



# NO MICROPLASTICS, JUST WAVES.

## BEST PRACTICES REPORT ACTION A2



BENEFICIARIO COORDINATORE



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## 1. Introduction (general context and finalities)

Plastic debris is a growing pollutant in worldwide environments. Due to the material properties, plastics hardly decompose and thus remain for a long time in the environment. Exposure to environmental conditions alters the material and slowly forms plastic debris with a large range of sizes, from meter to micrometer range. This last typology of debris of minuscule dimensions, which is commonly defined microplastics if its size is than 5 mm, is constantly increasing in aquatic and terrestrial ecosystem and it can cause several harmful physical effects on living organisms through such mechanisms as entanglement and ingestion. It was also observed that hotspots of microplastics can significantly reduce the number of certain animals vital to the ecosystems at the bottom of lakes, ponds and canals<sup>1</sup>.

In order to contrast this phenomenon of increasing plastic debris presence in natural landscapes and particularly in seawater and freshwater ecosystems, several projects have been implemented at national and international level and various strategies have been put in place to define possible and effective solutions on the topic of plastic reduction. The main objective of this study is to specifically analyze the main relevant best practices and lessons learnt through these projects, in order to collect useful references and operative and technical suggestions for the definition of a successful management strategy to contrast the increasing presence of microplastics in lakes.

The best practices collected were subdivided into three main categories:

1. monitoring techniques and data collection;
2. awareness activities and citizen science;
3. initiative to boost governance capacity.

The first category includes experiences gained from monitoring studies and campaigns specifically focused on microplastic collection, analysis and identification. These studies provide useful information on operative aspects that it is important to take into account when dealing with microplastic, stressing on the importance to implement a standardized monitoring procedure.

The second group of best practices refers to different ways used to communicate the issue of plastic pollution to stakeholders and target groups and it includes the best strategies put in place to involve these categories in order to increase their perception and awareness on this topic. Finally, the third category of best practices refers to initiative implemented at national and international level to involve administrators and municipal authorities, identifying the possible political processes and agreements to be realized in order to manage ecological issues as plastic pollution.

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<sup>1</sup> Paula E. Redondo-Hasselerharm, Dede Falahudin, Edwin T. H. M. Peeters and Albert A. Koelmans, 2018. Microplastic Effect Thresholds for Freshwater Benthic Macroinvertebrates. Environmental Science and Technology

The research constitutes a specific activity realized under the purpose of the LIFE Project Blue Lakes, an international project co-financed by the European Commission through the LIFE Programme and PlasticsEurope, which intends to specifically address the problem of microplastic in lakes through a set of governance, training, information and awareness actions, addressed to institutions, relevant stakeholders and citizens.

## 2. Legal Framework

A broad and systematic approach at European Union level to address the issue of plastics - including microplastics – in the environment came with the adoption in 2013 of the Commission's Green Paper on a European Strategy on Plastic Waste in the Environment. This fed into the development of the Circular Economy Package (2015) with the target to reduce marine litter by 30 % by 2020 and proposals for revision of the waste legislation.

In response to the threats posed by plastic pollution, in December 2015, the Commission adopted an EU Action Plan for a circular economy. There, plastics is identified as a key priority and the Commission committed itself to “prepare a strategy addressing the challenges posed by plastics throughout the value chain and taking into account their entire lifecycle”.

In 2017, the Commission confirmed it would focus on plastics production and use and work towards the goal of ensuring that all plastic packaging is recyclable by 2030<sup>2</sup>. This strategy lays the foundations to a new plastics economy, where the design and production of plastics and plastic products fully respect reuse, repair and recycling needs and more sustainable materials are developed and promoted. By pursuing these aims, the strategy will also help achieve the priority set by this Commission for an Energy Union with a modern, low-carbon, resource and energy-efficient economy and will make a tangible contribution to reaching the 2030 Sustainable Development Goals and the Paris Agreement<sup>3</sup>.

Plastic pollution was also identified as one of the main pressures on healthy oceans at the international “Our Ocean Conference”, hosted by the EU in October 2017. A resolution on marine litter and microplastics was adopted at the United Nation Environment Assembly in December 2017<sup>4</sup>.

<sup>2</sup> Commission Work Programme 2018 - COM (2017) 650

<sup>3</sup> A European Strategy for Plastics in a Circular Economy see:  
[https://eur-lex.europa.eu/resource.html?uri=cellar:2df5d1d2-fac7-11e7-b8f5-01aa75ed71a1.0001.02/DOC\\_1&format=PDF](https://eur-lex.europa.eu/resource.html?uri=cellar:2df5d1d2-fac7-11e7-b8f5-01aa75ed71a1.0001.02/DOC_1&format=PDF)

<sup>4</sup> UNEP/EA.3/L.20 see: <https://papersmart.unon.org/resolution/uploads/k1709154.docx>

In January 2018, the European Commission launched its European Strategy for Plastics in a Circular Economy. The strategy is part of Europe's transition towards a circular economy aimed at contributing to reach the Sustainable Development Goals, the global climate commitments and the EU's industrial policy objectives. Considering plastics from a circular economy perspective, the Strategy proposes actions at EU level to enhance the reusability and recyclability of plastics, improve waste management and support innovation – such as improved eco-design.

The EU Strategy for Plastics in a Circular Economy asks for innovative solutions to prevent microplastics from reaching the seas. Their origin, routes of travel, and effects on human health should be better understood, and industry and public authorities shall work together to prevent them from ending up in oceans air, drinking water or on our plates<sup>5</sup>.

Microplastics intentionally added to products represent a relatively small proportion of all those in the sea. However, since they are relatively easy to prevent and in response to public concern, several countries have already taken action to restrict their use, while the cosmetic industry has also taken voluntary action. With a report published in late January 2019 The European Chemicals Agency presented a proposal, to the European Commission for the reduction of microplastics intentionally added in cosmetics and other products. According to several studies, plastic microgranules specifically added in the body exfoliants are more likely to accumulate in terrestrial and aquatic environments, that's why the Agency urged the European Community to reduce their presence on the market by 2020 and to report their presence to consumers through specific labels.

Bans are under consideration or planned in several Member States and this may lead to fragmentation in the single market. In line with the REACH procedures for restricting substances that pose a risk to the environment or health, the Commission has started the process to restrict the use of intentionally added microplastics, by requesting the European Chemicals. However, for unintentional releases of microplastics (such as from the abrasion of tires or washing clothes), more has to be done.

In September 2018, the European Parliament called on the European Commission to introduce an EU-wide ban on intentionally added microplastics in products such as cosmetics and detergents by 2020, and to take measures to minimize the release of microplastics from textiles, tyres, paint and cigarette butts.

Up to now, only several EU countries have started banning microplastics including France (ban on sale, manufacture and import of rinse-off products); Ireland (ban on microbeads in rinse-off cosmetics); Italy (ban on microbeads in rinse-off cosmetics); Netherlands (ban on import, manufacture and sale of microbeads in rinse-off cosmetics); Sweden (ban on import, manufacture and sale of microbeads in rinse-off cosmetics); and United Kingdom (ban on the use of microbeads in rinse-off cosmetics and personal care products).

<sup>5</sup> A European Strategy for Plastics in a Circular Economy

In Italy, the ban of marketing of rinse-off cosmetics containing microplastics, entered into force starting from 1 January 2020. The ban was introduced by the Italian legislator with the 2018 budget law, n. 205 of December 27, 2017.

On 6 November 2019, the German Federal Ministry for the Environment (BMU) has presented a draft law to ban disposable plastic bags with a wall thickness of less than 50 micrometers. Following the cabinet decision, the parliamentary procedure is now being initiated. Parallel to this, the so-called notification of the draft to the European Commission has already been initiated. The ban is to come into force six months after the announcement of the law<sup>6</sup>.

On 26 November 2018, the "5-point plan of the German Federal Ministry for the Environment for less plastic and more recycling" has been published, according to which alliances will be forged with manufacturers to avoid unnecessary packaging<sup>7</sup>.

In order to end the use of microplastics in cosmetic products, the German Federal Ministry for the Environment (BMU) has established the so-called Cosmetics Dialogue in 2013 and reached a voluntary agreement with the cosmetics industry. By 2017, microplastics in products such as toothpaste and shower gel had already decreased by 97 percent and were thus practically non-existent. The BMU is campaigning at EU level for a complete ban on microplastics in cosmetic products. At the request of the European Commission, the European Chemicals Agency has now published a draft for a comprehensive ban on microplastics in March 2019<sup>8</sup>.

<sup>6</sup> <https://www.bmu.de/gesetz/gesetzentwurf-eines-ersten-gesetzes-zur-aenderung-des-verpackungsgesetzes/>

<sup>7</sup> <https://www.bmu.de/download/5-punkte-plan-des-bundesumweltministeriums-fuer-weniger-plastik-und-mehr-recycling/>

<sup>8</sup> <https://www.bmu.de/wenigeristmehr/unsere-politik-fuer-weniger-plastikmuell/>

### 3. Best Practices (national and international level) on the topic of plastic reduction in lakes, rivers and seas

#### 3.1 Monitoring techniques and data collection

TITLE	Monitoring of microplastics in the Tagliamento River
Typology of good practice	Monitoring techniques in freshwater ecosystems
Coordinating Institution	Regional Environmental Protection Agency of Friuli Venezia Giulia (ARPA FVG)
Funded through	N.A.
Study area	Tagliamento River, Italy
<b>Description</b>  <p>The Agency ARPA FVG carried out a monitoring campaign using a method similar to that developed in the Marine Strategy (module 2).</p> <p>The Tagliamento river was chosen as it is characterized by "calm" waters and because most of the trunks, which could have broken the manta net, are blocked by a fixed barrier in the municipality of Latisana.</p> <p>Sampling was carried out using a "manta net" for 20 minutes at a speed of 3 knots.</p> <p>It was carried out at low tide and in freshwater not coming from the sea (it was checked with the probe before putting the manta net into the water).</p> <p>Then in the laboratory the microplastics were sorted and surveyed according to shape and color as recommended in the Marine Strategy protocol.</p>	
<b>Interest for Blue Lake Project purposes</b>  <p>Actions B.2 Monitoring protocol: Pilot on Trasimeno and Bracciano Lakes, C.1 Monitoring of project impact, C.1.2 Staff of the Regional Environmental Protection Agencies (ARPA)</p>	
<b>Reference</b>  <p><a href="http://www.arpa.fvg.it">www.arpa.fvg.it</a></p>	

TITLE	Plastics in Freshwater Environments: from monitoring to management options – how can we get there?
Typology of good practice	State of play
Coordinating Institution	German Environment Agency (UBA), Berlin (Lilian Busse)

<b>Funded through</b>	N.A.
<b>Study area</b>	Europe
<b>Description</b>	
<p>First results were reported in 2012 (Faure, 2012) and since then several rivers and lakes have been investigated in eleven European countries (UBA, 2016). Monitoring efforts of plastics in freshwater environments were given less attention. Most of the available data on the occurrence of freshwater plastic pollution is from Central Europe and Scandinavia whereas data are largely missing for Southern and Eastern Europe. In general, monitoring studies focused more on microplastics, and less data are present for meso- and macroplastic particles. There are no temporal trends available on plastics in freshwater environments. Samples from environmental specimen banks may be an option for retrospective trend analysis. In addition to the lack of monitoring data, the data that are available are often not comparable because a standardization is missing in collecting, processing, analyzing and reporting of plastic particles of different sizes in environmental samples. At the moment, funding agencies are reluctant to support further investigations until harmonized approaches are available.</p> <p>All macroplastic and all primary microplastics are produced onshore while fragmentation from larger to smaller secondary plastic particles may occur in all environmental compartments. It is estimated that up to 80 % of the plastic waste found in the marine environment originated from land sources (UNEP, 2005). Plastic waste inputs from coastal areas into the oceans were estimated to be close to 9.1 million metric tons in 2015 (Jambeck, 2015). The authors of the EU study 'Identification and Assessment of Riverine Input of (Marine) Litter' anticipate that in the absence of mitigation measures, any region with large rivers can be considered to substantially contribute to marine pollution (van der Wal, 2015). This assumption can be extended to lakes and sediment beds, as they are also sinks of riverine pollution. It is therefore surprising that only very few spatial and temporal data are available for micro-, meso- and macroplastics in freshwater environments and that only very little is known about the riverine input into the marine compartment.</p>	
<b>Interest for Blue Lake Project purposes</b>	
<p>To summarize the monitoring situation for micro-, meso- and macroplastics in European rivers and lakes:</p> <ul style="list-style-type: none"> <li>- data quality is ambiguous since standards are missing for sampling, processing and analysis,</li> <li>- consistent spatial data from representative sampling sites and temporal trends are missing,</li> <li>- monitoring is mostly directed at microplastics, meso- and macroparticles are often ignored,</li> <li>- very little is known on the effects of microplastics in freshwater organisms and no data are available for meso- and macroplastics,</li> <li>- scale and size distribution of plastic riverine input is largely unknown.</li> </ul> <p><b>UBA MEASURE RECOMMENDATIONS</b></p>	

- The establishment of standardized monitoring methods and an impact-related basis for assessment for plastics in inland waters;
- The establishment of a monitoring procedure to account for large watercourses (e. g. Rhine/Danube);
- The improvement of the data situation through joint activities of the Working Group of the Federal States and the Federal Government on Water Issues (LAWA), soil protection (LABO), waste (LAGA), the Federal States and the Federal Government Working Group on Waste water as well as the Federal Committee for Air Pollution Control (LAI).

#### Reference

<https://www.umweltbundesamt.de/en/publikationen/plastics-in-the-environment>

TITLE	Monitoring activities for plastics in rivers and lakes in Germany
Typology of good practice	Current monitoring activities
Coordinating Institution	Bavarian Environment Agency (LfU), Wielenbach German Environment Agency (UBA), Berlin
Funded through	N.A.
Study area	1 - Bavaria, 2 - Baden Wurttemberg , 3 - Rhineland-Palatinate, 4 - Hesse, 5 - North Rhine-Westphalia
<b>Description</b>	
<p>In June 2014, the Bavarian Environment Agency organized a first national workshop on microplastics in freshwater environments (Augsburg, June 2014). At the end of the conference a memorandum captured the state of knowledge:</p> <ul style="list-style-type: none"> <li>- Accumulation of microplastic in the marine ecosystem has been demonstrated.</li> <li>- Accumulation of microplastic in rivers and lakes is indicated by few investigations and has to be accepted as a nationwide phenomenon.</li> <li>- There are no standardized analytical methods. Therefore, the results of the current studies are not mutually comparable.</li> <li>- Microplastics are taken up by organisms - very little is known about their effects.</li> </ul> <p>Media reports on microplastic in food are not considered to be scientifically reliable. Since then, projects have started at different scales in Bavaria, Baden-Wurttemberg, Hesse, Rhineland- Palatinate and North Rhine-Westphalia. In March 2016, the German Environment Agency and the Bavarian Environment Agency organized a formal discussion on the level of the Federal Government and federal states on plastics in freshwater environments to discuss the newest state of knowledge. The agenda covered discussions on the analytical methods and first analytical data provided by the federal states, the future coordination and harmonization of different federal activities, the identification of knowledge gaps, and the possibilities for cooperation. In preparation of the workshop, a questionnaire</p>	

on research and water management activities related to plastics in rivers and lakes was sent to all federal states. The results of the survey are summarized below. Furthermore, an overview on the current monitoring activities for microplastic performed by the federal states will be given.

### Interest for Blue Lake Project purposes

Five federal states in Germany have initialized monitoring programs to assess the microplastic load of inland water systems: Bavaria, Baden-Wurttemberg, North Rhine-Westphalia, Rhineland-Palatinate and Hesse. Even if the individual projects might have different regimes, the main requirements are given to compare the study results. The most important conformities of the studies refer to the methods applied. The Department of Animal Ecology I, University of Bayreuth, is the contract partner for all five state monitoring programs and performs the environmental sampling, preparation of samples as well as microplastic analysis by means of FTIR-Spectroscopy. All monitoring programs include the investigation of rivers while two states, Bavaria and Baden-Wurttemberg, also monitor microplastics in lakes.

### Reference

To see European Conference on Plastics in Freshwater Environments Abstracts:  
[https://www.umweltbundesamt.de/sites/default/files/medien/1968/dokumente/abstracts\\_plastic2016\\_final.pdf](https://www.umweltbundesamt.de/sites/default/files/medien/1968/dokumente/abstracts_plastic2016_final.pdf)

TITLE	Overview on plastics in European freshwater environments – Results of a survey
Typology of good practice	State of play
Coordinating Institution	German Environment Agency
Funded through	The survey was performed in a project funded by the German Environment Agency (project number: 3715 22 20 20).
Study area	Europe
Description	
<p>In order to prepare an overview on monitoring and effect studies as well as on risk perception and management options referring to plastics in European freshwaters, a survey on the current status of European activities was conducted. The questionnaire, consisting of overall 11 questions, was sent to the representatives of the European countries in the Strategic Coordination Group (SCG). The SCG coordinates and gives advice to the Common Implementation Strategy (CIS) of the European Water Framework Directive. The questionnaire comprised ten content questions of which the first seven related to monitoring studies, riverine loads and riverine inputs into the marine compartment, main sources and</p>	

pathways of plastics, and effect studies. Questions 8 to 10 referred to the issues of risk perception and management options.

### Completed monitoring studies on plastics in freshwater environments

Completed studies were reported by the survey participants of **Austria** (River Danube), **Belgium** (River Leie), **Germany** (River Rhine and four tributaries, River Weser), and the **Netherlands** (River Rhine estuaries) (Hohenblum et al. (2015), Craenenbroeck et al. (2014), Laforsch (2015), Leslie et al. (2013). In addition, the Netherlands survey participant referred to various transboundary monitoring studies including Netherlands freshwaters like the Rivers Rhine and Meuse and the Lake IJssel (Mani et al. (2015), Urgert (2015), Brandsma et al. (2015)). A study by van der Wal et al. (2014) covered rivers in the **Netherlands** (Rhine), **Italy** (Po), **Romania** (Danube) and **Sweden** Dalälven).

In **Finland** monitoring of litter in freshwaters was performed in a citizen science project.

### Ongoing and planned monitoring studies on plastics in freshwater environments

Beyond the already conducted studies, several further monitoring programs on plastics in freshwater environments are ongoing, currently scheduled or under discussion. 57 % of the survey participants, who represented **Austria, Belgium, Denmark, Germany, Lithuania, Luxembourg, the Netherlands and Portugal**, stated further plans for monitoring studies.

### Interest for Blue Lake Project purposes

There are needs for harmonization and further investigations particularly with regard to the following issues:

- So far, a generally accepted definition of the lower boundary of the particle size is missing for microplastics. Therefore, the size range of particles, on which the various monitoring studies on freshwater refer, is quite different particularly depending on the lower limit of sampling and analytical methods.
- To enable the comparison of monitoring data standardized methods for sampling, sample treatment and particle identification have to be developed. Since especially the smallest micro- plastic particles are suspected to be of special interest in studies on organisms it is important to be capable of gathering and detecting particles much smaller than 300 µm.
- The completed and ongoing monitoring studies on rivers and lakes cover only a part of the European countries. Occurrence and loads of plastics in numerous freshwaters, among them major rivers probably contributing to relevant inputs into the connecting seas, have not been investigated so far.
- Furthermore, knowledge of accumulation, sources, sinks and environmental impacts of micro-, meso- and macroplastics in freshwater environments is currently limited. Further investigations are required to evaluate the potential physical and chemical impacts.

### Reference

To see European Conference on Plastics in Freshwater Environments Abstracts:

[https://www.umweltbundesamt.de/sites/default/files/medien/1968/dokumente/abstracts\\_plastic2016\\_final.pdf](https://www.umweltbundesamt.de/sites/default/files/medien/1968/dokumente/abstracts_plastic2016_final.pdf)

TITLE	<b>Microplastics: Development of an environmental assessment concept - First considerations on the relevance of synthetic polymers in the environment (in German)</b>
Typology of good practice	Monitoring techniques for microplastics in the environment
Coordinating Institution	German Federal Environment Agency in cooperation with Technical University Berlin
Funded through	German Federal Environment Agency April 2016
Study area	Germany
<b>Description</b>	
<p>Plastics are important raw materials and our daily life without plastic products in both households and the economy is barely imaginable. Due to their versatility, the amount of plastics used in various sectors and the total demand for plastics is constantly rising. There are certain properties like a high resistance towards physical and chemical effects and a low degradability that lead to plastics being a superior raw material compared to their predecessors. On the other hand, these properties lead to various disadvantages: the low degradability also affects plastics that were disposed improperly or got into the environment by mistake. Hence, the existence of plastics in coastal waters can be traced back to the early 1960s. This exceptional resistance leads to plastics in the environment that may remain for centuries. However, plastics are slowly degraded by physical, chemical and microbial processes. This effect leads to a multitude of small plastic fragments - so called microplastics (MP).</p> <p>MPs have been detected in various media like aquatic (both salt and fresh water) and terrestrial ecosystems as well as biota. In addition to that, some daily care products contain MP, which then enter the wastewater cycle and may reach rivers and other receiving waters. This seemingly careless use of MP, paired with the knowledge about the existence of MP in our environment and the potential of a MP accumulation in the food chain provoked a significant media attention in the previous months. However, neither the MP input nor the fate and behavior of MP have been fully analyzed. Furthermore, there is no information about a scientific paper dealing with the ecological assessment or the determination of the environmental impact of MP.</p> <p>The absences of scientifically reliable statements lead to the first part of this report: a comprehensive overview of scientific papers dealing with MP inputs, MP sources and MP induced effects in aquatic ecosystems. In addition to that, varying sampling techniques, sample preparations and the subsequent MP detection procedures are analyzed and their ability to provide reliable results is discussed.</p> <p>Until now, there is no standardized procedure that determines the ecological effects of MP. This report also focuses on a possible transferability of reliable procedures used for different</p>	

materials and the emerging additional conditions that have to be fulfilled when working with MP.

The exemplary derivation of assessment values for a municipal wastewater treatment plant and the aquatic ecosystem is set up using harmonized data from various case studies. First of all, studies analyzing the MP content of several German rivers and lakes are used for the aquatic assessment values. Second, a study analyzing the MP input of municipal wastewater treatment plants in northern Germany leads to the wastewater assessment. Without a classification scheme, assessments have little value. Therefore, a guideline dealing with the classification and the interpretation of MP sample values is derived. Furthermore, assessment values are directly related to legal frameworks. The admission of MP in these frameworks is discussed with respect to national and international requirements. One pillar of the EU's Water Framework Directive is to take precautionary measures to prevent possible environmental damages. Based on this principle, the report closes with proposals to limit the MP input.

### Interest for Blue Lake Project purposes

In this paper a comprehensive literature review on (potential) environmental inputs, occurrence and effects of MP in the aquatic environment is given. In addition, current investigation methods of sampling, sample preparation and analysis are considered, critically discussed and open questions are identified. Ecotest procedures for the determination of potential MP effects are reviewed with regard to methodology and transferability. In this context, the limnic range and MP inputs via the discharge of municipal sewage treatment plants are particularly considered. A first preliminary proposal for assessment values for MP in surface waters and in the effluents of municipal sewage treatment plants in Germany will be derived. Finally, an action guideline for the interpretation and classification of findings of MP in the environment is presented, a possible integration of the MP issue into existing legal systems is discussed and proposals for mitigation measures are made.

### Reference

<https://www.umweltbundesamt.de/en/publikationen/mikroplastik-entwicklung-eines>

TITLE	<b>Microplastics of Textile Origin – A Holistic Approach: Optimised Processes and Materials, Material Flows and Environmental Behaviour (TextileMission)</b>
<b>Typology of good practice</b>	Plastics in the Environment – Sources, Sinks, Solutions
<b>Coordinating Institution</b>	Bundesverband der Deutschen Sportartikel-Industrie (BSI) e.V.
<b>Funded through</b>	Bundesministerium für Bildung und Forschung / German Federal Ministry of Education and Research (BMBF) Grant Number 13NKE010A-E Duration: September 1, 2017 – August 31, 2020

<b>Study area</b>	Germany
<b>Description</b>	
<p>TextileMission – An Initiative against Microplastics from Textiles - Plastics in the Environment – Sources, Sinks, Solutions</p> <p>Textiles made of synthetic fibers such as polyester can lose tiny particles during production and washing, which enter rivers, lakes and seas via wastewater and might accumulate in the food chain. Fleece materials used for functional clothing are of particular concern. Synthetic fiber particles with a diameter of less than 5 millimeters are only partially filtered out by modern wastewater treatment plants. The partners of the joint research project TextileMission have taken on the task of reducing this environmental impact.</p>	
<b>Interest for Blue Lake Project purposes</b>	
<p><b>Improving Processes and Wastewater Treatment</b></p> <p>Current studies assume that 250,000 microplastic particles are washed out of a garment during laundry. For 100,000 fleece jackets, this corresponds to the amount of 11,900 plastic bags per year. The project partners of TextileMission are taking a multidisciplinary approach to this important entry point of microplastics into the environment: On the one hand, through research into textiles and improved production processes, they intend to develop fleece materials that release significantly fewer microplastic fibers than today. The textile research partners and the sportswear manufacturers involved are also testing bioplastics as an environmentally friendly alternative. On the other hand, the project participants are investigating the fate of microplastic fibers in the environment. To this end, they are examining material flows and developing wastewater treatment technologies for more effective removal of microplastics from wastewater. Such processes could also help to reduce the input of microparticles from non-textile sources.</p> <p><b>Determining the Status Quo</b></p> <p>First, the researchers systematically collect data in laundry washing tests to determine the volumes of microplastic particles washed out of various textiles. In addition, textiles available on the market and fleece garments newly developed by the project partners – including textiles made of bioplastics – are separated into different washes according to composition and colour. These are then laundered several times with equal temperature, duration and revolutions. Researchers collect the emitted microplastic particles in special filters and determine their number and size. The laundry washing tests are intended to identify materials, processing and finishing methods that release as little microplastic particles as possible. The technical factors of household laundry should be optimized in such a way that significantly fewer microplastic is released from the fabrics.</p> <p>In order to learn more about the material flows, the research partners are following the course of microparticles released into the environment; their retention and persistence is investigated at different purification stages of a laboratory wastewater treatment plant. This</p>	

provides important information for enhancing wastewater treatment processes. The research partners then determine the short- and long-term effects of non-retaining synthetic and biopolymer fibers on aquatic organisms. In addition, they are testing the biological degradation of fleece made of bioplastics under various (environmental) conditions. These findings are incorporated into the development of new materials.

### Strengthen Germany as a Production Location

The results of the joint research project TextileMission could contribute to strengthening Germany as a location for the development and manufacture of environmentally friendly products in various sectors: sports goods industry, household appliances and washing detergents as well as water technology. Furthermore, operators of wastewater treatment plants receive detailed knowledge about the retention of synthetic and biopolymer fibers in their facilities and thus indications for the further development of treatment technologies.

### Reference

[www.textilemission.bsi-sport.de](http://www.textilemission.bsi-sport.de)

TITLE	Microplastics and synthetic polymers in cosmetic products and detergents and cleaning agents (in German)
Typology of good practice	Microplastics and synthetic polymers in cosmetic products and detergents and cleaning agents
Coordinating Institution	Fraunhofer Institute for Environmental, Safety, and Energy Technology UMSICHT, Germany
Funded through	NABU Naturschutzbund Deutschland e.V. - Berlin
Study area	Germany
Description	
<p>Fraunhofer UMSICHT has compiled the current state of knowledge on micro- and macroplastics in the "Microplastic Consortium Study". September 2018.</p> <p>The study focuses on polymeric ingredients in cosmetics as well as washing, care and cleaning products. Many of these products are discharged directly into wastewater and are therefore of particular relevance with regard to their aquatic toxicity. The study makes estimates of the quantities emitted and analyzes whether current product labeling provides consumers with sufficient information for environmentally conscious purchasing behavior. The regulatory framework, which ranges from legal regulations and eco-labels to voluntary self-commitments, is examined in terms of its effectiveness and the procedure for classifying substance hazards in relation to polymers is critically reviewed. A proposal for amendment is also being submitted.</p>	

<b>Interest for Blue Lake Project purposes</b>
<p>The study focuses on numerous topics relevant to the Blue Lakes project and provides insight and background information on the current state of the art.</p> <ul style="list-style-type: none"> <li>- Recommendations for the definition of the term "microplastics"</li> <li>- Overview of quantities, labelling and function of microplastics, soluble, gel-like and liquid polymers</li> <li>- Legal and voluntary measures to reduce microplastics, such as eco-labels or voluntary commitments on cosmetics</li> <li>- Assessment of the environmental risks of polymers and potential for less hazardous substitutes.</li> </ul>
<b>Reference</b>
<a href="https://www.umsicht.fraunhofer.de/en/research-for-the-market/microplastics.html">https://www.umsicht.fraunhofer.de/en/research-for-the-market/microplastics.html</a>

<b>TITLE</b>	<b>Plastics in the environment: micro- and macroplastics causes, quantities, environmental fate, effects, solutions, recommendations (in German), June 2018</b>
<b>Typology of good practice</b>	Microplastics and synthetic polymers in cosmetic products and detergents and cleaning agents
<b>Coordinating Institution</b>	Fraunhofer Institute for Environmental, Safety, and Energy Technology UMSICHT, Germany
<b>Funded through</b>	BASF SE, Evonik Ressource Efficiency GmbH, Beiersdorf AG, Nestec Ltd, DSD - Duales System Holding GmbH Co. KG, Wupperverband, Gelsenwasser AG, hanseWasser, Emschergenossenschaft/Lippeverband, RWTH Aachen and TU Dresden
<b>Study area</b>	Germany
<b>Description</b>	
<p>For companies in the plastics and consumer goods industry who want to assume their producer responsibility, as well as for companies in urban water management, whose facilities and waters are particularly relevant as input paths, transport routes and retention systems for plastics in the aquatic environment, there is therefore already a need for action in terms of preventive environmental protection.</p> <p>However, what exactly the right measures are and how they should be prioritised is still open, controversial or unknown. Against this background, the authors of the study have compiled, structured and analysed the current state of knowledge and, based on this, formulated recommendations.</p>	

<b>Interest for Blue Lake Project purposes</b>
<p>The study focuses on numerous topics relevant to the Blue Lakes project and provides insight and background information on the current state of the art.</p> <ul style="list-style-type: none"> <li>- Terms, chronology and perception</li> <li>- Sources and quantities</li> <li>- Propagation, recovery</li> <li>- Environmental fates and effects</li> <li>- Assessment, regulation and guidance</li> <li>- Plastic - a material with image problems</li> <li>- Recommendations</li> </ul>
<b>Reference</b>
<a href="https://www.umsicht.fraunhofer.de/en/research-for-the-market/microplastics.html">https://www.umsicht.fraunhofer.de/en/research-for-the-market/microplastics.html</a>

<b>TITLE</b>	<b>Microplastics in lakes in Bavaria, Germany – A pilot study</b>
<b>Typology of good practice</b>	Monitoring activities
<b>Coordinating Institution</b>	Bavarian State Agency for Environmental Protection, University Bayreuth
<b>Funded through</b>	Bavarian Government, Germany
<b>Study area</b>	Bavarian lakes (Chiemsee, Starnberger See, Ammersee, Altmühlsee) and running waters (Altmühl, Danube, Isar, Inn), Germany
<b>Description</b>	
<p>Investigations on Bavarian waters, October 2019</p> <p>In the years 2014 and 2015 samples were taken at Bavarian lakes (Chiemsee, Starnberger See, Ammersee, Altmühlsee) and running waters (Altmühl, Danube, Isar, Inn) to detect microplastic particles. Since the distribution of microplastic particles in the water body depends on various factors, such as the density of the plastic type, samples were taken from different water body compartments.</p>	
<b>Interest for Blue Lake Project purposes</b>	
<p>This report provides a first overview of the occurrence of plastic particles in Bavarian lakes. The three alpine lakes Chiemsee (focus lake of Blue Lakes project), Starnberger See and Ammersee as well as the Altmühlsee, a low mountain range lake (reservoir) were selected. Within the framework of the pilot study, the four different water compartments water surface, water column, shore sediment and bottom sediment were included in the investigations for the first time. The project partner, the Department of Animal Ecology I at the University of Bayreuth, took a total of 42 samples using currently accepted sampling methods, processed</p>	

them and examined them using FTIR spectroscopy. The analytical results now available form one of the world's largest, methodologically uniformly obtained data sets on the occurrence of plastic particles in lakes.

#### FTIR spectroscopy:

Fourier - transformation - infrared - spectroscopy is used to characterize materials. Infrared radiation is irradiated into a sample and certain wavelengths are absorbed or transmitted. The resulting spectrum is characteristic for each polymer (type of plastic), so that it can be identified via it.

#### Reference

[https://www.lfu.bayern.de/analytik\\_stoffe/mikroplastik/bayerische\\_seen/index.htm](https://www.lfu.bayern.de/analytik_stoffe/mikroplastik/bayerische_seen/index.htm)

TITLE	Microplastics in the aquatic environment: sources, sinks and transport pathways (essentials)
Typology of good practice	Sources and risks of microplastics in the environment
Coordinating Institution	The author of the publication is working at the Institute of Hydraulic Engineering and Water Management at RWTH Aachen University, Germany
Funded through	No information available. The book can be bought in a book shop.
Study area	Germany
<b>Description</b>	
<p>Microplastics is currently an omnipresent topic in the media and is therefore also perceived by the public as an environmentally relevant problem. However, since a lot of half-knowledge contributes to the formation of opinion, this essential information prepares the current state of research and presents it in a generally understandable way. Beginning with the basics of the definition of microplastics and the currently known sources, continuing with previously proven concentrations in the aquatic environment and ending with the sinks, the path of microplastics through the waters of this earth is described. Finally, the environmental risks that microplastics pose to ecosystems, aquatic organisms and humans are discussed. Many gaps in knowledge are pointed out, which will have to be closed in the future and which are not presented in this way within the usually short contributions in mass media.</p>	
<b>Interest for Blue Lake Project purposes</b>	
<p>The book, published in Sept. 2019 provides useful background information. The author, Kryss Waldschläger, studied civil engineering and is currently working as a research assistant at the Institute of Hydraulic Engineering and Water Management at RWTH Aachen</p>	

University. There she is investigating the transport behavior of microplastics in flowing waters.

The publication provides information on:

- Sources and entry paths of microplastics
- Microplastics in the aquatic environment
- Lowering of microplastics
- Risks of microplastics in the environment

The target groups are: Students and lecturers of natural and environmental sciences, especially water management, Practitioners in the field of environment and water management and employees in public authorities.

#### Reference

<https://www.springer.com/de/book/9783658277659>

TITLE	<b>Microplastics in inland waters South and West Germany. Interstate studies in Baden-Württemberg, Bavaria, Hesse, North Rhine-Westphalia and Rhineland-Palatinate (German)</b>
<b>Typology of good practice</b>	Monitoring and analysis of plastic particles in the near-surface water phase
<b>Coordinating Institution</b>	Baden-Württemberg State Institute for the Environment (LUBW), Bavarian State Office for the Environment (LfU), Hessian State Agency for Nature Conservation, Environment and Geology (HLNUG), North Rhine-Westphalia State Office for Nature, Environment and Consumer Protection (LANUV), Rhineland-Palatinate State Office for the Environment (LfU RLP), University of Bayreuth (UBT), Department of Animal Ecology
<b>Funded through</b>	Baden-Württemberg State Institute for the Environment (LUBW), Bavarian State Office for the Environment (LfU), Hessian State Agency for Nature Conservation, Environment and Geology (HLNUG), North Rhine-Westphalia State Office for Nature, Environment and Consumer Protection (LANUV), Rhineland-Palatinate State Office for the Environment (LfU RLP)
<b>Study area</b>	Inland waters South and West Germany
<b>Description</b>	
Although rivers have long been discussed as a path for the introduction of (micro)plastics into marine ecosystems, systematic investigations in flowing waters have only been carried	

out more recently. As a result, there are no uniform analytical methods yet, so that the data available to date are generally not comparable.

In order to generate a uniform data set over a larger geographical area with different stream types, five German states (Baden-Württemberg, Bavaria, Hesse, North Rhine-Westphalia and Rhineland-Palatinate) have joined forces and, together with their joint cooperation partner (the University of Bayreuth), have determined microplastic concentrations in different compartments of southern and western German streams.

The comparability of the data was ensured by the fact that the sampling and analysis of all measurement programs was carried out by the University of Bayreuth using uniform methods.

The present report summarizes and evaluates the results of the investigations on the occurrence of microplastics at the water surface of selected German watercourses. With 52 measuring points in two large river basins (Rhine and Danube), the transnational investigation programme represents one of the most comprehensive measuring programmes in inland waters. With the analysis of more than 19,000 objects, of which 4,335 were clearly identified as plastic particles and characterised in terms of polymer type, size and shape, one of the largest comparable data sets on microplastics in flowing waters is now available.

With this report we give a first overview of the microplastic pollution of inland waters. At the same time it is an important basis for the development of future monitoring strategies.

### Interest for Blue Lake Project purposes

Within the framework of these pilot projects, qualitative and quantitative analyses of microplastic particles were carried out in different water body compartments of running waters. In this first part of the report the results of the near-surface water samples presented, which were measured at a total of 52 measuring points in 22 watercourses in the catchment area of the Rhine and Danube. Besides the two major rivers, tributaries samples of different sizes and a broad spectrum of hydrological conditions and anthropogenic influences.

### Reference

[https://www.lfu.bayern.de/analytik\\_stoffe/mikroplastik/laenderbericht\\_2018/index.htm](https://www.lfu.bayern.de/analytik_stoffe/mikroplastik/laenderbericht_2018/index.htm)

TITLE	LIMNOPLAST - Microplastics in Europe's freshwater ecosystems: From sources to solutions
Typology of good practice	Project
Coordinating Institution	Universitat Bayreuth (Germany)

<b>Funded through</b>	Grant agreement ID: 860720 Horizon 2020, MSCA-ITN-2019-ETN, H2020-EU.1.3.1. 1/11/2019-31/10/2023
<b>Study area</b>	Germany + 11 European countries, no Italy
<b>Description</b>	<p>Microscopic plastic debris, so-called microplastics (MP), pose a global challenge. As most plastic is produced and used inland, the considerable lack of knowledge on their sources and impacts in freshwater ecosystems inhibits effective mitigation measures. To meet this challenge, LimnoPlast will for the first time bring together environmental, technical, and social sciences with the vision to transform a new understanding of freshwater MP to innovative solutions. LimnoPlast will:</p> <ul style="list-style-type: none"> <li>- Train a new type of scientists able to tackle the complex plastics issue holistically and contribute to Europe's innovation and Circular Economy capacity. Working at the interface of three usually very distant disciplines, they will promote a step change in how we deal with this and future environmental challenges.</li> <li>- Provide the first comprehensive assessment of the sources and impacts of freshwater MP based on the analysis of three major urban areas as hotspots of plastic pollution.</li> <li>- Innovate technological solutions to the plastics issue, including novel processes to remove MP from municipal and industrial wastewater as well as biodegradable, environmentally sound polymers.</li> <li>- Promote societal change by understanding the economic, legislative and social context of freshwater MP.</li> <li>- Transform science into a set of specific solutions, including (I) the prioritization of actions based on the sources and impacts of MP, development of (II) better processes and polymers, (III) risk communication strategies and societal interventions, (IV) effective policy and legislative interventions.</li> <li>- Transfer the LimnoPlast outcomes to European decision makers, stakeholders and the public to enable and promote action on freshwater MP using an innovative communication and dissemination strategy.</li> </ul>
<b>Interest for Blue Lake Project purposes</b>	<p><b>ESR04: Monitoring and modelling MP in the greater Paris and the river Seine; pollutants associated with MP.</b></p> <p>The project of ESR4 will focus on 1) providing a detailed overview of the abundance and sources of MP in the greater Paris area, including polymer identification, 2) assessing the contribution of the Paris area to the MP contamination of the Seine river catchment, and 3) modelling the MP sources, fate, and sinks in the Seine catchment. For the monitoring, ESR4 will collaborate with the other involved ESRs to design a harmonised sampling strategy of</p>

sources and sinks at urban (Greater Paris) and Seine catchment scale. Annual MP loads will be modelled following a source fluxes analysis approach.

#### Reference

<https://www.limnoplast-itn.eu>

<https://cordis.europa.eu/project/id/860720>

TITLE	Microplastic pollution in the surface waters of Italian Subalpine Lakes
Typology of good practice	Research paper on microplastic monitoring campaign in Italy
Coordinating Institution	Legambiente onlus and ENEA
Funded through	This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.
Study area	Italian Subalpine lakes
<b>Description</b>	
In 2016 Legambiente and ENEA started together to monitor microplastic in Italian lakes assuming that “there is a knowledge gap related to microplastics abundance and dispersion in lakes, and, particularly, little is known as regards the situation in lakes of Italy.”. This paper is born from this first experience and it is related to the survey conducted in three subalpine Italian lakes during the summer edition of Goletta dei Laghi campaign.	
<b>Interest for Blue Lake Project purposes</b>	
Action B.2 Monitoring protocol: Pilot on Trasimeno and Bracciano Lakes	
<b>Reference</b>	
Sighicelli, M., Pietrelli, L., Lecce, F., Iannilli, V., Falconieri, M., Coscia, L., Di Vito S., Nuglio S., Zampetti, G. (2018). Microplastic pollution in the surface waters of Italian Subalpine Lakes. <i>Environmental Pollution</i> , 236, 645-651. <a href="https://doi.org/10.1016/j.envpol.2018.02.008">https://doi.org/10.1016/j.envpol.2018.02.008</a>	

## 3.2 Awareness activities and citizen science

TITLE	Microplastics Apps for smartphones: How to detect harmful products
Typology of good practice	Consumers' information
Coordinating Institution	N.A.
Funded through	N.A.
Study area	Germany, Europe
<b>Description</b>  <p>With an app consumers can make it easier for themselves to search for microplastics in cosmetics and regular products. There are many different ingredients that indicate microplasty. The easiest way to detect harmful products is to scan them using an App. The barcode provides a detailed summary of the ingredients immediately.</p> <p>Examples for microplastic detecting apps:</p> <p><b>CodeCheck</b> offers comprehensive product information and ratings. By scanning the barcode with the CodeCheck app, you will be shown, among other things, whether parabens, silicones, palm oil or even microplastics are contained in your cosmetics. The product can be checked directly while shopping. Just leave products with microplastic on the shelf.  <a href="https://codecheck-app.com/">https://codecheck-app.com/</a></p> <p><b>Beat the Microbead</b>  The app Beat the Microbead works very simply: the user selects his country, scans the product's barcode and a traffic light scale shows him whether the product contains microplastics.  <a href="https://www.beatthemicrobead.org/download-btmb-app/">https://www.beatthemicrobead.org/download-btmb-app/</a>  Products can also be checked online: <a href="https://www.beatthemicrobead.org/product-lists/">https://www.beatthemicrobead.org/product-lists/</a></p> <p><b>ToxFox: Scan, ask, buy tox-free</b>  Invisible, but dangerous: many everyday products contain harmful substances that have been linked to diseases such as cancer or infertility. With ToxFox, the German NGO BUND has developed a product check that helps consumers to test cosmetics and everyday products for harmful substances including microplastics.  <a href="https://www.bund.net/themen/chemie/toxfox/">https://www.bund.net/themen/chemie/toxfox/</a></p>	
<b>Interest for Blue Lake Project purposes</b>  <p>Most consumers would like to avoid microplastics in their skin care products, but how can you tell if they contain synthetic particles? In Germany, there is no obligation to declare so far, in the list of contents the plastics can be concealed under cryptic names.</p>	

In the framework of the awareness campaign, consumers can be informed about the different apps that could help them to avoid further microplastic pollution by using environmentally friendlier products.

## Reference

<https://codecheck-app.com/>

<https://www.bund.net/themen/chemie/toxfox/>

TITLE	Lables for microplastic free products
<b>Typology of good practice</b>	Consumers' information
<b>Coordinating Institution</b>	N.A.
<b>Funded through</b>	N.A.
<b>Study area</b>	Germany, Europe
<b>Description</b>	
<p>Research (UNEP; Tauw; ECHA) shows that many more types of plastics are added to personal care products than just the 'classic' plastic microbeads: Polyethylene (PE), Polypropylene (PP), Polyethylene terephthalate (PET), Polymethyl methacrylate (PMMA) or Nylon. To make sure that cosmetic products are completely free of any microplastic ingredients, consumers need a guarantee. There are different labels that mark microplastic-free products.</p> <p>Examples of labels that allow consumers to identify microplastic-free products:</p> <p><b>Look for the Zero Label</b></p>  <p><a href="https://www.beatthemicrobead.org/zero-products/">https://www.beatthemicrobead.org/zero-products/</a></p> <p>Many drugstores in Germany developed an own "Microplastic free product" label.</p> <p><b>Rossmann:</b></p>  <p><a href="https://www.rossmann.de/de/neu-mikroplastikfrei">https://www.rossmann.de/de/neu-mikroplastikfrei</a></p>	

dm:



<https://www.dm.de/tipps-und-trends/nachhaltigkeit/mikroplastik>

Müller:



<https://www.mueller.de/marken/eigenmarken/mikroplastik/>

### Interest for Blue Lake Project purposes

As part of the blue lakes awareness campaign, consumers can be informed about the labels and thus influence consumer behavior.

### Reference

<https://www.beatthemicrobead.org/zero-products/>  
<https://www.rossmann.de/de/neu-mikroplastikfrei>  
<https://www.dm.de/tipps-und-trends/nachhaltigkeit/mikroplastik>  
<https://www.mueller.de/marken/eigenmarken/mikroplastik/>

TITLE	GOLETTA DEI LAGHI 2019
Typology of good practice	flash mob and citizen science actions
Coordinating Institution	Legambiente Onlus
Funded through	Legambiente Umbria
Study area	Italy
Description	
<p>Goletta dei Laghi (Lake Schooner) is an awareness campaign pursued by Legambiente. The activities organized during almost a month and a half of campaign include monitoring and awareness initiatives. During the 2019 edition of the Goletta dei Laghi, volunteers painted the manholes in some municipalities, and wrote messages, as "Lakes starts here", to remind citizens about direct consequences of their bad habits, especially those of throwing waste into the manholes. The paints were 100% non-toxic, water-based and composed of natural pigments.</p>	

Moreover, since 2014, Legambiente's volunteer monitor the waste on Italian and Mediterranean beaches, during Spiagge e Fondali Puliti - Clean Up the Med campaign. This is one of greatest citizen science experience and scientific research conducted by citizens, at Italian and international level. The protocol is also used on the lake's beaches. Is a standardized protocol, and allows comparison between data collected from whoever uses it. Standard is also the list of names and specific codes used for cataloging the garbage.



#### Interest for Blue Lake Project purposes

Actions B.1 Campaign for local authorities and stakeholders and D.2 Awareness campaign


#### Reference

<https://www.legambiente.it/golettadelaghi/>

TITLE	Monitoring surface water quality using social media in the context of citizen science
Typology of good practice	Lake water pollution monitoring by citizen science and social media support
Coordinating Institution	National Natural Science Foundation of China, Chinese Ministry of Water Resource Program
Founded through	Dr. Hang Zheng, Professor Hong Yang, Mr. Jing Hua for TEMP platform
Study area	Cina (Social media & citizen science)
Description	
<p>Surface water quality monitoring (SWQM) provides essential information for water environmental protection. However, SWQM is costly and is limited in terms of equipment and sites. The global popularity of social media and intelligent mobile devices with GPS and photograph functions provide immense opportunity for citizens to monitor surface water quality. This study aims to establish and demonstrate a method to monitor surface water quality using social media platforms. A WeChat-based application platform is built to collect water quality reports from volunteers. Results show that the monitoring reports are reliable if the volunteers are trained. The key application functions and the methods for data washing and volunteer recruitment are also discussed in this study. The proposed framework and method can provide a mechanism to collect water quality data from citizens and offer a primary foundation for big data analysis in future research.</p>	
Interest for Blue Lake Project purposes	
Action D.2 Awareness campaign	

## Reference

direct [link](#) to Hydrol. Earth Syst. Sci. Discuss

TITLE	10 RIVERS 1 OCEAN
<b>Typology of good practice</b>	awareness activity
<b>Coordinating Institution</b>	N.A.
<b>Funded through</b>	N.A.
<b>Study area</b>	worldwide
<b>Description</b>  <p>The project mission is to navigate the ten most plastic-polluted rivers in the world and cross the great pacific garbage patch. Alex Bellini undertakes a new journey: 10 Rivers 1 Ocean. On a raft built by waste materials assembled on site for each leg of his journey, Alex will navigate the ten most plastic-polluted rivers on our planet to tell the story of the little-known trip that plastic makes: over 80% of the plastic polluting the oceans originates from rivers. He is supported by invaluable partners who want to act to help us change and protect our planet. Alex Bellini is one of the most in-demand Italian public speakers. Alex draws in the audience and leads them to discover a new dimension. His life and adventures are the proof of the extraordinary capacity for adapting and preserving that we all have as human beings.</p>	
	
<b>Interest for Blue Lake Project purposes</b> Action D.2 Awareness campaign	
<b>Reference</b> <a href="https://www.10rivers1ocean.com/en/">https://www.10rivers1ocean.com/en/</a>	

TITLE	WAKE UP! MUSIC WILL SAVE THE PLANET! UMBRIA JAZZ PRESERVE THE ENVIRONMENT
<b>Typology of good practice</b>	Sustainable festival
<b>Coordinating Institution</b>	Umbria Jazz Foundation
<b>Funded through</b>	N.A.
<b>Study area</b>	Umbria region (Italy)

## Description

Umbria Jazz is the most important Italian jazz music festival born in 1973 that takes place annually in Perugia in July. Umbria Jazz invites the music world, its audience and anyone wants to join, to fight against climate change, against the biosphere pollution and to promote the environmental and social sustainability of the planet, to make intelligent action, peaceful mobilization, that pushes politics and the economy to make clear sustainable decisions. The environmental protection focus will be the leitmotif until the 2023 edition that in will be the half century birthday of Umbria Jazz. So ... wake up!!!! music will save the planet!

**REDUCTION OF PLASTIC ACTION:** crockery and cutlery in biodegradable and compostable material (Mater-Bi type) at the refreshment points of the Festival; substitution in the Arena Santa Giuliana of plastic beer beakers with returnable glasses (20,000 units purchased from Amico Bicchiere) or with biodegradable beakers; installation of two water distribution stations (one paid, the other free) located respectively in the town centre and at the Arena Santa Giuliana; the staff and artists of the Festival (1,500 people) will be provided with aluminium water bottles.

**OTHER ACTION:** differentiated waste collection; entertainment and education for children; renewable energy; automotive; digitalisation; food waste; adherence of artists.



## Interest for Blue Lake Project purposes

Action D.2 Awareness campaign

## Reference

<https://www.umbriajazz.it/en/useful-informations/umbria-jazz-to-save-the-planet/>

### 3.3 Initiative to boost governance capacity

TITLE	Alliance Great Lakes, <a href="https://greatlakes.org/">https://greatlakes.org/</a>
Typology of good practice	Federal ban on the manufacture and sale of microbeads
Coordinating Institution	Alliance for the Great Lakes
Founded through	N.A.
Study area	USA
<b>Description</b> <p>The Alliance for the Great Lakes, our partners, and tens of thousands of advocates across the region led the fight for legislation to phase out microbeads in personal care products. <a href="#"><u>Eventually, this momentum led Congress to take legislative action, phasing out the manufacture and finally the sale of microbeads nationwide in July 2018.</u></a></p> <p>A number of large companies in the cosmetic and personal care industry have voluntarily pledged to remove plastic microbeads from their products. We applaud these efforts as examples of good corporate stewardship. There are no national or international standards for the biodegradability of plastics in ambient water environments. The industry's first job as good stewards of the Great Lakes must be to demonstrate that alternatives to plastic microbeads can truly and completely biodegrade, or mineralize, in the naturally occurring conditions of the Great Lakes and other water bodies. This should occur rapidly without creating harmful byproducts.</p> <p>Until peer-reviewed scientific research or testing by the American Society for Testing and Materials can provide standards for the biodegradability of plastics that confirm real biodegradability in Great Lakes water conditions, biodegradable plastics should not be exempt from a ban.</p> <p>We are encouraged that several states, including Illinois, New Jersey, and Maine, have banned plastic microbeads in cosmetic and personal care products. Other states, including Indiana, Wisconsin, Michigan, New York and others, are currently working on bans. The Alliance believes that the right federal regulatory approach can solve this problem. To completely protect the Great Lakes and other water bodies in the United States from plastic microbeads, we urge Congress to pass a federal ban on all forms of plastic microbeads in cosmetic and personal care products that:</p> <ul style="list-style-type: none"> <li>- Charges the Food and Drug Administration (FDA) with clearly defining plastic microbeads based on current scientific research and standards testing by authorities such as the American Society for Testing and Materials;</li> <li>- If terms such as "synthetic" and "biodegradable" are used in statute and regulation with regard to microbeads, these terms should also be clearly defined by FDA to ensure that substances such as bioplastics are not excluded from biodegradability</li> </ul>	

requirements, and that biodegradability occurs to mineralization in freshwater and marine environments;

- Sets a realistic and achievable timeline to phase out cosmetic and personal care products that contain plastic microbeads, beginning one year from the passage of this legislation; and
- Ensures that any products marketed and labeled as biodegradable meet Federal Trade Commission standards as articulated in FTC “Green Guides” for environmental marketing claims.

### Interest for Blue Lake Project purposes

Action B5 Campaign for cosmetic/outdoor clothing/rubber tyres production companies

### Reference

<https://greatlakes.org/2015/05/alliance-testimony-before-committee-on-energy-and-commerce-subcommittee-on-health-microbeads-in-cosmetic-products/>

TITLE	MULTI.PARK project
Typology of good practice	Project
Coordinating Institution	N.A.
Funded through	PSR Umbria 2014-2020, Misura 16.1: “Sostegno per costituzione e gestione Gruppi Operativi dei PEI in materia di produttività/sostenibilità dell’agricoltura” - Focus Area 6.B “Progetti di innovazione per stimolare lo sviluppo locale nelle zone rurali attraverso il ruolo della multifunzionalità delle aziende agricole”
Study area	Trasimeno Regional Park
Description	<p>The Multi.Park Project aims at Multifunctionality in the Park Areas of Umbria to stimulate local development in rural areas through the role of multifunctionality of farms. A project action is dedicated to the definition of business agreement models for bio compostable materials to reduce the amount of plastic used in the protected areas of Umbria where the project is developed: the Trasimeno and Monte Cucco Park. Legambiente Umbria is preparing models of commercial agreements for compostable materials for tourist services operators, educational farms and associations that organize festivals, fairs and events during the summer. In addition, the association is collaborating writing municipal regulations and plastic free resolutions to be submitted to Regional Park of Monte Cucco and Regional Park of Trasimeno area administrations in order to reduce waste, increase separate waste collection and reduce environmental impact and that also provide prohibition to use disposable plastic food service supports in favor of disposable biodegradable and compostable in accordance with European legislation En 13432 during public holidays and festivals.</p>

<b>Interest for Blue Lake Project purposes</b>
Actions B1 Campaign for local authorities and stakeholders and D2 Awareness campaign
<b>Reference</b>
<a href="https://www.multipark.it/">https://www.multipark.it/</a>

TITLE	ECOSISTEMA URBANO (Urban Ecosystem)
<b>Typology of good practice</b>	collecting environmental data from administrations
<b>Coordinating Institution</b>	Legambiente onlus
<b>Funded through</b>	N.A.
<b>Study area</b>	Italy
<b>Description</b>	
<p><i>Ecosistema Urbano</i> is a survey on the environment sustainability of 104 Italian municipalities that are provincial seats, realised by <i>Legambiente</i> (the most wide-spread environmental organisation in Italy) together with <i>Ambiente Italia</i> (scientific partner) and <i>Il Sole 24 Ore</i> (media partner).</p> <p>Since 1994, when the first edition came out, <i>Ecosistema Urbano</i> aims at evaluating the environmental loads, the quality of the natural resources, and the environmental management of the 104 municipalities at issue.</p> <p>Every year, <i>Ecosistema Urbano</i> gathers (by means of questionnaires, interviews addressed to the cities, and national statistical data) information on 125 environmental parameters for a total amount of more than 125.000 data collected.</p> <p>Seventeen sustainability indicators, according to a balanced P-S-R approach, are used for estimating the sustainability of the cities rather than the environmental quality of a city which is closely linked to not quantifiable elements.</p> <p>The indicators used by <i>Ecosistema Urbano</i> allow to make out how is changing the environmental policy in Italy, and where are the critical points concerning the ecological quality of a city.</p>	
<b>Interest for Blue Lake Project purposes</b>	
<p>As regards awareness raising <b>activities for citizens</b> (2.3) and <b>boost governance capacity</b> (2.4), it is useful to point out as a good practice the model already used by Legambiente in some of its annual reports. Starting from questionnaires addressed to Municipalities and others Public structures, in fact, the association has structured a tested system of in-depth study, study, verification and processing of data that makes it easier and more specific to adequately inform and disseminate to Municipalities and citizens on a specific problem. A good example to start from could be the Urban Ecosystem questionnaire.</p>	

Following the example of the Urban Ecosystem report, we propose to interview specifically the lake towns and at the same time citizens to build a grid of indicators that can make the individual technical interventions more effective and especially those aimed at information and involvement of the citizenship. At the same time, this research and study will also aim to make the governance action of the municipalities themselves easier and more direct thanks to the specific information collected.

## Reference

<https://www.legambiente.it/ecosistema-urbano/>

TITLE	Citizen science to save Bengaluru's lakes
Typology of good practice	Lake water pollution monitoring by citizen science and technologies support
Coordinating Institution	"Friends of Lakes" Bengaluru association
Founded through	Local agreement
Study area	India (citizen science, water pollution)
<b>Description</b>  Groups of citizen in Bengaluru area are working with the municipal authorities to keep a tab on the city's heavily polluted lakes.  Thanks new technologies, citizens can test water quality without expert help. A combination of a smartphone-based application, reagents and an online dashboard as data repository, Mira is the brainchild of Foundation for Environmental Monitoring, a not-for-profit company that creates open source products for field use, and NextDrop, a startup creating mobile technology for solving water issues. It is driven and supported by Ashoka Trust for Research in Environment and Ecology or ATREE, Bengaluru and BIOME Environmental Solution and has been designed as open source software to minimize the cost and avoid vendor lock-in. Moreover, while currently being developed for Bengaluru's lakes, the dashboard aspect of the software can be customized to be used in other cities too.	
<b>Interest for Blue Lake Project purposes</b>  Action D2 Awareness campaign	
<b>Reference</b>  <a href="http://www.scroll.in">www.scroll.in</a> (direct <a href="#">link</a> ), <a href="#">Mira</a> , lake monitoring dashboard	

TITLE	Monitoring surface water quality using social media in the context of citizen science
Typology of good practice	Lake water pollution monitoring by citizen science and social media support
Coordinating Institution	National Natural Science Foundation of China, Chinese Ministry of Water Resource Program
Founded through	Dr. Hang Zheng, Professor Hong Yang, Mr. Jing Hua for TEMP platform
Study area	Cina (Social media & Citizen science)
<b>Description</b>	
<p>Surface water quality monitoring (SWQM) provides essential information for water environmental protection. However, SWQM is costly and is limited in terms of equipment and sites. The global popularity of social media and intelligent mobile devices with GPS and photograph functions provide immense opportunity for citizens to monitor surface water quality. This study aims to establish and demonstrate a method to monitor surface water quality using social media platforms. A WeChat-based application platform is built to collect water quality reports from volunteers. Results show that the monitoring reports are reliable if the volunteers are trained. The key application functions and the methods for data washing and volunteer recruitment are also discussed in this study. The proposed framework and method can provide a mechanism to collect water quality data from citizens and offer a primary foundation for big data analysis in future research.</p>	
<b>Interest for Blue Lake Project purposes</b>	
Action D2 Awareness campaign	
<b>Reference</b>	
direct <a href="#">link</a> to Hydrol. Earth Syst. Sci. Discuss	

TITLE	PO D'AMARE – Collection and plastic waste recovery on Po river
Typology of good practice	Waste collection and monitoring in river water
Coordinating Institution	Fondazione per lo Sviluppo Sostenibile
Founded through	Fondazione per lo Sviluppo Sostenibile
Study area	Po river interregional basin
<b>Description</b>	
<p>The project aim is to collect waste from the largest Italian river thanks to floating barriers before reaching the Adriatic Sea. The partners of this pilot are Fondazione per lo Sviluppo Sostenibile, Corepla e Castalia Associations, Po River District Basin Authority, Municipality of Ferrara and Aipo (Interregional Agency for the Po River). The collection device (Seasweeper) has floating polyethylene barriers that do not interfere with the river</p>	

flora and fauna. The waste has been recycled and the plastic granule obtained from recycling has been sent to an English company for the construction of a small refuge house. Specifics project goals are raise public awareness, develop an effective collection system and support policies against marine litter.

### Interest for Blue Lake Project purposes

Action D2 Awareness campaign

### Reference

<https://www.youtube.com/watch?v=YtnxKYEtYUk>

TITLE	PROJECT LIFE RII
<b>Typology of good practice</b>	Advocacy and involvement of
<b>Coordinating Institution</b>	Emilia Romagna region
<b>Founded through</b>	UE (LIFE program)
<b>Study area</b>	Italy (Emilia Romagna)
<b>Description</b>	
<p>The RII project concerns the piedmont belt of the Apennines near Reggio Emilia, an area where the density of infrastructures and the high level of urbanization cause a high flood risk.</p> <p>The project aims at launching and testing the efficacy of some innovative strategies for land management together with experimental interventions aimed at restoring a safer path for water streams, more similar to their natural course, with the goal to improve their self-purification capacity and to improve the quality of waters and their ecological status.</p> <p>A specific activity implemented within the framework of the LIFE RII project was the definition of the work programme developed through a <b>participatory process</b>, involving public and private, social and economic stakeholders, with particular attention to local stakeholders, as provided by Regional Law R.L. no. 3/2010 and as enshrined in the Treaty of the European Union, in the Italian Constitution and in the Regional Articles of Association.</p> <p>The stakeholders group involved in the project has included various types of organisations, institutions, representatives of the general interests of the sector, citizens, as well as other stakeholders who have shown interest in listening to and discussing land-related issues.</p> <p>In order to identify the most effective actions to be implemented to achieve the project objectives, the Participatory process was mainly designed to:</p> <ul style="list-style-type: none"> <li>- Raise awareness about land-related issues,</li> <li>- Put forward possible and innovative solutions,</li> <li>- Apply a cross-sectoral approach to problem-solving,</li> </ul>	

- Promote a structured and targeted discussion,
- Promote active participation in the implementation of the LIFE Project RII,

The **methodology**, focused on two levels of action, informative and consultative, with different consultation provisions envisaged for several distinct phases, work objectives and communication tools:

- The initial public information **Forum**.
- A **Workshop** for the development of strategic shared actions and scenarios.
- **Laboratories** to carry out in-depth analyses and discussions in the four Municipalities involved, including local study visits to carry out assessment and monitoring actions "in the field".
- The **Final Forum** is meant to illustrate and disseminate the process results and technical transpositions in the final design.

In addition to live meetings, on-line Web-based communication tools have been used to promote a greater stakeholders' involvement, through the web site dedicated to the LIFE RII Project and through the so-called "Piazza virtuale ioPartecipo+", i.e. the "virtual participation square" specifically dedicated to stakeholders' participation.

The **public consultation timing** was concentrated to let it coincide with the development of the final design. The local benchmarking **activities** were carried out using various locations scattered throughout the four municipalities, in afternoon hours, in order to ensure a smooth participation in the meetings.

The various events were promoted by means of direct invitations by e-mail, advertisements on regional, municipal and Reclamation Consortium web sites, and further supported and disseminated through the distribution of leaflets at the local level to involve the local community.



The **Participatory process** of the LIFE RII Project began with the public information Forum, held on 7th June in San Polo d'Enza followed by a study visit to the Rio Lavezza water stream, to better understand the questions addressed by the Workshop on "Scenarios and ideas for river regeneration", held on June 21st in Bibbiano, during which participants were grouped together into different interest groups to discuss the topics under question, to outline future expected scenarios for the rivers, to identify problems and solutions and to express ideas and proposals for their regeneration.

In July, six thematic workshops were held on the individual water stream included in the project, in different locations, some through indoor sessions and others directly on site.

As a matter of fact, at this stage all the ideas / projects were immersed in a concrete context, identifying the real problems, discussing how to solve them and identifying the entities responsible for their solution (what, how and who), and highlighting specific and local issues. During the last two workshops, conducted through an inspection visit along the rivers, the participants filled in a "logbook" to record strengths and weaknesses with a view to put forward their suggestions.

The Participatory process has taken place through formalized involvement methods and has enabled all participants to express their points of view, thus showing great maturity and collaborative spirit. This brainstorming has led to a substantial quantity and quality of suggestions, knowledge and information sharing. All these topics will be further discussed and analysed and they will feed the following final Public Forum, during which the first answers will be provided to meet the expectations and suggestions that have emerged.

To stimulate the discussion even further, the results emerging from the meetings were promptly disseminated through various social media.

The **final Public Forum** is scheduled on 28th September, in Albinea, and it will conclude the participatory phase.

During the meeting the various requests and proposals were discussed and then taken into account in the design of actions as much as possible.

The Participatory process has taken place along with all the other activities undertaken locally as well as through the web, by experiencing the new service platform "ioPartecipo+ (I participate+)" **The participation squares** of the Emilia-Romagna Region".

The participatory process virtual square, active from 1st July to 30th September, was connected to the LIFE Project RII website, containing all the information and reports. Its functions and versatility were thus enhanced through an **online** discussion and participation forum.

Thanks to a set of dynamic tools, users were able to take part in various activities, to receive timely information, read the news (the LIFE Project RII newsletters) and directly participate in the discussion with questions, reports or proposals on the online forum.

The environmental topics covered in the LIFE RII square were shared on the network through 5 keywords to channel the discussion on Twitter and to relaunch it directly on the platform, on regional portals and on the project web site.

Participants could discuss local issues in the virtual square: citizens were directly invited, and reached out through the social media, by means of "virtual flyers", or banners posted

on the websites of the four project partner municipalities and of the Central Emilia Reclamation Consortium. In so doing it was possible to open special channel of collaboration and exchange among all stakeholders.

The setting (choice of topics and interest groups) and the discussion method that were adopted have been widely appreciated and shared, thus reflecting a strong demand for participation by citizens. The discussion Forum was also highly appreciated since it gave everyone an opportunity to express their suggestions, to learn from and listen to different points of view, to work in mixed groups (including local administrators, technicians, citizens, associations), in an extremely mature and open context involving all participants.

At the end of the process, it can be stated that the RII LIFE Project partnership has been strengthened by it and made more aware and ready to work out a solution to very sensitive spatial problems in a difficult situation characterized by poor financial resources.

#### Interest for Blue Lake Project purposes

Action B1 Campaign for local authorities and stakeholders

#### Reference

<https://progeu.regione.emilia-romagna.it/en/life-rii/topics/project-life-rii-1>

TITLE	App "Replace Plastic"
Typology of good practice	Influencing manufacturers and suppliers to provide environmentally friendly packaging
Coordinating Institution	Küste gegen Plastik e.V.
Founded through	German Federal Ministry of Education and Research (BMBF) and the Science in Dialogue (WiD) initiative
Study area	Germany
Description	
<p>App "Replace Plastic"</p> <p>There is too much plastic packaging for everyday products. Manufacturers and suppliers often say, "It's what the consumer wants." The developers of the app see it differently. With this app, they want to let product suppliers know that consumers want different packaging so they can start developing degradable materials and provide alternatives. With the app, consumers can scan products they would use or buy to indicate that they want these products to be packaged without plastic. This feedback will be forwarded to the manufacturers.</p> <p>Using a smartphone or tablet, the app can be used to scan the barcodes of products and report them to the operator "Coast against plastic". When 20 reports of a product are received or after four weeks - if less than 20 reports are received - the association forwards the number of reports by e-mail to the manufacturer. This is intended to</p>	

encourage the manufacturer to change his mind. So far, the association has sent around 32,000 such e-mails. These include Rewe, Edeka, Lidl, Aldi, Nestlé, Unilever and other food players. Those who do not own a smartphone or tablet can scan the products via the website.

Concept developed as part of a competition: The concept for the app was developed within the framework of the competition "Seas and Oceans: Science Year" organized by the Federal Ministry of Education and Research (BMBF) and the Science in Dialogue (WiD) initiative. The competition aims to promote public dialogue on the many different aspects of marine research.

### **Interest for Blue Lake Project purposes**

Provides methodologies how consumers can influence companies and how they can bring about a change in thinking.

### **Reference**

[www.replaceplastic.de](http://www.replaceplastic.de)

# ANNEX:

## REPORT ON BEST PRACTICES on treatment plants typology and efficiency

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## 1. INTRODUCTION

This report is structured in four parts:

- R&D&I projects which BlueLakes can be built on or relate to
- Literature review about sampling, treatment processes and efficiencies concerning
  - a. Wastewater treatment plants
  - b. Drinking water treatment plants
  - c. Combined sewers overflows

## 2. PROJECTS RELATED TO MPs

### 2.1 Introduction

Microplastics detection and removal from water matrix is a theme of always bigger concern in all European level and a wide range of projects are developing innovative solutions for their management. The first step often consists in the choice of a simple, affordable and exploitable sampling method, that allows results comparison and sharing. Many projects, as CLAIM, TextileMission, EMISTOP, ENSURE and RUSEKU, report studies, as the ones for HELCOM BASE Project and Norwegian Institute for Water Research, and guidelines, as those of CCB, contemplate the development of a sampling method. Projects as RUSEKU and Sub $\mu$ Track and the HELCOM BASE study are focusing on MPs detection in the WWTPs. REPLAWA, PLASTRAT, TextileMission and ENSURE projects will analyse treatment efficiencies. As concern CSOs management, projects as INTCHATCH and InRePlast and CCB Guidelines provide useful information on MP removal in wetlands, stormwater ponds and drainage systems. New treatment technologies are developing in SMART-Plant, CLAIM, Plastfri Roskilde Fjord and SimConDrill projects. New commercial products are also developing, such as Wasser 3.0 PE-X® technology.

## 2.2 List of projects

Project-Activity Title	Description	Links	Funded through	Coordinating Institution	Duration	Interest for BlueLakes
<b>INTCATHC</b>	Monitoring and management of surface water quality; developing efficient, user-friendly water monitoring strategies and systems based on innovative technologies that will provide real time data for important parameters, moving towards SMART Rivers.	<a href="https://www.intcathc.eu/">https://www.intcathc.eu/</a>	Horizon 2020	BRUNEL UNIVERSITY LONDON	Start date: 1 June 2016 End date: 31 January 2020	Manage water pollution in surface runoffs and CSO:  Expert Team provides customers with the most effective and low-cost solutions of Combined Sewer Outflow (CSO) and surface runoff treatment systems  A wide range of completely automatic and fully adaptive treatment systems are offered depending on customer's needs including combination of coarse screening system, rotating dynamic filter, quartzite filter, GAC adsorption system and UV disinfection
<b>SMARTPLANT</b> Scale-up of low-carbon footprint MATERIAL Recovery Techniques in existing wastewater treatment PLANTS	SMART-Plant will scale-up in real environment eco-innovative and energy-efficient solutions to renovate existing wastewater treatment plants and close the circular value chain by applying low-carbon techniques to recover materials that are otherwise lost.	<a href="https://www.smartplant.eu/">https://www.smartplant.eu/</a>	Horizon 2020	UNIVERSITÄ POLITECNICA DELLE MARCHE	Start date: 1 June 2016 End date: 31 May 2020	<b>Salsnes Filter AS</b> is a technology provider and a partner of SMART-Plant. Salsnes filters have been tested for the treatment of different water fluxes, including the effluent from WWTPs. Salsnes has developed a unique fine mesh sieve system for treatment of municipal and industrial wastewater, a mechanical wastewater treatment system, with integrated thickening and sludge dewatering. The patented filter technology is a very compact unit for mechanical separation of suspended solids from wastewater. With the integrated sludge dewatering unit, Salsnes Filter wastewater treatment processing plants meet the highest standards and the specifications of the European Commission for reduction of waste effluents (primary treatment). Salsnes Filter has significant experience from extensive national and international R&D activities, including FP6 and FP7 projects.

<b>CLAIM</b> - Cleaning Litter by developing and Applying Innovative Methods in european seas	Development of innovative cleaning technologies and approaches, targeting the prevention and in situ management of micro and macroplastics in the Mediterranean and Baltic Sea.	<a href="https://www.claim-h2020project.eu/">https://www.claim-h2020project.eu/</a>	Horizon 2020	HELLENIC CENTRE FOR MARINE RESEARCH , EL	Start date: 2017/11/01 End date: 2021/10/31 Duration: 48 months	<ul style="list-style-type: none"> <li>Pre-filtering system to retain larger plastics, while simultaneously taking two samplers;</li> <li><b>Photocatalytic nanocoating device for cleaning microplastics in wastewater treatment plants</b> to obtain the degradation of low-density polyethylene (LDPE) microplastic, by visible light-induced heterogeneous photocatalysis activated by Zinc oxide nanorods.</li> </ul>
<b>REPLAWA</b> Reduction of the Input of Plastics via Wastewater into the Aquatic Environment .	The project will investigate and quantitatively assess entry points into water bodies through treatment plants, storm water drainage, and combined sewer overflows as well as swales at treatment facilities and in sewage sludge.	<a href="http://www.replawa.de">www.replawa.de</a>	BMBF German Federal Ministry for Education and Reserach	Emscher Wassertechnik GmbH, Essen	January 2018 - December 2020	The project will test and rate various practical methods of reducing and eliminating plastic emissions into waterways during wastewater treatment. Based on the results of these investigations and of assessments regarding international regulatory approaches in this field, the project will derive strategies for reducing plastic release from wastewater treatment into waterways.
<b>HELCOM BASE</b> Project - Implementation of the Baltic Sea Action Plan in Russia	Preliminary study on synthetic microfibers and particles at a municipal wastewater treatment plant	<a href="https://helcom.fi/helcom-at-work/projects/basel/">https://helcom.fi/helcom-at-work/projects/basel/</a>	EU	Helsinki Region Environmental Services HSY	2012-2014	Study the amount of microplastic litter arriving at the Central Wastewater Treatment Plant (WWTP) of St. Petersburg and the effect of the purification process. Helsinki Region Environmental Services Authority HSY developed a microplastic sampling method targeted at wastewaters.

Mapping microplastics in sludge - Research Report	Characterization of microplastics in sewage sludge from Norwegian domestic wastewater treatment plants applying different wastewater and sludge treatment technologies.	<a href="https://niva.brage.unit.no/niva-xmlui/handle/11250/2493527">https://niva.brage.unit.no/niva-xmlui/handle/11250/2493527</a>	Norwegian Institute for Water Research		2017	Fenton's reagent was used to remove organic matter and density separations were employed to extract microplastics from sludge samples. Plastics were found in all ten sludge samples investigated from eight WWTPs. The overall average plastic abundance was 6 077 particles kg <sup>-1</sup> (d.w.) (1701 – 19 837) or 1 176 889 particles m <sup>-3</sup> (470 270 – 3 394 274).
Guidance on concrete ways to reduce microplastic inputs from municipal stormwater and wastewater discharges	Concrete ways to reduce micropalstics from stormwater and wastewater and simple methodology to monitor riverine inputs of micropalstics.	<a href="https://www.ccb.se/documents/Postkod2017/CCB%20-%20Guidance%20on%20concrete%20ways%20to%20reduce%20microplastics%20in%20stormwater%20and%20sewage.pdf">https://www.ccb.se/documents/Postkod2017/CCB%20-%20Guidance%20on%20concrete%20ways%20to%20reduce%20microplastics%20in%20stormwater%20and%20sewage.pdf</a>	Coalition Clean Baltic for protection of the Baltic Sea environment		2017	Constructed free water surface wetlands can be efficient in reducing microplastics from effluents of WWTPs to the water bodies. High MP concentrations found in urban stormwater. Stormwater ponds used as end of pipe solutions show good removal efficiency for microplastics. Methods for sampling and analyzing microplastic contents in water. Abundance of microplastics smaller than 300 µm in stormwater and sewage water.

<b>Plastfri</b> Roskilde Fjord project	Investigating, mapping and identifying plastic pollution effects and sources, and finding concrete solutions and actions to prevent plastic pollution	<a href="https://plasticchange.dk/vi-denscenter/plastfri-roskilde-fjord-plastikfor-urening-i-danmark/">https://plasticchange.dk/vi-denscenter/plastfri-roskilde-fjord-plastikfor-urening-i-danmark/</a>				<b>Alfa Laval</b> supplied a <b>pilot membrane filtration system</b> that was used to determine the amount and type of microplastics in the main wastewater treatment plant, which releases treated water into Roskilde Fjord.
<b>Wasser 3.0 PE-X®</b>	Simple, reproducible and cost-efficient processes with no negative environmental effects for the elimination of microplastics from sewage water	<a href="https://wasserdreinull.com/">https://wasserdreinull.com/</a>		University Koblenz- Landau, Dr. Katrin Schuhen		With <b>Wasser 3.0 PE X</b> it has been developed the first method to remove microplastics from the water without any additional complicated filter technology. By applying a non-toxic hybrid silica gel, table tennis ball sized balls float on the water surface and are easily removed from there.
<b>SimConDrill</b> - Innovative filter modules for the separation of microplastics from wastewater	Development of a filter that is ready for serial production, which enables the filtration of particles down to 0.01mm (this equals the thickness of household aluminium foil) based on the patented cyclone filter.	<a href="https://www.simcandrill.com/">https://www.simcandrill.com/</a>	Federal Ministry of Education and Research (BMBF)	Fraunhofer Institute for Laser Technology		New water filter removes microplastics with laser-drilled tiny holes. A group of five partners from industry and research now wants to develop a <b>new filter</b> that uses <b>laser-drilled holes</b> to efficiently filter out particles as small as 10 micrometres even in large amounts of water.

<p><b>TextileMission</b> – Microplastics of Textile Origin - A Holistic View: Optimized Processes and Materials, Material Flows and Environmental Behavior.</p>	<p>Synthetic fiber particles with a diameter of less than 5 millimetres are only partially filtered out by modern wastewater treatment plants. The partners of the joint research project TextileMission have taken on the task of reducing this environmental impact.</p>	<p><a href="https://textilemission.bsi-sport.de/en/">https://textilemission.bsi-sport.de/en/</a></p>	<p>BMBF (German Federal Ministry for Education and Research)</p>	<p>Federal Association of the German Sporting Goods Industry e.V. / BSI</p>	<p>September 2017 August 2020</p>	<p><b>WP 4 Polyester fibres:</b> At the TU Dresden, <b>analysis and sample preparation method</b> is established to quantify microparticles from wastewater streams and fractionate them according to size. <b>Investigation of the retention capacity of textile (fluorescence-labelled) microparticles in the different stages of a laboratory wastewater treatment plant and identification of efficient retention possibilities.</b> Material flows are analysed including a first estimate of the Germany-wide textile microplastic emission from wastewater into water bodies /soils. <b>WP 5: Consideration of other environmental issues related to the project, stakeholder involvement and communication at the end of the project.</b> Focus on the retention of textile microfibre particles through various purification stages in wastewater treatment plants.</p>
<p><b>InRePlast</b> – Environmental Policy Instruments to Reduce Plastic Pollution of Inland Waters through Drainage Systems</p>	<p>How and which plastics end up in wastewater and how these inputs can be reduced with the help of environmental legislation is the focus of the joint research project InRePlast. Based on an analysis of sources, entry points and polluters, the researchers are developing and testing measures for behavioural changes.</p>	<p><a href="http://www.inreplast.de">www.inreplast.de</a> <a href="https://bmbf-plastik.de/en/joint-project/inreplast">https://bmbf-plastik.de/en/joint-project/inreplast</a></p>	<p>BMBF (German Federal Ministry for Education and Research)</p>	<p>University of Kassel, Department of Economics, Division of Economic Policy, Innovation and Entrepreneurship</p>	<p>January 2019 - December 2021</p>	<p><b>WP 1: Inventory of the entry points of plastics into the drainage systems.</b> Determine the status quo of plastic discharges into the drainage systems in four selected model municipalities, which represent different settlement structures. For this purpose, the type and quantity of plastic products as well as their sources from households, industry, traffic and other activities related to wastewater collection and drainage of paved areas will be determined. <b>WP 4: Material flow models of plastic inputs into canalisation systems and wastewater treatment plants.</b> Material flow models for plastic discharges of macro- and microplastics from the identified sources into the drainage systems will be developed for the four model communities. Based on the model results, the sources and product types are analysed and evaluated with regard to their relevance for the plastic inputs. The data from the municipalities is then extrapolated to the federal level in a general model.</p>

<p><b>EmiStop</b> - Identification of Industrial Plastic Emissions by Means of Innovative Detection Methods and Technology Development to Prevent the Input into the Environment via the Wastewater Pathway</p>	<p>Detect emissions of plastics into wastewater from relevant industries. Select wastewater treatment technologies that will optimise reduction of emissions of plastics for the respective value chain. The project will evaluate existing technologies for separating particles, investigate deposition rates, and develop approaches for technical optimisation. Optimisation also includes technological developments such as flocculants. Researchers will conduct tests in both laboratory and pilot project settings – selected large scale technical wastewater treatment plants will be investigated at industrial facilities.</p>	<p><a href="http://www.emistop.de/page8.html">http://www.emistop.de/page8.html</a> <a href="https://bmfp.plastik.de/en/joint-project/emistop">https://bmfp.plastik.de/en/joint-project/emistop</a></p>	<p>BMBF (German Federal Ministry for Education and Research)</p>	<p>EnviroChemie GmbH, Rossdorf</p>	<p>January 2018 - December 2020</p>	<p>Standardisation of sampling and sample preparation for <b>industrial wastewater</b> (in alignment with Plastik-Net and other joint research projects). Quantitative and qualitative measurement of plastic concentrations in industrial wastewater using Raman spectroscopy and dynamic differential calorimetry. Extended data collection at the sampled industrial wastewater treatment plants for the derivation of the plastic loads and testing of a correlation between the measurement results and routine water chemical analyses. Development of magnetic plastic particles in the micrometre range with the physical properties of relevant types of plastic. Development of a tracer test with magnetic plastic particles. Assessment of technologies for particle separation with regard to the retention of (micro-) plastic particles. Optimisation of particle separation technologies. Development of flocculants for the targeted improvement of the retention of individual types of plastics and their mixtures</p>
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<b>ENSURE</b> Development of New Plastics for a Clean Environment by Determining of Relevant Entry Points.	Holistic approach to reduce plastic in the environment as well as the related negative consequences, including improving methods of analyzing the environmental impact of plastics.	<a href="https://www.ensure-project.de/bf-plastik.de/en/joint-project/ensure">https://www.ensure-project.de/bf-plastik.de/en/joint-project/ensure</a>	BMBF (German Federal Ministry for Education and Research)	University of Stuttgart	April 2018 - March 2021	In the "Traceability" module, undesirable plastic inputs in prioritised sectors (soils, wastewater treatment plants, composting plants and biogas plants) are detected and identified. In a first step, <b>sampling strategies</b> are developed so that in a second step representative investigations can be carried out to <b>determine the current states of plastics in fermentation, compost and wastewater treatment plants.</b>
<b>PLASTRAT</b> - Strategies for Reducing the Entry of Urban Plastics into Limnic Systems	Development of solution strategies for the sustainable limitation of plastic residues propagation in the aquatic environment. Emphasis will be put on the analysis and evaluation of degradation levels of various types of plastic as well as leaching, adsorption, and desorption in different wastewater treatment stages, The focus will also be on the quantification and technical reduction potential (e.g. use of membrane technology) of plastic emissions in the field of urban water management including sewage sludge treatment	<a href="http://www.w.plastrat.de/project/ect/">http://www.w.plastrat.de/project/ect/</a> <a href="https://bmbf-plastik.de/en/joint-project/plastrat">https://bmbf-plastik.de/en/joint-project/plastrat</a>	BMBF (German Federal Ministry for Education and Research)	Bundeswehr University Munich Institute of Hydroscience / UniBwM Chair of Sanitary Engineering and Waste Management	September 2017 - August 2020	<p><b>WP 2: Degradation and material dynamics.</b> The release of pollutants (oligomers, additives and their transformation products) is analysed depending on the type of polymer and the degree of degradation. Furthermore, differences in the adsorption/desorption of environmental chemicals are investigated for different types of polymers and the role of wastewater treatment plants regarding the pollutant load of microplastics (enrichment or depletion).</p> <p><b>WP 3: Entry points and elimination.</b> Different entry points of microplastics into limnic systems are assessed, focusing on the analysis and evaluation of the wastewater management system including measures for microplastic retention (e.g. membrane technology) that already exist or have been modified or developed in the course of the project. Core areas comprise rain and mixed water discharge, the assessment and evaluation of the entire wastewater treatment plant system, and an analysis of sewage sludge, digestate and compost as possible microplastic sinks. Emphasis is also put on the development and selection of suitable processing and analytical methods.</p>

	under consideration of sampling, sampling preparation, and analysis methods.					
<b>RUSEKU</b> – Precise Detection of Microplastics in Water	Plastics in the Environment: Sources - Sinks – Solutions. Development of representative test methods that can accurately and quickly determine the microplastic content over various parts of the water cycle. The focus is on sampling methods in urban wastewater systems and watercourses.	<a href="https://netzwerke.bam.de/ruseku">https://netzwerke.bam.de/ruseku</a> <a href="https://bmfp-plastik.de/en/joint-project/ruseku">https://bmfp-plastik.de/en/joint-project/ruseku</a>	BMBF (German Federal Ministry for Education and Research)	Federal Institute for Materials Research and Testing / BAM Berlin	March 2018 - January 2021	<p><b>WP 2 Development of sampling methods</b></p> <p><b>WP 3 Simulations</b> software that simulates geometrically complex, application-oriented cases will be used to derive sampling strategy</p> <p><b>WP 4 Sampling of real environmental compartment.</b> quantification of the microplastic volume and transport in the real, urban wastewater system for the wastewater and precipitation water, domestic wastewater (partial flows grey and black water), industrial wastewater, and mixed wastewater. Further work will focus on sample preparation and preservation to evaluate the comparability of different sampling strategies. The investigations focus on the quantities and the importance of microplastic volumes in the individual entry points of the urban wastewater system into the water bodies.</p>
<b>SubpTrack</b>	Tracking of (Sub)Microplastics of Different Identities - Innovative Analysis Tools for Toxicological and Process-engineering Evaluation. Development of new methods of analysis and evaluation, which will allow for assessment and toxicological investigations of plastic particles of different sizes.	<a href="https://www.wasser.tum.de/en/submuetrack/starseite/">https://www.wasser.tum.de/en/submuetrack/starseite/</a> <a href="https://bmfp-plastik.de/en/joint-project/submtrack">https://bmfp-plastik.de/en/joint-project/submtrack</a>	BMBF (German Federal Ministry for Education and Research)	Technical University of Munich	September 2017 - August 2020	<p><b>WP 4 Investigations on entry points and process-related evaluation.</b> Real scenarios are first simulated with reference particles in laboratory wastewater treatment plants at the partner LfU to analyse the fate of the particles within the system. Parallel to this, <b>investigations will be carried out at various measuring points in real wastewater treatment plants.</b></p>

## 2.3 Selected projects and focus on their relationship with UNVPM activity in BLUE LAKES

From the list previously presented, 6 projects have been selected for their correlation with UNIVPM activity in BlueLakes.

### INTCATCH – Development and application of novel, integrated tools for monitoring and managing catchments

INTCATCH is a Horizon 2020 funded programme that aims to instigate a paradigm shift in the monitoring and management of river and lake water quality, by bringing together, validating and exploiting a range of innovative monitoring tools into a single efficient and replicable business model for water quality monitoring that engages the widest set of stakeholders and will be fit for European Waters in the period 2020-2050. INTCATCH Technology Innovations include:

- Autonomous and radio-controlled boats equipped with innovative sensors
- Next generation DNA test kits
- Innovative Treatment systems for combined sewer overflows
- Real-time water quality data
- Decision Support Systems turn data into information to inform action

INTCATCH has many aspects in common with the activity of UNIVPM for BlueLakes. First of all, one of the demonstration sites is located in Lake Garda, where was set up the monitoring activity. Another experimental site is represented by the CSO treatment plant of Villa Bagatta, that was implemented with an integrated system of Rotating Belt Filter, Activated Carbon and UV Disinfection. UNIVPM was directly involved in this activity and acquired experiences about specific working conditions of CSOs in Garda Lake.

The treatment and monitoring solution for Combined Sewer Outflow (CSO) and surface runoff treatment systems individuated by INTCATCH included a monitoring strategy of discharges and the development of an integrated treatment system provided with innovative technologies:

- Dynamic rotating filtration unit (90 µm mesh size) for the removal of solids, provided by Salsnes (Norway);
- Rapid adsorption on granular activated carbon (GAC) into 4 filters mounted on a skid;
- Disinfection with UV lamps provided by Trojan UV (Canada).

### CLAIM – Cleaning Litter by developing and Applying Innovative Methods in European seas

CLAIM focuses on the development of innovative cleaning technologies and approaches, targeting the prevention and in situ management of micro- and macro-plastics in the Mediterranean and Baltic Sea. The project will power 5 innovative marine cleaning technologies to reduce the amount and impact of plastic pollution on the Mediterranean and Baltic Seas. Models will be developed to forecast the impacts of marine plastic litter pollution on ecosystem services. As concern the

innovative technologies tested during the project, removal efficiencies and economic feasibility will be evaluated, taking into account the existing legal and policy frameworks in the CLAIM countries, as well as acceptance of the new technologies by their end-users and relevant stakeholders.

The main technologies developed in this project that could be related with UNIVPM work for BlueLakes, consist in a filtration system and a photocatalytic device, that will be experimented at the effluent of WWTP. The pre-filtration system is developed by HCMR and will sample wastewater and retain larger plastics, while the photocatalytic device will be used for speeding up UV-fueled degradation and breaking down fragmented, low-density polyethylene (LDPE) microplastic residues, by visible light-induced heterogeneous photocatalysis activated by zinc oxide nanorods.

For the sampling campaign that took place at WWTP effluent, 3 cartridge filters in stainless steel were used in line with filtration range of 1500 µm, 70 µm and 30 µm to hold microplastics. The filter arrangement consisted of two parallel streams (70µm + 30µm in line) with a common wastewater supply, prefiltered by the common filter of 1500 µm. During the testing total of 5300 L of wastewater has passed through the sampling system. The preliminary results showed that 80 synthetic filaments were found in the filter of 70 µm. The black filaments contributed to 68,75 %, the blue to 15%, the red to 8,75 % and the transparent and green filaments contributed to 3,75 % each.

First results from the analysis of the efficiency of the photocatalytic system showed a 30% increase of the carbonyl index, a marker used to demonstrate the degradation of polymeric residues. Additionally, an increase of brittleness accompanied by a large number of wrinkles, cracks and cavities on the surface were recorded.

## REPLAWA – Reduction of the Input of Plastics via Wastewater into the Aquatic Environment

The project will analyse the potential sinks of plastic into water bodies, such as treatment plants, storm water drainage, and combined sewer overflows. REPLAWA project will develop practical and robust methods for sampling, sample preparation and analysis, that will be used to detect microplastics entering in the environment and to evaluate treatment efficiencies. The effectiveness of various technical procedures and solutions for plastic elimination will be evaluated. Technical and regulatory recommendations will be developed to help representatives from politics, administration, industry and society to identify reasonable solutions for reducing plastic emissions into the environment.

UNIVPM interest will focus on the investigations conducted for the different treatment stages of conventional wastewater treatment plants: inlet, screen, grit trap, pre-clarification, activation, secondary clarification and effluent. The other discharged material flows, such as sewage sludge, are also a matter of concern. Additionally, the project is evaluating the quality of discharge from wastewater treatment plants using advanced processes for solids separation, e.g. spatial filters, micro sieves or membrane aeration, on several large-scale plants in Germany.

## PLASTRAT - Strategies for Reducing the Entry of Urban Plastics into Limnic Systems

PLASTRAT project will evaluate the degradation stages of different types of plastics as well as leaching, adsorption and desorption in different wastewater treatment stages, the effects of different plastic species (in different degradation stages) and their additives on aquatic organisms in limnic

systems, as well as a risk characterisation of the human toxicological effect of microplastics on consumers of drinking water. The project will develop suitable methods for sampling, processing and analysing microplastics in various media such as water, sediment and sludge. Environmental changes in various types of plastics will be analysed, including mechanisms of breakdown of residues in freshwater and sewage sludge, the presence of potentially dangerous additives, such as plasticizers, and changes in the plastic surface, significant for the absorption and desorption of pollutants from microplastic particles.

The relationship of this project with UNIVPM activity consists in the evaluation of membrane technology and advanced wastewater treatment, such as ozonisation and sand-activated carbon filtration or ultrafiltration membranes, for the elimination of microplastics.

### RUSEKU – Representative Investigation Strategies for an Integrative System Approach to Specific Emissions of Plastics into the Environment

The aim of the joint research project RUSEKU is to develop a reliable and practical method for water sampling in urban wastewater systems and watercourses. The movement and distribution of microplastic particles in watercourses and the wastewater system will be quantitatively predicted and the results integrated into a software that simulates complex, application-oriented cases. As products of the project, a commercially usable simulation code will be developed, that allow the selection of suitable sampling points and a market-ready procedure for efficient and reliable microplastic sampling should be in place.

UNIVPM is interested in the analytical procedures and sampling methods analysed, that include conventional flow-through centrifuges, cascade filtration system, suspended matter traps, hydrodynamic modelling and lysimeter tests. A particular attention is paid also to the simulation model through which evaluate dynamics of microplastic particles in waters.

### 3. WASTEWATER

#### 3.1 WASTEWATER SAMPLING

##### 3.1.1 Introduction

##### 3.1.2 List of sampling methods

<u>SOURCE</u>	<u>PROCESS</u>	<u>VOLUME</u>	<u>METHOD</u>	<u>REFERENCE</u>
Municipal wastewater	Grit-grease	60.1 L	<ul style="list-style-type: none"> <li>Grabbed in glass bottles, both in the morning and in the afternoon</li> <li>Filter through diameter 110 mm, pore size 0.45 mm</li> </ul>	(Bayo, Olmos, & López-Castellanos, 2020)
	Primary clarifier	59.3 L		
	Activated sludge	103.4 L		
	Secondary clarifier effluent	143 L		
Municipal wastewater	Influent (after 6mm screen)	4-30 L	Collected with a 10-L stainless steel bucket attached to a metal wire and poured to a cascade of two test sieves with mesh sizes of 0.25 and 5.0 mm	(Lares, Ncibi, Sillanpää, & Sillanpää, 2018)
	After the primary clarification			
	After the disinfection			
Municipal wastewater	Influent	30 L	<ul style="list-style-type: none"> <li>In the morning (9-11 am)</li> <li>Filtered in loco with a suite of steel sieves with a mesh of 5 mm, 2 mm and 63 µm.</li> </ul>	(Magni et al., 2019)
	After the settler			
	Effluent			
Municipal wastewater	Effluent	500-21,000 L	<ul style="list-style-type: none"> <li>Filtered through a set of Tyler sieves at a flow rate of 12-18 L per minute for a period of 2-24 h</li> <li>A 0.355 mm-mesh sieve was stacked atop a 0.125 mm mesh sieve for the shorter (2 h) sampling times, while the 0.355 mm-mesh sieve was used in isolation for the longer sampling periods</li> </ul>	(Mason et al., 2016)

Municipal wastewater	Influent	1-2 L	<ul style="list-style-type: none"> <li>Grab samples were collected in plastic containers</li> </ul>	(Michielssen, Michielssen, Ni, & Duhaime, 2016)
	Pretreated influent	1-6 L		
	Primary effluent	10-20 L		
	Secondary effluent	10-20 L		
	Final effluent	34-38 L		
Municipal (+industrial) wastewater	Effluent from different configurations of WWTPs	390-1,000 L	<ul style="list-style-type: none"> <li>Custom made mobile pumping device with a filter housing containing a 10 mm stainless steel cartridge filter</li> </ul>	(Mintenig, Int-Veen, Löder, Primpke, & Gerds, 2017)
Municipal wastewater	Influent	30-50 L	<ul style="list-style-type: none"> <li>n=303</li> <li>First passed through steel sieves (65 µm), then vacuum filtered through Whatman No. 1 qualitative circles, 90 mm filter paper, with a pore size of 11 µm.</li> </ul>	(Murphy, Ewins, Carbonnier, & Quinn, 2016)
	Grit&grease effluent			
	Primary effluent			
	Final effluent			
Municipal wastewater	Disc filter	Different volumes for different filter size and unit (2-1,000L) (see the paper)	<ul style="list-style-type: none"> <li>Custom made filtering device with in-situ fractionation</li> <li>The mesh-sizes of the filters were 300, 100 and 20 mm, giving particle size fractions of &gt;300 mm, 100-300 mm and 20-100 mm</li> <li>Additional composite samples for 24 h</li> </ul>	(Talvitie, Mikola, Koistinen, & Setälä, 2017)
	Rapid sand filter			
	Dissolved air floatation			
	MBR			
	CAS			
Municipal wastewater	Post primary treatment	3-200	<ul style="list-style-type: none"> <li>Each sampling event took approximately 1 h with a maximum flow rate of 10 L/min</li> </ul>	(Ziajahromi, Neale, Rintoul, & Leusch, 2017)
	Post primary and secondary treatment			

	Post primary, tertiary and RO treatment		<ul style="list-style-type: none"> <li>The sampling device consists of four removable stainless-steel mesh screens (plain Dutch weave) with sizes of 500, 190, 100 and 25 mm with a diameter of 12 cm.</li> </ul>	
Raw wastewater		1 l	<p>Retsch AS 200 vibratory sieve shaker through 2 mm, 1mm and 500 mm sieve meshes. Sodium dodecyl sulfate (SDS) as a surfactant added to a final concentration of 0.15 g/L before sieving to detach adhered MP particles from the larger solids. 200mL of the pre-sieved wastewater was incubated with cellulase enzyme (<i>Aspergillus</i> sp., Sigma-Aldrich, CAS no. 9012-54-8) for 48 h at 40 °C to degrade cellulose fibers deriving mainly from toilet paper. Organic material was oxidized with hydrogen peroxide where iron (II) was added to catalyze the reaction (Fenton reaction). Peroxide was added to a final concentration of 250 g/L and iron (II) sulfate to 2.5 g/L. The pH of the mixture was adjusted to approximately 3 with sodium hydroxide. The oxidized sample was wet-sieved (demineralized water with 0.15 g/L SDS) into two size fractions through an 80 µm sieve mesh. The effluent containing particles &lt;80 µm was collected into a glass beaker. Particles &gt;80 µm were removed from the sieve mesh into filtered demineralized water containing 0.15 g/L SDS by treatment in an Elma S50R ultrasonic bath. Particles from this liquid and the collected effluent were gathered on separate 10 µm steel meshes. Particles were removed from the filters into 25mL HPLC grade ethanol by ultrasonic treatment. The resulting particle-ethanol suspensions of the two size fractions were transferred into glass vials where their final volume was set to 5mL by evaporation with nitrogen gas. The chemical composition of the extracted particles was determined with an FPA-based FT-IR imaging technique.</p>	(Simon, van Alst, & Vollertsen, 2018)
Treated wastewater			<p>10 µm steel filters, ultrasonic treatment, collection in filtered demineralized water containing 0.15 g/L SDS. Incubation in a serum flask for 48 h at 40 °C with cellulase enzyme. Samples oxidized in 180 g/L hydrogen peroxide catalyzed by 1.8 g/L iron (II) sulfate and pH adjusted to 3 by sodium hydroxide. Size fractionation by wet-sieving and transferring the particle-ethanol suspension into glass vials.</p>	

Municipal wastewater effluent	Screening Grit and grease removal Settling tank Aeration basin Clarifier	30-50 L	Steel buckets and sieve	(Murphy et al., 2016)
Municipal wastewater effluent			Fractionated filtering	(Triebkorn et al., 2019)
Municipal wastewater effluent			Sieving and filtering method	
Municipal wastewater effluent			Custom made pump +stainless steel cartridge filter	
Municipal wastewater effluent		2 L	Effluent: grab samples	
Wastewater, 24-hour composite samples	Influent wastewater, after mechanical purification and after the process from discharged wastewater.	From 100 ml (incoming wastewater) to 8 litres (purified wastewater). 50 liters of purified wastewater were filtered through 300 and 100 µm	Filter device consists of three transparent plastic tubes (diameter 60 mm) and screw-on plastic connectors attaching the tubes to one another. Round (diameter 80 mm) filters are placed into the filter device between the connectors and tubes are screwed tightly together with rubber o-rings. Round filters are cut from different mesh size plankton nets. The largest mesh size filter 300 µm is placed on the top of the device, 100 µm filter in the middle and 20 µm filter at the bottom. All equipment has to be rinsed thoroughly prior to sampling.	(Talvitie et al., 2017)

		filters and 1 liter through the 20 µm filter.		
Sewage sludge	Anaerobic digestion	2 kg	<ul style="list-style-type: none"> <li>• Composite over one day in each month</li> <li>• Suspended, pre-washed and then filtered through 5 mm stainless steel</li> </ul>	(Xu et al., 2020)
Sewage sludge	Activated sludge MBR sludge Anaerobic digestion	150-200 mL	Poured in glass flasks with metal funnel, kept in dark	(Lares et al., 2018)
Sewage sludge	Drained	500 g	Taken by shovel, stored in dark	(Mintenig et al., 2017)
Sewage sludge	Anaerobic digestion	30 g	<ul style="list-style-type: none"> <li>• Three replicates</li> <li>• Pellets of TD sludge were placed in water for 1 week to induce softening, transferred to a water bath (30 °C) for 24 h, and placed in an shaker for 12 h.</li> </ul>	(Mahon et al., 2017)
	Thermal drying			
	Lime stabilization			

### 3.1.3 Discussion

### 3.1.4 Suggestions on the best practise

**Continuous composite sampling with as much volume of wastewater as possible using steel buckets and sieves (50 µm mesh size or lower are recommended).**

## 3.2 WASTEWATER TREATMENT PLANTS (WWTPs) TYPOLOGIS AND EFFICIENCIES

### 3.2.1 Introduction

### 3.2.2 List of treatments and efficiency

<u>WWTPs</u>	<u>SCALE</u>	<u>PROCESS</u>	<u>REMOVAL EFFICIENCIES</u>	<u>Ref.</u>
Vancouver, Canada	Full Scale	Sedimentation	91.7%	(Ngo, Pramanik, Shah, & Roychand, 2019)
Wuhan, China	Full Scale	Sedimentation and Aerated grit chamber	40.7%	
Beijing, China	Full Scale	Aerated grit chamber	58.8%	
Hameenlinna, Southern Finland	Full Scale	Dissolved air flotation	95%	
Beijing, China	Full Scale	A2O	54.4%	
Sydney, Australia	Full Scale	Activated sludge	66.7%	
Vancouver, Canada	Full Scale	Trickling filters	80.8%	
Sydney, Australia	Full Scale	RO	90.4%	
Mikkeli, Finland	Full Scale	MBR	99.9%	
Western New York, USA	Full Scale	Sand and anthracite coal filtration	15%	
Turku, Finland	Full Scale	Rapid sand filter	97.1%	
Helsinki, Finland	Full Scale	Disc filter	98.5%	

Wuhan, China	Full Scale	Chlorinate disinfection	16.7	
Plum Island	180000 PE	Primary screening, Primary clarifiers, Activated sludge, Secondary clarifiers, Sludge handling, Dewatering, Disinfection (NaOCl)	97.12%	(Conley, Clum, Deepe, Lane, & Beckingham, 2019)
Rifle Range Road	53000 PE	Primary screening, Anoxic selectors, Activated sludge, Secondary clarifiers, Sludge handling, Dewatering (Belt Press), Disinfection (NaOCl)	80.2%	
Center Street	32000 PE	Primary screening, Anoxic selectors, Activated sludge, Secondary clarifiers, Sludge handling, Dewatering (Belt Press), Disinfection (NaOCl)	83.7%	
Sweden	12000 PE	Primary and Secondary treatments	99.9%	(Sun, Dai, Wang, van Loosdrecht, & Ni, 2019)
France	800000 PE	Primary and Secondary treatments	88.1%	
United States	Pilot Scale	Primary and AnMBR	99.4%	
Finland	Pilot Scale	Primary and MBR	99.3%	
United States	9900 PE	Primary, Secondary, Tertiary (GF)	97.2%	
Finland	800000 PE	Primary, Secondary, Tertiary (BAF)	97.8%	
Italy, Falconara	Pilot scale	UASB and AnMBR	96%	(Pittura et al., 2020) (UNIVPM, submitted paper)
China, Wuxi	50000 m3/d	Aerated grit chambers, Oxidation ditch, secondary clarifier, UV disinfection	97%	(Lv et al., 2019)
China, Wuxi	70000 m3/d	A/A/O and MBR tank	99.5%	

Scotland	650000 PE	Primary and Secondary treatments	98.4%	(Edo, González-Pleiter, Leganés, Fernández-Piñas, & Rosal, 2020)
Spain, Cartagena	210000 PE	Primary and secondary activated sludge process plus chlorine disinfection	90.1%	
Spain, Madrid	300000 PE	Primary and A2O (Anaerobic, Anoxic, Oxidic) biotreatment	93.7%	
WWTP	Full scale	Primary treatment, aeration, sedimentation and UV disinfection.	66% MPs (> 25 µm)	(Ziajahromi et al., 2017)
WWTP	Full scale	Biological treatment, flocculation, disinfection/de-chlorination, ultrafiltration, reverse osmosis and de-carbonation	> 90 % MPs (> 25 µm)	
WWTP	Full scale	Membrane bioreactor MBR treating primary effluent	99.9 % (from 6.9 to 0.005 MP/l) for grab samples, n = 3; 94% for 24h composite samples	(Talvitie et al., 2017)
WWTP	Full scale	Rapid sand filter	97% (from 0.7 to 0.02 MP/l) for grab samples, n = 3; > 90% for 24h composite samples	
WWTP	Full scale	Dissolved air flotation	95% (from 2.0 to 0.1 MP/l) for grab samples, n = 3; 48% for 24h composite samples	
WWTP	Full scale	Disc filter	40-98.5% (from 0.5-2.0 to 0.03-0.3 MP/l) for grab samples, n = 3	
WWTP effluent	Full scale	Free water surface (FWS) wetlands	close to	Jönsson, 2016

			100 % for MPs > 20 µm	
Örsundsbro wetland	1430 PE, 667 m3/d Inlet: 950 objects/L	Free water surface (FWS) wetlands after WWTP	-Microplastic 20-300 µm: 99,7% -Microplastic >300 µm: 100% -Red "potential" microplastics >20 µm: 81% -Black partickles > 20 µm: 89%	Jönsson, 2016
Wetland Alhagen	13000 PE, 5100 m3/d Inlet: 4 objects/L	free water surface (FWS) wetlands after WWTP	-Microplastic 20-300 µm: 99,8% -Microplastic >300 µm: 100% -Red "potential" microplastics >20 µm: 100% -Black partickles > 20 µm: 49%	Jönsson, 2016
WWTP Vodokanal of St. Petersburg	Full scale	Mechanical treatment	-Textile fibers: 92.93 % -Synthetic particles: 86.88% -Black particles: 90.44 %	Julia Talvitie, Mari Heinonen. 2014
WWTP Vodokanal of St. Petersburg	Full scale	Purification after mechanical treatment	-Textile fibers: 51.5 % -Synthetic particles: 66.7% -Black particles: 58.6 %	Julia Talvitie, Mari Heinonen. 2014
WWTP	Full scale		98% (MPs > 250 µm)	(Lares et al., 2018)

WWTP, USA	1.51 million m <sup>3</sup> /d		99.9% (MPs > 100 µm)	(Carr, Liu, & Tesoro, 2016)
WWTP	650000 PE, 260954 m <sup>3</sup> /d	Grit and grease removal	44.59%	(Murphy et al., 2016)
WWTP	650000 PE, 260954 m <sup>3</sup> /d	Primary treatment	60.92%	
WWTP	650000 PE, 260954 m <sup>3</sup> /d	Whole plant	98.41% (MPs > 65 µm)	
Denmark	Full scale	Whole plant	99% (MPs > 10 µm)	(Simon et al., 2018)
Netherlands	Full scale		72% (MPs > 10 µm)	(Leslie, Brandsma, van Velzen, & Vethaak, 2017)

### 3.2.3 Discussion

### 3.2.4 Suggestions on the best practise

**Physical treatments (filtration, settling, mechanical units) are more efficient and have the most drastic effect on MPS removal due to affinity of MPs onto solids. If possible, the use of MBRs are highly recommended. On the other hand, conventional treatment schemes (i.e. CAS) can also remove MPs up to 90% and even more.**

## 4. DRINKING WATER

### 4.1 DRINKING WATER SAMPLING

#### 4.1.1 Introduction

#### 4.1.2 List of sampling methods

<b><u>SAMPLING POINTS</u></b>	<b><u>VOLUME</u></b>	<b><u>TYPE of SAMPLE</u></b>	<b><u>METHODS OF SAMPLING AND DETENTION</u></b>	<b><u>FREQUENCY or num° of samples</u></b>	<b><u>Ref.</u></b>
Raw and treated drinking water (after each process)	1L	<i>Grab samples</i>	Digestion with 30% hydrogen peroxide (H <sub>2</sub> O <sub>2</sub> ) for 24 h. Filtration through a series of 5 µm (PTFE) membrane filters followed by a 0.22 µm pore sizes. The purpose of this two-filtration was to descend mesh size to pass the entire sample through the filter without clogging. These filters were used for scanning electron microscope (SEM) analysis of retained particles. For each sample, a volume of 250 ml was separately filtered for quantitative and qualitative analysis of particles. The filters after drying in an oven at 30°C for 30 min were stored in covered glass petri dishes for subsequent analysis. DXR2 micro-Raman imaging microscope system (Thermo Fisher Scientific, USA) was employed (532 nm laser, laser spot size around 0.5 µm, Raman shift 50–3550 cm <sup>-1</sup> , spectral resolution of 5 cm <sup>-1</sup> ) for qualitative analysis of particles.	3 times /winter	(Wang, Lin, & Chen, 2020)
Raw and treated drinking water	27L each sample	<i>Average daily samples</i>	Wet peroxide oxidation was conducted to remove organic material, Filtration through a series of 5 µm (PTFE) membrane filters followed by a 0.22 µm pore sizes. The purpose of this two-filtration was to descend mesh size to pass the entire sample through the filter without clogging. These filters were used for scanning electron microscope (SEM) analysis of retained particles. For each sample, a volume of 250 ml was separately filtered for quantitative and qualitative analysis	3 times within a 24-hour period (every 8 h) and repeated three times in winter period	(Pivokonsky et al., 2018)

			of particles. The filters after drying in an oven at 30°C for 30 min were stored in covered glass petri dishes for subsequent analysis		
Raw and treated drinking water	9-27 L		Scanning electron microscopy analysis for particle counts; both micro-Raman spectroscopy and $\mu$ -FT-IR were used for identification of particles with size of 1e10mm and >10mm		(Eerkes-Medrano, Leslie, & Quinn, 2019)
Raw and treated drinking water	1000 L	<i>Grab samples</i>	Samples directly sieved, tap water require no digestion.		(Koelmans et al., 2019)
Raw and treated drinking water	300-2500 L	<i>3<math>\mu</math>m stainless steel cartridge filters 4 7/8", Wolftechnik, Germany</i>	Residual raw water and drinking water was removed from the filter units by using filtered (0.2 $\mu$ m) compressed air. Then, the units were filled again with diluted hydrochloric acid (Carl Roth GmbH & Co. KG, Germany, 0.2 $\mu$ m filtered, pH=2) to dissolve calcium carbonate and iron precipitates. After 24 h the filter units were emptied, the cartridge filters removed from the units and rinsed with Milli-Q and ethanol (30%, Carl Roth GmbH & Co. KG, Germany, filtered over 0.2 $\mu$ m). The retentate was collected on 3 $\mu$ m stainless steel filters (47mm in diameter) that were subsequently transferred into glass bottles and covered with 30 mL hydrogen peroxide (35%, Carl Roth GmbH & Co. KG, Germany). The bottles were closed using aluminium foil and incubated for 24 h at 40 °C. Finally, each sample was enriched onto a 0.2 $\mu$ m aluminium oxide filter (Anodisc 25 mm, Whatman, U.K.) by using an in-house fabricated filter-funnel with an inner diameter of 11 mm. The filters were dried at 40 °C in half closed glass petri dishes for subsequent analysis.	24 samples	(Mintenig et al., 2017)

#### 4.1.3 Discussion

#### 4.1.4 Suggestions on the best practise

**Higher volumes of water should be sampled compared to wastewater. Composite sampling is recommended using steel buckets and sieves (50  $\mu$ m mesh size or lower are recommended).**

## 4.2 DRINKING WATER TREATMENT PLANTS (DWTPs) TYPOLOGIES AND EFFICIENCIES

### 4.2.1 Introduction

### 4.2.2 List of treatments and efficiency

TREATMENT	SCALE	PROCESS	REMOVAL EFFICIENCIES	NOTES	Ref.
ADWTP Yangtze River (China)	120-150 million m <sup>3</sup> /d	Coagulation combined with sedimentation	40.5-54.5 %	MPs > 10 µm almost completely removed. 44.9–75.0% for 5–10 µm. 28.3–47.5% for 1–10 µm. 53.5–74.6% for MPs < 10 µm Mainly fibres removal: 50.7–60.6%	(Wang et al., 2020)
		Sand filtration	29.0-44.4 %		
ADWTP	120-150 million m <sup>3</sup> /d	Ozonation combined with GAC filtration	56.8-60.9 %	Mainly small-sized MPs. 73.7–98.5% of MPs removed by GAC filtration was the particles ranging in size from 1 to 5 µm. The removal efficiencies of fibres, spheres and fragments were 38–52.1%, 76.8–86.3% and 60.3–69.1%, respectively	
ADWTP TOTAL	120-150 million m <sup>3</sup> /d	Coagulation-flocculation, sedimentation, sand filtration and advanced treatment units, ozonation combined with GAC filtration	82.1-88.6 %	Microplastics in the effluent with size from 1 to 5 µm (around 84.4–86.7% of MPs).	
DWTP		Coagulation-flocculation, sedimentation and sand filtration	58.9–70.5%		

DWTP supplied by large surface water reservoir		flocculation and one-step separation (sand filtration);	70 %	Majority of MPs detected in treated water < 10 µm. Fiber removal 20%	(Pivokonsky et al., 2018)
DWTP supplied by small surface water reservoir		Coagulation-flocculation, sedimentation, sand filtration and granular activated carbon (GAC) filtration	81 %	Majority of MPs detected in treated water < 10 µm. Fiber removal > 80%	
DWTP supplied by river		coagulation/flocculation, sedimentation, sand filtration and granular activated carbon (GAC) filtration	83 %	Majority of MPs detected in treated water < 10 µm. Fiber removal > 80%	
Water treatment	Lab scale	Coagulation	PE removal (17 ± 2%)	at pH 8 at the coagulant dose of 2.0 mmol/l.	(Ma et al., 2019)
Water treatment	Lab scale	Coagulation with Fe	37±3% PE removal	obtained (at pH 7) with Al-based coagulant dose of 15 mmol/l = 112 mg/l Fe	
Water treatment	Lab scale	Coagulation with Al	PE removal 8±1%	0.5 mmol/l = 13.5 mg/l Al	
Water treatment	Lab scale	Coagulation with flocculant polyacrylamide (PAM)	PE removal 85–90%	2.0 mmol/L FeCl <sub>3</sub> ·6H <sub>2</sub> O (at pH 7) (> maximum authorized dose of 1 mg/l)	
Water treatment	Lab scale	Coagulation with flocculant polyacrylamide (PAM)	PE removal 50–60%	5mmol/l AlCl <sub>3</sub> ·6H <sub>2</sub> O with 3–15 mg/l anionic PAM (at pH 7) (>maximum authorized dose of 1 mg/l)	

#### 4.2.3 Discussion

#### 4.2.4 Suggestions on the best practise

Similar to WWTPs, physical treatment units have the best performance to remove MPs; however, other processes like chemical treatment (i.e. coagulation-flocculation) and disinfection can enhance the removal efficiency.

## 5. COMBINED SEWER OVERFLOWS (CSOs)

### 5.1 CSOs SAMPLING METHODS

#### 5.1.1 Introduction

#### 5.1.2 List of sampling methods

<u>SAMPLING POINTS</u>	<u>VOLUME</u>	<u>TYPE OF SAMPLE</u>	<u>METHODS OF SAMPLING AND DETENTION</u>	<u>FREQUENCY or num° of samples</u>	<u>Ref.</u>
stormwater runoff	1L per each sample	Grab sample	Iron bucket that was rinsed three times with the runoff before taking the samples. The samples were a combination of sediment and water due to the strength of the runoff streams in the streets or storm drains. These samples were collected at the beginning of the rain event and at approx 10 min and 30 min after the first samples were collected.	94 samples	(Piñon-Colin, Rodriguez-Jimenez, Rogel-Hernandez, Alvarez-Andrade, & Wakida, 2020)
Stormwater pond	up to several thousand liters for the bigger mesh size, 10-70 liters with a mesh size of 20 µm.	Grab sample	Sampling method consisted of a gasoline pump, hoses, filter holder and filter. Two types of filters were tested; plankton net (mesh size 300 µm) manually cut into circles and prefabricated polycarbonate filters (mesh size 10 µm). A mechanical volumeter was attached to the outlet hose in order to measure the volume of water filtered. The filter holder consisted of stainless-steel pipes, gaskets, and a clamp. The inner diameter of the stainless-steel pipes was in this case 2 inches. The inlet and outlet hoses chosen had inner diameters of 1,5 and 1 inch. The inlet hose was of sturdier material, not to deflate due to the suction pressure of the pump. Polyester plankton nets (Sefar Petex), where cut into circles to fit the filter holder. Two mesh sizes were used. The mesh size of 300 µm was used to allow for comparison of results with the majority of studies conducted thus far. Quantification performed manually by counting MPs using a microscope. Some of the detected MPs were analyzed with FTIR spectroscopy.		Coalition Clean Baltic, 2017

### 5.1.3 Discussion

### 5.1.4 Suggestions on the best practise

**Practices on CSO/runoff water are very limited up to date, including only grab samples. The methodology on the wastewater can be followed.**

## 5.2 CSOs TYPOLOGIES AND EFFICIENCIES

### 5.2.1 Introduction

### 5.2.2 List of treatments and efficiency

TREATMENT	SCALE	REMOVAL EFFICIENCIES	Ref.
Tibbledammen Stormwater pond	5.7 ha, 4300 m3/d Inlet: 5.4-10 MPs/L	<ul style="list-style-type: none"> <li>- Microplastic 20-300 µm: 98%</li> <li>- Microplastic &gt;300 µm: 73%</li> <li>- Red "potential" microplastics &gt;20 µm: 99%</li> <li>- Black partickles &gt; 20 µm: 89%</li> </ul>	Jönsson 2016
Korsängen vattenpark Stormwater pond	9 ha, 3440 m3/d Inlet: 5.4-10 MPs/L	<ul style="list-style-type: none"> <li>- Microplastic 20-300 µm: 90%</li> <li>- Microplastic &gt;300 µm: 100%</li> <li>- Red "potential" microplastics &gt;20 µm: 100%</li> <li>- Black partickles &gt; 20 µm: 99%</li> </ul>	Jönsson 2016

### 5.2.3 Discussion

### 5.2.4 Suggestion on the best practice

**Up to date, only ponds were tested for MPs removal in runoff waters. Compact treatment technologies can be designed and applied specifically for CSOs (Filtration + GAC/PAC + UV).**

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## 1. INTRODUCTION

This report is structured in four parts:

- R&D&I projects which BlueLakes can be built on or relate to
- Literature review about sampling, treatment processes and efficiencies concerning
  - a. Wastewater treatment plants
  - b. Drinking water treatment plants
  - c. Combined sewers overflows

## 2. PROJECTS RELATED TO MPs

### 2.1 Introduction

Microplastics detection and removal from water matrix is a theme of always bigger concern in all European level and a wide range of projects are developing innovative solutions for their management. The first step often consists in the choice of a simple, affordable and exploitable sampling method, that allows results comparison and sharing. Many projects, as CLAIM, TextileMission, EMISTOP, ENSURE and RUSEKU, report studies, as the ones for HELCOM BASE Project and Norwegian Institute for Water Research, and guidelines, as those of CCB, contemplate the development of a sampling method. Projects as RUSEKU and Sub $\mu$ Track and the HELCOM BASE study are focusing on MPs detection in the WWTPs. REPLAWA, PLASTRAT, TextileMission and ENSURE projects will analyse treatment efficiencies. As concern CSOs management, projects as INTCHATCH and InRePlast and CCB Guidelines provide useful information on MP removal in wetlands, stormwater ponds and drainage systems. New treatment technologies are developing in SMART-Plant, CLAIM, Plastfri Roskilde Fjord and SimConDrill projects. New commercial products are also developing, such as Wasser 3.0 PE-X® technology.

## 2.2 List of projects

Project-Activity Title	Description	Links	Funded through	Coordinating Institution	Duration	Interest for BlueLakes
<b>INTCATHC</b>	Monitoring and management of surface water quality; developing efficient, user-friendly water monitoring strategies and systems based on innovative technologies that will provide real time data for important parameters, moving towards SMART Rivers.	<a href="https://www.intcathc.eu/">https://www.intcathc.eu/</a>	Horizon 2020	BRUNEL UNIVERSITY LONDON	Start date: 1 June 2016 End date: 31 January 2020	Manage water pollution in surface runoffs and CSO:  Expert Team provides customers with the most effective and low-cost solutions of Combined Sewer Outflow (CSO) and surface runoff treatment systems  A wide range of completely automatic and fully adaptive treatment systems are offered depending on customer's needs including combination of coarse screening system, rotating dynamic filter, quartzite filter, GAC adsorption system and UV disinfection
<b>SMARTPLANT</b> Scale-up of low-carbon footprint MATERIAL Recovery Techniques in existing wastewater treatment PLANTS	SMART-Plant will scale-up in real environment eco-innovative and energy-efficient solutions to renovate existing wastewater treatment plants and close the circular value chain by applying low-carbon techniques to recover materials that are otherwise lost.	<a href="https://www.smartplant.eu/">https://www.smartplant.eu/</a>	Horizon 2020	UNIVERSITÀ POLITECNICA DELLE MARCHE	Start date: 1 June 2016 End date: 31 May 2020	<b>Salsnes Filter AS</b> is a technology provider and a partner of SMART-Plant. Salsnes filters have been tested for the treatment of different water fluxes, including the effluent from WWTPs. Salsnes has developed a unique fine mesh sieve system for treatment of municipal and industrial wastewater, a mechanical wastewater treatment system, with integrated thickening and sludge dewatering. The patented filter technology is a very compact unit for mechanical separation of suspended solids from wastewater. With the integrated sludge dewatering unit, Salsnes Filter wastewater treatment processing plants meet the highest standards and the specifications of the European Commission for reduction of waste effluents (primary treatment). Salsnes Filter has significant experience from extensive national and international R&D activities, including FP6 and FP7 projects.

<b>CLAIM</b> - Cleaning Litter by developing and Applying Innovative Methods in european seas	Development of innovative cleaning technologies and approaches, targeting the prevention and in situ management of micro and macroplastics in the Mediterranean and Baltic Sea.	<a href="https://www.claim-h2020project.eu/">https://www.claim-h2020project.eu/</a>	Horizon 2020	HELLENIC CENTRE FOR MARINE RESEARCH, EL	Start date: 2017/11/01 End date: 2021/10/31 Duration: 48 months	<ul style="list-style-type: none"> <li>Pre-filtering system to retain larger plastics, while simultaneously taking two samplers;</li> <li><b>Photocatalytic nanocoating device for cleaning microplastics in wastewater treatment plants</b> to obtain the degradation of low-density polyethylene (LDPE) microplastic, by visible light-induced heterogeneous photocatalysis activated by Zinc oxide nanorods.</li> </ul>
<b>REPLAWA</b> Reduction of the Input of Plastics via Wastewater into the Aquatic Environment .	The project will investigate and quantitatively assess entry points into water bodies through treatment plants, storm water drainage, and combined sewer overflows as well as swales at treatment facilities and in sewage sludge.	<a href="http://www.replawa.de">www.replawa.de</a>	BMBF German Federal Ministry for Education and Reserach	Emscher Wassertechnik GmbH, Essen	January 2018 - December 2020	The project will test and rate various practical methods of reducing and eliminating plastic emissions into waterways during wastewater treatment. Based on the results of these investigations and of assessments regarding international regulatory approaches in this field, the project will derive strategies for reducing plastic release from wastewater treatment into waterways.
<b>HELCOM BASE</b> Project - Implementation of the Baltic Sea Action Plan in Russia	Preliminary study on synthetic microfibers and particles at a municipal wastewater treatment plant	<a href="https://helcom.fi/helcom-at-work/projects/basel/">https://helcom.fi/helcom-at-work/projects/basel/</a>	EU	Helsinki Regional Environmental Services HSY	2012-2014	Study the amount of microplastic litter arriving at the Central Wastewater Treatment Plant (WWTP) of St. Petersburg and the effect of the purification process. Helsinki Region Environmental Services Authority HSY developed a microplastic sampling method targeted at wastewaters.

Mapping microplastics in sludge - Research Report	Characterization of microplastics in sewage sludge from Norwegian domestic wastewater treatment plants applying different wastewater and sludge treatment technologies.	<a href="https://niva.unit.no/xmlui/handle/11250/2493527">https://niva.unit.no/xmlui/handle/11250/2493527</a>	Norwegian Institute for Water Research		2017	Fenton's reagent was used to remove organic matter and density separations were employed to extract microplastics from sludge samples. Plastics were found in all ten sludge samples investigated from eight WWTPs. The overall average plastic abundance was 6 077 particles kg <sup>-1</sup> (d.w.) (1701 – 19 837) or 1 176 889 particles m <sup>-3</sup> (470 270 – 3 394 274).
Guidance on concrete ways to reduce microplastic inputs from municipal stormwater and wastewater discharges	Concrete ways to reduce micropalstics from stormwater and wastewater and simple methodology to monitor riverine inputs of micropalstics.	<a href="https://www.ccb.se/documents/Postkod2017/CB%20-%20Guidance%20on%20concrete%20ways%20to%20reduce%20microplastics%20in%20stormwater%20and%20sewage.pdf">https://www.ccb.se/documents/Postkod2017/CB%20-%20Guidance%20on%20concrete%20ways%20to%20reduce%20microplastics%20in%20stormwater%20and%20sewage.pdf</a>	Coalition Clean Baltic for protection of the Baltic Sea environment		2017	Constructed free water surface wetlands can be efficient in reducing microplastics from effluents of WWTPs to the water bodies. High MP concentrations found in urban stormwater. Stormwater ponds used as end of pipe solutions show good removal efficiency for microplastics. Methods for sampling and analyzing microplastic contents in water. Abundance of microplastics smaller than 300 µm in stormwater and sewage water.

<b>Plastfri</b> Roskilde Fjord project	Investigating, mapping and identifying plastic pollution effects and sources, and finding concrete solutions and actions to prevent plastic pollution	<a href="https://plasticchange.dk/vi-denscenter/plastfri-roskilde-fjord-plastikforurening-i-danmark/">https://plasticchange.dk/vi-denscenter/plastfri-roskilde-fjord-plastikforurening-i-danmark/</a>				<b>Alfa Laval</b> supplied a <b>pilot membrane filtration system</b> that was used to determine the amount and type of microplastics in the main wastewater treatment plant, which releases treated water into Roskilde Fjord.
<b>Wasser 3.0 PE-X®</b>	Simple, reproducible and cost-efficient processes with no negative environmental effects for the elimination of microplastics from sewage water	<a href="https://wasserdreinull.com/">https://wasserdreinull.com/</a>		University Koblenz- Landau, Dr. Katrin Schuhen		With <b>Wasser 3.0 PE X</b> it has been developed the first method to remove microplastics from the water without any additional complicated filter technology. By applying a non-toxic hybrid silica gel, table tennis ball sized balls float on the water surface and are easily removed from there.
<b>SimConDrill</b> - Innovative filter modules for the separation of microplastics from wastewater	Development of a filter that is ready for serial production, which enables the filtration of particles down to 0.01mm (this equals the thickness of household aluminium foil) based on the patented cyclone filter.	<a href="https://www.simcndrill.com/">https://www.simcndrill.com/</a>	Federal Ministry of Education and Research (BMBF)	Fraunhofer Institute for Laser Technology		New water filter removes microplastics with laser-drilled tiny holes. A group of five partners from industry and research now wants to develop a <b>new filter</b> that uses <b>laser-drilled holes</b> to efficiently filter out particles as small as 10 micrometres even in large amounts of water.

<b>TextileMission</b> – Microplastics of Textile Origin - A Holistic View: Optimized Processes and Materials, Material Flows and Environmental Behavior.	<p>Synthetic fiber particles with a diameter of less than 5 millimetres are only partially filtered out by modern wastewater treatment plants. The partners of the joint research project TextileMission have taken on the task of reducing this environmental impact.</p>	<a href="https://textilemission.bsi-sport.de/en/">https://textilemission.bsi-sport.de/en/</a>	<p>BMBF (German Federal Ministry for Education and Research)</p>	<p>Federal Association of the German Sporting Goods Industry e.V. / BSI</p>	<p>September 2017 August 2020</p>	<p><b>WP 4 Polyester fibres:</b> At the TU Dresden, <b>analysis and sample preparation method</b> is established to quantify microparticles from wastewater streams and fractionate them according to size. <b>Investigation of the retention capacity of textile (fluorescence-labelled) microparticles in the different stages of a laboratory wastewater treatment plant and identification of efficient retention possibilities.</b> Material flows are analysed including a first estimate of the Germany-wide textile microplastic emission from wastewater into water bodies /soils. <b>WP 5: Consideration of other environmental issues related to the project, stakeholder involvement and communication at the end of the project.</b> Focus on the retention of textile microfibre particles through various purification stages in wastewater treatment plants.</p>
<b>InRePlast</b> – Environmental Policy Instruments to Reduce Plastic Pollution of Inland Waters through Drainage Systems	<p>How and which plastics end up in wastewater and how these inputs can be reduced with the help of environmental legislation is the focus of the joint research project InRePlast. Based on an analysis of sources, entry points and polluters, the researchers are developing and testing measures for behavioural changes.</p>	<p>www.inreplast.de <a href="https://bmbf-plastik.de/en/joint-project/inreplast">https://bmbf-plastik.de/en/joint-project/inreplast</a></p>	<p>BMBF (German Federal Ministry for Education and Research)</p>	<p>University of Kassel, Department of Economics, Division of Economic Policy, Innovation and Entrepreneurship</p>	<p>January 2019 - December 2021</p>	<p><b>WP 1: Inventory of the entry points of plastics into the drainage systems.</b> Determine the status quo of plastic discharges into the drainage systems in four selected model municipalities, which represent different settlement structures. For this purpose, the type and quantity of plastic products as well as their sources from households, industry, traffic and other activities related to wastewater collection and drainage of paved areas will be determined. <b>WP 4: Material flow models of plastic inputs into canalisation systems and wastewater treatment plants.</b> Material flow models for plastic discharges of macro- and microplastics from the identified sources into the drainage systems will be developed for the four model communities. Based on the model results, the sources and product types are analysed and evaluated with regard to their relevance for the plastic inputs. The data from the municipalities is then extrapolated to the federal level in a general model.</p>

<p><b>EmiStop</b> - Identification of Industrial Plastic Emissions by Means of Innovative Detection Methods and Technology Development to Prevent the Input into the Environment via the Wastewater Pathway</p>	<p>Detect emissions of plastics into wastewater from relevant industries. Select wastewater treatment technologies that will optimise reduction of emissions of plastics for the respective value chain. The project will evaluate existing technologies for separating particles, investigate deposition rates, and develop approaches for technical optimisation. Optimisation also includes technological developments such as flocculants. Researchers will conduct tests in both laboratory and pilot project settings – selected large scale technical wastewater treatment plants will be investigated at industrial facilities.</p>	<p><a href="http://www.emistop.de/page8.html">http://www.emistop.de/page8.html</a> <a href="https://bmfpplastic.de/en/joint-project/emistop">https://bmfpplastic.de/en/joint-project/emistop</a></p>	<p>BMBF (German Federal Ministry for Education and Research)</p>	<p>EnviroChemie GmbH, Rossdorf</p>	<p>January 2018 - December 2020</p>	<p>Standardisation of sampling and sample preparation for <b>industrial wastewater</b> (in alignment with Plastik-Net and other joint research projects). Quantitative and qualitative measurement of plastic concentrations in industrial wastewater using Raman spectroscopy and dynamic differential calorimetry. Extended data collection at the sampled industrial wastewater treatment plants for the derivation of the plastic loads and testing of a correlation between the measurement results and routine water chemical analyses. Development of magnetic plastic particles in the micrometre range with the physical properties of relevant types of plastic. Development of a tracer test with magnetic plastic particles. Assessment of technologies for particle separation with regard to the retention of (micro-) plastic particles. Optimisation of particle separation technologies. Development of flocculants for the targeted improvement of the retention of individual types of plastics and their mixtures</p>
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<b>ENSURE</b> Development of New Plastics for a Clean Environment by Determining of Relevant Entry Points.	Holistic approach to reduce plastic in the environment as well as the related negative consequences, including improving methods of analyzing the environmental impact of plastics.	<a href="https://www.ensure-project.de/bf-plastik.de/en/joint-project/ensure">https://www.ensure-project.de/bf-plastik.de/en/joint-project/ensure</a>	BMBF (German Federal Ministry for Education and Research)	University of Stuttgart	April 2018 - March 2021	In the "Traceability" module, undesirable plastic inputs in prioritised sectors (soils, wastewater treatment plants, composting plants and biogas plants) are detected and identified. In a first step, <b>sampling strategies</b> are developed so that in a second step representative investigations can be carried out to <b>determine the current states of plastics in fermentation, compost and wastewater treatment plants.</b>
<b>PLASTRAT</b> - Strategies for Reducing the Entry of Urban Plastics into Limnic Systems	Development of solution strategies for the sustainable limitation of plastic residues propagation in the aquatic environment. Emphasis will be put on the analysis and evaluation of degradation levels of various types of plastic as well as leaching, adsorption, and desorption in different wastewater treatment stages, The focus will also be on the quantification and technical reduction potential (e.g. use of membrane technology) of plastic emissions in the field of urban water management including sewage sludge treatment	<a href="http://www.plastrat.de/project/mbf-plastik.de/en/joint-project/plastrat">http://www.plastrat.de/project/mbf-plastik.de/en/joint-project/plastrat</a>	BMBF (German Federal Ministry for Education and Research)	Bundeswehr University Munich Institute of Hydroscience / UniBwM Chair of Sanitary Engineering and Waste Management	September 2017 - August 2020	<p><b>WP 2: Degradation and material dynamics.</b> The release of pollutants (oligomers, additives and their transformation products) is analysed depending on the type of polymer and the degree of degradation. Furthermore, differences in the adsorption/desorption of environmental chemicals are investigated for different types of polymers and the role of wastewater treatment plants regarding the pollutant load of microplastics (enrichment or depletion).</p> <p><b>WP 3: Entry points and elimination.</b> Different entry points of microplastics into limnic systems are assessed, focusing on the analysis and evaluation of the wastewater management system including measures for microplastic retention (e.g. membrane technology) that already exist or have been modified or developed in the course of the project. Core areas comprise rain and mixed water discharge, the assessment and evaluation of the entire wastewater treatment plant system, and an analysis of sewage sludge, digestate and compost as possible microplastic sinks. Emphasis is also put on the development and selection of suitable processing and analytical methods.</p>

	under consideration of sampling, sampling preparation, and analysis methods.					
<b>RUSEKU</b> – Precise Detection of Microplastics in Water	Plastics in the Environment: Sources - Sinks – Solutions. Development of representative test methods that can accurately and quickly determine the microplastic content over various parts of the water cycle. The focus is on sampling methods in urban wastewater systems and watercourses.	<a href="https://netzwerke.bam.de/ruseku">https://netzwerke.bam.de/ruseku</a> <a href="https://bmfp-plastik.de/en/join-t-project/ruseku">https://bmfp-plastik.de/en/join-t-project/ruseku</a>	BMBF (German Federal Ministry for Education and Reserach)	Federal Institute for Materials Research and Testing / BAM Berlin	March 2018 - January 2021	<p><b>WP 2 Development of sampling methods</b></p> <p><b>WP 3 Simulations</b> software that simulates geometrically complex, application-oriented cases will be used to derive sampling strategy</p> <p><b>WP 4 Sampling of real environmental compartment.</b> quantification of the microplastic volume and transport in the real, urban wastewater system for the wastewater and precipitation water, domestic wastewater (partial flows grey and black water), industrial wastewater, and mixed wastewater. Further work will focus on sample preparation and preservation to evaluate the comparability of different sampling strategies. The investigations focus on the quantities and the importance of microplastic volumes in the individual entry points of the urban wastewater system into the water bodies.</p>
<b>SubpTrack</b>	Tracking of (Sub)Microplastics of Different Identities - Innovative Analysis Tools for Toxicological and Process-engineering Evaluation. Development of new methods of analysis and evaluation, which will allow for assessment and toxicological investigations of plastic particles of different sizes.	<a href="https://www.wasser.tum.de/en/submuetrack/star-tseite/">https://www.wasser.tum.de/en/submuetrack/star-tseite/</a> <a href="https://bmfp-plastik.de/en/join-t-project/submtrack">https://bmfp-plastik.de/en/join-t-project/submtrack</a>	BMBF (German Federal Ministry for Education and Reserach)	Technical University of Munich	September 2017 - August 2020	<p><b>WP 4 Investigations on entry points and process-related evaluation.</b> Real scenarios are first simulated with reference particles in laboratory wastewater treatment plants at the partner LfU to analyse the fate of the particles within the system. Parallel to this, <b>investigations will be carried out at various measuring points in real wastewater treatment plants.</b></p>

## 2.3 Selected projects and focus on their relationship with UNVPM activity in BLUE LAKES

From the list previously presented, 6 projects have been selected for their correlation with UNIVPM activity in BlueLakes.

### INTCATCH – Development and application of novel, integrated tools for monitoring and managing catchments

INTCATCH is a Horizon 2020 funded programme that aims to instigate a paradigm shift in the monitoring and management of river and lake water quality, by bringing together, validating and exploiting a range of innovative monitoring tools into a single efficient and replicable business model for water quality monitoring that engages the widest set of stakeholders and will be fit for European Waters in the period 2020-2050. INTCATCH Technology Innovations include:

- Autonomous and radio-controlled boats equipped with innovative sensors
- Next generation DNA test kits
- Innovative Treatment systems for combined sewer overflows
- Real-time water quality data
- Decision Support Systems turn data into information to inform action

INTCATCH has many aspects in common with the activity of UNIVPM for BlueLakes. First of all, one of the demonstration sites is located in Lake Garda, where was set up the monitoring activity. Another experimental site is represented by the CSO treatment plant of Villa Bagatta, that was implemented with an integrated system of Rotating Belt Filter, Activated Carbon and UV Disinfection. UNIVPM was directly involved in this activity and acquired experiences about specific working conditions of CSOs in Garda Lake.

The treatment and monitoring solution for Combined Sewer Outflow (CSO) and surface runoff treatment systems individuated by INTCATCH included a monitoring strategy of discharges and the development of an integrated treatment system provided with innovative technologies:

- Dynamic rotating filtration unit (90 µm mesh size) for the removal of solids, provided by Salsnes (Norway);
- Rapid adsorption on granular activated carbon (GAC) into 4 filters mounted on a skid;
- Disinfection with UV lamps provided by Trojan UV (Canada).

### CLAIM – Cleaning Litter by developing and Applying Innovative Methods in European seas

CLAIM focuses on the development of innovative cleaning technologies and approaches, targeting the prevention and in situ management of micro- and macro-plastics in the Mediterranean and Baltic Sea. The project will power 5 innovative marine cleaning technologies to reduce the amount and impact of plastic pollution on the Mediterranean and Baltic Seas. Models will be developed to forecast the impacts of marine plastic litter pollution on ecosystem services. As concern the

innovative technologies tested during the project, removal efficiencies and economic feasibility will be evaluated, taking into account the existing legal and policy frameworks in the CLAIM countries, as well as acceptance of the new technologies by their end-users and relevant stakeholders.

The main technologies developed in this project that could be related with UNIVPM work for BlueLakes, consist in a filtration system and a photocatalytic device, that will be experimented at the effluent of WWTP. The pre-filtration system is developed by HCMR and will sample wastewater and retain larger plastics, while the photocatalytic device will be used for speeding up UV-fueled degradation and breaking down fragmented, low-density polyethylene (LDPE) microplastic residues, by visible light-induced heterogeneous photocatalysis activated by zinc oxide nanorods.

For the sampling campaign that took place at WWTP effluent, 3 cartridge filters in stainless steel were used in line with filtration range of 1500 µm, 70 µm and 30 µm to hold microplastics. The filter arrangement consisted of two parallel streams (70µm + 30µm in line) with a common wastewater supply, prefiltered by the common filter of 1500 µm. During the testing total of 5300 L of wastewater has passed through the sampling system. The preliminary results showed that 80 synthetic filaments were found in the filter of 70 µm. The black filaments contributed to 68,75 %, the blue to 15%, the red to 8,75 % and the transparent and green filaments contributed to 3,75 % each.

First results from the analysis of the efficiency of the photocatalytic system showed a 30% increase of the carbonyl index, a marker used to demonstrate the degradation of polymeric residues. Additionally, an increase of brittleness accompanied by a large number of wrinkles, cracks and cavities on the surface were recorded.

## REPLAWA – Reduction of the Input of Plastics via Wastewater into the Aquatic Environment

The project will analyse the potential sinks of plastic into water bodies, such as treatment plants, storm water drainage, and combined sewer overflows. REPLAWA project will develop practical and robust methods for sampling, sample preparation and analysis, that will be used to detect microplastics entering in the environment and to evaluate treatment efficiencies. The effectiveness of various technical procedures and solutions for plastic elimination will be evaluated. Technical and regulatory recommendations will be developed to help representatives from politics, administration, industry and society to identify reasonable solutions for reducing plastic emissions into the environment.

UNIVPM interest will focus on the investigations conducted for the different treatment stages of conventional wastewater treatment plants: inlet, screen, grit trap, pre-clarification, activation, secondary clarification and effluent. The other discharged material flows, such as sewage sludge, are also a matter of concern. Additionally, the project is evaluating the quality of discharge from wastewater treatment plants using advanced processes for solids separation, e.g. spatial filters, micro sieves or membrane aeration, on several large-scale plants in Germany.

## PLASTRAT - Strategies for Reducing the Entry of Urban Plastics into Limnic Systems

PLASTRAT project will evaluate the degradation stages of different types of plastics as well as leaching, adsorption and desorption in different wastewater treatment stages, the effects of different plastic species (in different degradation stages) and their additives on aquatic organisms in limnic

systems, as well as a risk characterisation of the human toxicological effect of microplastics on consumers of drinking water. The project will develop suitable methods for sampling, processing and analysing microplastics in various media such as water, sediment and sludge. Environmental changes in various types of plastics will be analysed, including mechanisms of breakdown of residues in freshwater and sewage sludge, the presence of potentially dangerous additives, such as plasticizers, and changes in the plastic surface, significant for the absorption and desorption of pollutants from microplastic particles.

The relationship of this project with UNIVPM activity consists in the evaluation of membrane technology and advanced wastewater treatment, such as ozonisation and sand-activated carbon filtration or ultrafiltration membranes, for the elimination of microplastics.

### RUSEKU – Representative Investigation Strategies for an Integrative System Approach to Specific Emissions of Plastics into the Environment

The aim of the joint research project RUSEKU is to develop a reliable and practical method for water sampling in urban wastewater systems and watercourses. The movement and distribution of microplastic particles in watercourses and the wastewater system will be quantitatively predicted and the results integrated into a software that simulates complex, application-oriented cases. As products of the project, a commercially usable simulation code will be developed, that allow the selection of suitable sampling points and a market-ready procedure for efficient and reliable microplastic sampling should be in place.

UNIVPM is interested in the analytical procedures and sampling methods analysed, that include conventional flow-through centrifuges, cascade filtration system, suspended matter traps, hydrodynamic modelling and lysimeter tests. A particular attention is paid also to the simulation model through which evaluate dynamics of microplastic particles in waters.

### 3. WASTEWATER

#### 3.1 WASTEWATER SAMPLING

##### 3.1.1 Introduction

##### 3.1.2 List of sampling methods

<u>SOURCE</u>	<u>PROCESS</u>	<u>VOLUME</u>	<u>METHOD</u>	<u>REFERENCE</u>
Municipal wastewater	Grit-grease	60.1 L	<ul style="list-style-type: none"> <li>Grabbed in glass bottles, both in the morning and in the afternoon</li> <li>Filter through diameter 110 mm, pore size 0.45 mm</li> </ul>	(Bayo, Olmos, & López-Castellanos, 2020)
	Primary clarifier	59.3 L		
	Activated sludge	103.4 L		
	Secondary clarifier effluent	143 L		
Municipal wastewater	Influent (after 6mm screen)	4-30 L	Collected with a 10-L stainless steel bucket attached to a metal wire and poured to a cascade of two test sieves with mesh sizes of 0.25 and 5.0 mm	(Lares, Ncibi, Sillanpää, & Sillanpää, 2018)
	After the primary clarification			
	After the disinfection			
Municipal wastewater	Influent	30 L	<ul style="list-style-type: none"> <li>In the morning (9-11 am)</li> <li>Filtered in loco with a suite of steel sieves with a mesh of 5 mm, 2 mm and 63 µm.</li> </ul>	(Magni et al., 2019)
	After the settler			
	Effluent			
Municipal wastewater	Effluent	500-21,000 L	<ul style="list-style-type: none"> <li>Filtered through a set of Tyler sieves at a flow rate of 12-18 L per minute for a period of 2-24 h</li> <li>A 0.355 mm-mesh sieve was stacked atop a 0.125 mm mesh sieve for the shorter (2 h) sampling times, while the 0.355 mm-mesh sieve was used in isolation for the longer sampling periods</li> </ul>	(Mason et al., 2016)

Municipal wastewater	Influent	1-2 L	<ul style="list-style-type: none"> <li>Grab samples were collected in plastic containers</li> </ul>	(Michielssen, Michielssen, Ni, & Duhaime, 2016)
	Pretreated influent	1-6 L		
	Primary effluent	10-20 L		
	Secondary effluent	10-20 L		
	Final effluent	34-38 L		
Municipal (+industrial) wastewater	Effluent from different configurations of WWTPs	390-1,000 L	<ul style="list-style-type: none"> <li>Custom made mobile pumping device with a filter housing containing a 10 mm stainless steel cartridge filter</li> </ul>	(Mintenig, Int-Veen, Löder, Primpke, & Gerds, 2017)
Municipal wastewater	Influent	30-50 L	<ul style="list-style-type: none"> <li>n=303</li> <li>First passed through steel sieves (65 µm), then vacuum filtered through Whatman No. 1 qualitative circles, 90 mm filter paper, with a pore size of 11 µm.</li> </ul>	(Murphy, Ewins, Carbonnier, & Quinn, 2016)
	Grit&grease effluent			
	Primary effluent			
	Final effluent			
Municipal wastewater	Disc filter	Different volumes for different filter size and unit (2-1,000L) (see the paper)	<ul style="list-style-type: none"> <li>Custom made filtering device with in-situ fractionation</li> <li>The mesh-sizes of the filters were 300, 100 and 20 mm, giving particle size fractions of &gt;300 mm, 100-300 mm and 20-100 mm</li> <li>Additional composite samples for 24 h</li> </ul>	(Talvitie, Mikola, Koistinen, & Setälä, 2017)
	Rapid sand filter			
	Dissolved air floatation			
	MBR			
	CAS			
Municipal wastewater	Post primary treatment	3-200	<ul style="list-style-type: none"> <li>Each sampling event took approximately 1 h with a maximum flow rate of 10 L/min</li> </ul>	(Ziajahromi, Neale, Rintoul, & Leusch, 2017)
	Post primary and secondary treatment			

	Post primary, tertiary and RO treatment		<ul style="list-style-type: none"> <li>The sampling device consists of four removable stainless-steel mesh screens (plain Dutch weave) with sizes of 500, 190, 100 and 25 mm with a diameter of 12 cm.</li> </ul>	
Raw wastewater		1 l	<p>Retsch AS 200 vibratory sieve shaker through 2 mm, 1mm and 500 mm sieve meshes. Sodium dodecyl sulfate (SDS) as a surfactant added to a final concentration of 0.15 g/L before sieving to detach adhered MP particles from the larger solids. 200mL of the pre-sieved wastewater was incubated with cellulase enzyme (<i>Aspergillus</i> sp., Sigma-Aldrich, CAS no. 9012-54-8) for 48 h at 40 °C to degrade cellulose fibers deriving mainly from toilet paper. Organic material was oxidized with hydrogen peroxide where iron (II) was added to catalyze the reaction (Fenton reaction). Peroxide was added to a final concentration of 250 g/L and iron (II) sulfate to 2.5 g/L. The pH of the mixture was adjusted to approximately 3 with sodium hydroxide. The oxidized sample was wet-sieved (demineralized water with 0.15 g/L SDS) into two size fractions through an 80 µm sieve mesh. The effluent containing particles &lt;80 µm was collected into a glass beaker. Particles &gt;80 µm were removed from the sieve mesh into filtered demineralized water containing 0.15 g/L SDS by treatment in an Elma S50R ultrasonic bath. Particles from this liquid and the collected effluent were gathered on separate 10 µm steel meshes. Particles were removed from the filters into 25mL HPLC grade ethanol by ultrasonic treatment. The resulting particle-ethanol suspensions of the two size fractions were transferred into glass vials where their final volume was set to 5mL by evaporation with nitrogen gas. The chemical composition of the extracted particles was determined with an FPA-based FT-IR imaging technique.</p>	(Simon, van Alst, & Vollertsen, 2018)
Treated wastewater			<p>10 µm steel filters, ultrasonic treatment, collection in filtered demineralized water containing 0.15 g/L SDS. Incubation in a serum flask for 48 h at 40 °C with cellulase enzyme. Samples oxidized in 180 g/L hydrogen peroxide catalyzed by 1.8 g/L iron (II) sulfate and pH adjusted to 3 by sodium hydroxide. Size fractionation by wet-sieving and transferring the particle-ethanol suspension into glass vials.</p>	

Municipal wastewater effluent	Screening Grit and grease removal Settling tank Aeration basin Clarifier	30-50 L	Steel buckets and sieve	(Murphy et al., 2016)
Municipal wastewater effluent			Fractionated filtering	(Triebkorn et al., 2019)
Municipal wastewater effluent			Sieving and filtering method	
Municipal wastewater effluent			Custom made pump +stainless steel cartridge filter	
Municipal wastewater effluent		2 L	Effluent: grab samples	
Wastewater, 24-hour composite samples	Influent wastewater, after mechanical purification and after the process from discharged wastewater.	From 100 ml (incoming wastewater) to 8 litres (purified wastewater). 50 liters of purified wastewater were filtered through 300 and 100 µm	Filter device consists of three transparent plastic tubes (diameter 60 mm) and screw-on plastic connectors attaching the tubes to one another. Round (diameter 80 mm) filters are placed into the filter device between the connectors and tubes are screwed tightly together with rubber o-rings. Round filters are cut from different mesh size plankton nets. The largest mesh size filter 300 µm is placed on the top of the device, 100 µm filter in the middle and 20 µm filter at the bottom. All equipment has to be rinsed thoroughly prior to sampling.	(Talvitie et al., 2017)

		filters and 1 liter through the 20 µm filter.		
Sewage sludge	Anaerobic digestion	2 kg	<ul style="list-style-type: none"> <li>Composite over one day in each month</li> <li>Suspended, pre-washed and then filtered through 5 mm stainless steel</li> </ul>	(Xu et al., 2020)
Sewage sludge	Activated sludge MBR sludge Anaerobic digestion	150-200 mL	Poured in glass flasks with metal funnel, kept in dark	(Lares et al., 2018)
Sewage sludge	Drained	500 g	Taken by shovel, stored in dark	(Mintenig et al., 2017)
Sewage sludge	Anaerobic digestion	30 g	<ul style="list-style-type: none"> <li>Three replicates</li> <li>Pellets of TD sludge were placed in water for 1 week to induce softening, transferred to a water bath (30 °C) for 24 h, and placed in an shaker for 12 h.</li> </ul>	(Mahon et al., 2017)
	Thermal drying			
	Lime stabilization			

### 3.1.3 Discussion

### 3.1.4 Suggestions on the best practise

**Continuous composite sampling with as much volume of wastewater as possible using steel buckets and sieves (50 µm mesh size or lower are recommended).**

## 3.2 WASTEWATER TREATMENT PLANTS (WWTPs) TYPOLOGIS AND EFFICIENCIES

### 3.2.1 Introduction

### 3.2.2 List of treatments and efficiency

<u>WWTPs</u>	<u>SCALE</u>	<u>PROCESS</u>	<u>REMOVAL EFFICIENCIES</u>	<u>Ref.</u>
Vancouver, Canada	Full Scale	Sedimentation	91.7%	(Ngo, Pramanik, Shah, & Roychand, 2019)
Wuhan, China	Full Scale	Sedimentation and Aerated grit chamber	40.7%	
Beijing, China	Full Scale	Aerated grit chamber	58.8%	
Hameenlinna, Southern Finland	Full Scale	Dissolved air flotation	95%	
Beijing, China	Full Scale	A2O	54.4%	
Sydney, Australia	Full Scale	Activated sludge	66.7%	
Vancouver, Canada	Full Scale	Trickling filters	80.8%	
Sydney, Australia	Full Scale	RO	90.4%	
Mikkeli, Finland	Full Scale	MBR	99.9%	
Western New York, USA	Full Scale	Sand and anthracite coal filtration	15%	
Turku, Finland	Full Scale	Rapid sand filter	97.1%	
Helsinki, Finland	Full Scale	Disc filter	98.5%	

Wuhan, China	Full Scale	Chlorinate disinfection	16.7	
Plum Island	180000 PE	Primary screening, Primary clarifiers, Activated sludge, Secondary clarifiers, Sludge handling, Dewatering, Disinfection (NaOCl)	97.12%	(Conley, Clum, Deepe, Lane, & Beckingham, 2019)
Rifle Range Road	53000 PE	Primary screening, Anoxic selectors, Activated sludge, Secondary clarifiers, Sludge handling, Dewatering (Belt Press), Disinfection (NaOCl)	80.2%	
Center Street	32000 PE	Primary screening, Anoxic selectors, Activated sludge, Secondary clarifiers, Sludge handling, Dewatering (Belt Press), Disinfection (NaOCl)	83.7%	
Sweden	12000 PE	Primary and Secondary treatments	99.9%	(Sun, Dai, Wang, van Loosdrecht, & Ni, 2019)
France	800000 PE	Primary and Secondary treatments	88.1%	
United States	Pilot Scale	Primary and AnMBR	99.4%	
Finland	Pilot Scale	Primary and MBR	99.3%	
United States	9900 PE	Primary, Secondary, Tertiary (GF)	97.2%	
Finland	800000 PE	Primary, Secondary, Tertiary (BAF)	97.8%	
Italy, Falconara	Pilot scale	UASB and AnMBR	96%	(Pittura et al., 2020) (UNIVPM, submitted paper)
China, Wuxi	50000 m <sup>3</sup> /d	Aerated grit chambers, Oxidation ditch, secondary clarifier, UV disinfection	97%	(Lv et al., 2019)
China, Wuxi	70000 m <sup>3</sup> /d	A/A/O and MBR tank	99.5%	

Scotland	650000 PE	Primary and Secondary treatments	98.4%	(Edo, González-Pleiter, Leganés, Fernández-Piñas, & Rosal, 2020)
Spain, Cartagena	210000 PE	Primary and secondary activated sludge process plus chlorine disinfection	90.1%	
Spain, Madrid	300000 PE	Primary and A2O (Anaerobic, Anoxic, Oxidic) biotreatment	93.7%	
WWTP	Full scale	Primary treatment, aeration, sedimentation and UV disinfection.	66% MPs (> 25 µm)	(Ziajahromi et al., 2017)
WWTP	Full scale	Biological treatment, flocculation, disinfection/de-chlorination, ultrafiltration, reverse osmosis and de-carbonation	> 90 % MPs (> 25 µm)	
WWTP	Full scale	Membrane bioreactor MBR treating primary effluent	99.9 % (from 6.9 to 0.005 MP/l) for grab samples, n = 3; 94% for 24h composite samples	(Talvitie et al., 2017)
WWTP	Full scale	Rapid sand filter	97% (from 0.7 to 0.02 MP/l) for grab samples, n = 3; > 90% for 24h composite samples	
WWTP	Full scale	Dissolved air flotation	95% (from 2.0 to 0.1 MP/l) for grab samples, n = 3; 48% for 24h composite samples	
WWTP	Full scale	Disc filter	40-98.5% (from 0.5-2.0 to 0.03-0.3 MP/l) for grab samples, n = 3	
WWTP effluent	Full scale	Free water surface (FWS) wetlands	close to	Jönsson, 2016

			100 % for MPs > 20 µm	
Örsundsbro wetland	1430 PE, 667 m3/d Inlet: 950 objects/L	Free water surface (FWS) wetlands after WWTP	-Microplastic 20-300 µm: 99,7% -Microplastic >300 µm: 100% -Red "potential" microplastics >20 µm: 81% -Black partickles > 20 µm: 89%	Jönsson, 2016
Wetland Alhagen	13000 PE, 5100 m3/d Inlet: 4 objects/L	free water surface (FWS) wetlands after WWTP	-Microplastic 20-300 µm: 99,8% -Microplastic >300 µm: 100% -Red "potential" microplastics >20 µm: 100% -Black partickles > 20 µm: 49%	Jönsson, 2016
WWTP Vodokanal of St. Petersburg	Full scale	Mechanical treatment	-Textile fibers: 92.93 % -Synthetic particles: 86.88% -Black particles: 90.44 %	Julia Talvitie, Mari Heinonen. 2014
WWTP Vodokanal of St. Petersburg	Full scale	Purification after mechanical treatment	-Textile fibers: 51.5 % -Synthetic particles: 66.7% -Black particles: 58.6 %	Julia Talvitie, Mari Heinonen. 2014
WWTP	Full scale		98% (MPs > 250 µm)	(Lares et al., 2018)

WWTP, USA	1.51 million m <sup>3</sup> /d		99.9% (MPs > 100 µm)	(Carr, Liu, & Tesoro, 2016)
WWTP	650000 PE, 260954 m <sup>3</sup> /d	Grit and grease removal	44.59%	(Murphy et al., 2016)
WWTP	650000 PE, 260954 m <sup>3</sup> /d	Primary treatment	60.92%	
WWTP	650000 PE, 260954 m <sup>3</sup> /d	Whole plant	98.41% (MPs > 65 µm)	
Denmark	Full scale	Whole plant	99% (MPs > 10 µm)	(Simon et al., 2018)
Netherlands	Full scale		72% (MPs > 10 µm)	(Leslie, Brandsma, van Velzen, & Vethaak, 2017)

### 3.2.3 Discussion

### 3.2.4 Suggestions on the best practise

**Physical treatments (filtration, settling, mechanical units) are more efficient and have the most drastic effect on MPS removal due to affinity of MPs onto solids. If possible, the use of MBRs are highly recommended. On the other hand, conventional treatment schemes (i.e. CAS) can also remove MPs up to 90% and even more.**

## 4. DRINKING WATER

### 4.1 DRINKING WATER SAMPLING

#### 4.1.1 Introduction

#### 4.1.2 List of sampling methods

<b><u>SAMPLING POINTS</u></b>	<b><u>VOLUME</u></b>	<b><u>TYPE of SAMPLE</u></b>	<b><u>METHODS OF SAMPLING AND DETENTION</u></b>	<b><u>FREQUENCY or num° of samples</u></b>	<b><u>Ref.</u></b>
Raw and treated drinking water (after each process)	1L	<i>Grab samples</i>	Digestion with 30% hydrogen peroxide (H <sub>2</sub> O <sub>2</sub> ) for 24 h. Filtration through a series of 5 µm (PTFE) membrane filters followed by a 0.22 µm pore sizes. The purpose of this two-filtration was to descend mesh size to pass the entire sample through the filter without clogging. These filters were used for scanning electron microscope (SEM) analysis of retained particles. For each sample, a volume of 250 ml was separately filtered for quantitative and qualitative analysis of particles. The filters after drying in an oven at 30°C for 30 min were stored in covered glass petri dishes for subsequent analysis. DXR2 micro-Raman imaging microscope system (Thermo Fisher Scientific, USA) was employed (532 nm laser, laser spot size around 0.5 µm, Raman shift 50–3550 cm <sup>-1</sup> , spectral resolution of 5 cm <sup>-1</sup> ) for qualitative analysis of particles.	3 times /winter	(Wang, Lin, & Chen, 2020)
Raw and treated drinking water	27L each sample	<i>Average daily samples</i>	Wet peroxide oxidation was conducted to remove organic material, Filtration through a series of 5 µm (PTFE) membrane filters followed by a 0.22 µm pore sizes. The purpose of this two-filtration was to descend mesh size to pass the entire sample through the filter without clogging. These filters were used for scanning electron microscope (SEM) analysis of retained particles. For each sample, a volume of 250 ml was separately filtered for quantitative and qualitative analysis	3 times within a 24-hour period (every 8 h) and repeated three times in winter period	(Pivokonsky et al., 2018)

			of particles. The filters after drying in an oven at 30°C for 30 min were stored in covered glass petri dishes for subsequent analysis		
Raw and treated drinking water	9-27 L		Scanning electron microscopy analysis for particle counts; both micro-Raman spectroscopy and $\mu$ -FT-IR were used for identification of particles with size of 1e10mm and >10mm		(Eerkes-Medrano, Leslie, & Quinn, 2019)
Raw and treated drinking water	1000 L	<i>Grab samples</i>	Samples directly sieved, tap water require no digestion.		(Koelmans et al., 2019)
Raw and treated drinking water	300-2500 L	<i>3<math>\mu</math>m stainless steel cartridge filters 4 7/8", Wolftechnik, Germany</i>	Residual raw water and drinking water was removed from the filter units by using filtered (0.2 $\mu$ m) compressed air. Then, the units were filled again with diluted hydrochloric acid (Carl Roth GmbH & Co. KG, Germany, 0.2 $\mu$ m filtered, pH=2) to dissolve calcium carbonate and iron precipitates. After 24 h the filter units were emptied, the cartridge filters removed from the units and rinsed with Milli-Q and ethanol (30%, Carl Roth GmbH & Co. KG, Germany, filtered over 0.2 $\mu$ m). The retentate was collected on 3 $\mu$ m stainless steel filters (47mm in diameter) that were subsequently transferred into glass bottles and covered with 30 mL hydrogen peroxide (35%, Carl Roth GmbH & Co. KG, Germany). The bottles were closed using aluminium foil and incubated for 24 h at 40 °C. Finally, each sample was enriched onto a 0.2 $\mu$ m aluminium oxide filter (Anodisc 25 mm, Whatman, U.K.) by using an in-house fabricated filter-funnel with an inner diameter of 11 mm. The filters were dried at 40 °C in half closed glass petri dishes for subsequent analysis.	24 samples	(Mintenig et al., 2017)

#### 4.1.3 Discussion

#### 4.1.4 Suggestions on the best practise

**Higher volumes of water should be sampled compared to wastewater. Composite sampling is recommended using steel buckets and sieves (50  $\mu$ m mesh size or lower are recommended).**

## 4.2 DRINKING WATER TREATMENT PLANTS (DWTPs) TYPOLOGIES AND EFFICIENCIES

### 4.2.1 Introduction

### 4.2.2 List of treatments and efficiency

TREATMENT	SCALE	PROCESS	REMOVAL EFFICIENCIES	NOTES	Ref.
ADWTP Yangtze River (China)	120-150 million m <sup>3</sup> /d	Coagulation combined with sedimentation	40.5-54.5 %	MPs > 10 µm almost completely removed. 44.9–75.0% for 5–10 µm. 28.3–47.5% for 1–10 µm. 53.5–74.6% for MPs < 10 µm Mainly fibres removal: 50.7–60.6%	(Wang et al., 2020)
		Sand filtration	29.0-44.4 %		
ADWTP	120-150 million m <sup>3</sup> /d	Ozonation combined with GAC filtration	56.8-60.9 %	Mainly small-sized MPs. 73.7–98.5% of MPs removed by GAC filtration was the particles ranging in size from 1 to 5 µm. The removal efficiencies of fibres, spheres and fragments were 38–52.1%, 76.8–86.3% and 60.3–69.1%, respectively	
ADWTP TOTAL	120-150 million m <sup>3</sup> /d	Coagulation-flocculation, sedimentation, sand filtration and advanced treatment units, ozonation combined with GAC filtration	82.1-88.6 %	Microplastics in the effluent with size from 1 to 5 µm (around 84.4–86.7% of MPs).	
DWTP		Coagulation-flocculation, sedimentation and sand filtration	58.9–70.5%		

DWTP supplied by large surface water reservoir		flocculation and one-step separation (sand filtration);	70 %	Majority of MPs detected in treated water < 10 µm. Fiber removal 20%	(Pivokonsky et al., 2018)
DWTP supplied by small surface water reservoir		Coagulation-flocculation, sedimentation, sand filtration and granular activated carbon (GAC) filtration	81 %	Majority of MPs detected in treated water < 10 µm. Fiber removal > 80%	
DWTP supplied by river		coagulation/flocculation, sedimentation, sand filtration and granular activated carbon (GAC) filtration	83 %	Majority of MPs detected in treated water < 10 µm. Fiber removal > 80%	
Water treatment	Lab scale	Coagulation	PE removal (17 ± 2%)	at pH 8 at the coagulant dose of 2.0 mmol/l.	(Ma et al., 2019)
Water treatment	Lab scale	Coagulation with Fe	37±3% PE removal	obtained (at pH 7) with Al-based coagulant dose of 15 mmol/l = 112 mg/l Fe	
Water treatment	Lab scale	Coagulation with Al	PE removal 8±1%	0.5 mmol/l = 13.5 mg/l Al	
Water treatment	Lab scale	Coagulation with flocculant polyacrylamide (PAM)	PE removal 85–90%	2.0 mmol/L FeCl <sub>3</sub> ·6H <sub>2</sub> O (at pH 7) (> maximum authorized dose of 1 mg/l)	
Water treatment	Lab scale	Coagulation with flocculant polyacrylamide (PAM)	PE removal 50–60%	5mmol/l AlCl <sub>3</sub> ·6H <sub>2</sub> O with 3–15 mg/l anionic PAM (at pH 7) (>maximum authorized dose of 1 mg/l)	

#### 4.2.3 Discussion

#### 4.2.4 Suggestions on the best practise

Similar to WWTPs, physical treatment units have the best performance to remove MPs; however, other processes like chemical treatment (i.e. coagulation-flocculation) and disinfection can enhance the removal efficiency.

## 5. COMBINED SEWER OVERFLOWS (CSOs)

### 5.1 CSOs SAMPLING METHODS

#### 5.1.1 Introduction

#### 5.1.2 List of sampling methods

<u>SAMPLING POINTS</u>	<u>VOLUME</u>	<u>TYPE OF SAMPLE</u>	<u>METHODS OF SAMPLING AND DETENTION</u>	<u>FREQUENCY or num° of samples</u>	<u>Ref.</u>
stormwater runoff	1L per each sample	Grab sample	Iron bucket that was rinsed three times with the runoff before taking the samples. The samples were a combination of sediment and water due to the strength of the runoff streams in the streets or storm drains. These samples were collected at the beginning of the rain event and at approx 10 min and 30 min after the first samples were collected.	94 samples	(Piñon-Colin, Rodriguez-Jimenez, Rogel-Hernandez, Alvarez-Andrade, & Wakida, 2020)
Stormwater pond	up to several thousand liters for the bigger mesh size, 10-70 liters with a mesh size of 20 µm.	Grab sample	Sampling method consisted of a gasoline pump, hoses, filter holder and filter. Two types of filters were tested; plankton net (mesh size 300 µm) manually cut into circles and prefabricated polycarbonate filters (mesh size 10 µm). A mechanical volumeter was attached to the outlet hose in order to measure the volume of water filtered. The filter holder consisted of stainless-steel pipes, gaskets, and a clamp. The inner diameter of the stainless-steel pipes was in this case 2 inches. The inlet and outlet hoses chosen had inner diameters of 1,5 and 1 inch. The inlet hose was of sturdier material, not to deflate due to the suction pressure of the pump. Polyester plankton nets (Sefar Petex), where cut into circles to fit the filter holder. Two mesh sizes were used. The mesh size of 300 µm was used to allow for comparison of results with the majority of studies conducted thus far. Quantification performed manually by counting MPs using a microscope. Some of the detected MPs were analyzed with FTIR spectroscopy.		Coalition Clean Baltic, 2017

### 5.1.3 Discussion

### 5.1.4 Suggestions on the best practise

**Practices on CSO/runoff water are very limited up to date, including only grab samples. The methodology on the wastewater can be followed.**

## 5.2 CSOs TYPOLOGIES AND EFFICIENCIES

### 5.2.1 Introduction

### 5.2.2 List of treatments and efficiency

TREATMENT	SCALE	REMOVAL EFFICIENCIES	Ref.
Tibbledammen Stormwater pond	5.7 ha, 4300 m3/d Inlet: 5.4-10 MPs/L	<ul style="list-style-type: none"> <li>- Microplastic 20-300 µm: 98%</li> <li>- Microplastic &gt;300 µm: 73%</li> <li>- Red "potential" microplastics &gt;20 µm: 99%</li> <li>- Black partickles &gt; 20 µm: 89%</li> </ul>	Jönsson 2016
Korsängen vattenpark Stormwater pond	9 ha, 3440 m3/d Inlet: 5.4-10 MPs/L	<ul style="list-style-type: none"> <li>- Microplastic 20-300 µm: 90%</li> <li>- Microplastic &gt;300 µm: 100%</li> <li>- Red "potential" microplastics &gt;20 µm:100%</li> <li>- Black partickles &gt; 20 µm: 99%</li> </ul>	Jönsson 2016

### 5.2.3 Discussion

### 5.2.4 Suggestion on the best practice

**Up to date, only ponds were tested for MPs removal in runoff waters. Compact treatment technologies can be designed and applied specifically for CSOs (Filtration + GAC/PAC + UV).**

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