date of Publishing: June 2021

Joint Operational Programme Black Sea Basin 2014-2020 is co-financed by the European Union through the European Neighbourhood Instrument and by the participating countries: Armenia, Bulgaria, Georgia, Greece, Republic of Moldova, Romania, Turkey and Ukraine.

This publication was produced with the financial assistance of the European Union. Its contents are the sole responsibility of CRoCuS Project and do not necessarily reflect the views of the European Union.