

Interreg
Euregio Meuse-Rhine

LIVE2 litter free rivers
and streams



EUROPEAN UNION
European Regional
Development Fund



Review on **best practices** for
monitoring of plastic pollution
in the catchment area of the
Meuse and how to build a
cross-border dataset

Work Package 1



NORIA
SUSTAINABLE
INNOVATORS

December 2021

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Executive Summary

The project Litter free Rivers and Streams (LIVES) is a cross-border initiative with the primary goal to realise a coordinated cross border approach in reduction of plastic waste in the river Meuse basin. Therefore, international cooperation is required to tackle the litter problem. Specifically with respect to monitoring international cooperation is needed, since there is a lack of unified methodologies for monitoring of litter in the rivers. This results in the fact that gathered data from each country is often incomparable, hampering the planning and implementation of prevention strategies for the litter pollution problem.

Through a series of interviews with partners ranging from water managing governments, garbage processors to high-school teachers from Germany, Belgium, and the Netherlands, information for this report was gathered. This report focuses on the 'Inventory of best practices' and the 'Cross-border dataset'. The main objective is to give insight into the main lessons learned and give valuable insights for elements to be aware of in cross border litter monitoring projects.

From this project there are three categories of main practices can be distinguished, which will be summarised briefly in the following paragraphs. These categories are:

1. Political agenda priorities cultural differences
2. Importance of collaboration and project management
3. Future innovative methods and knowledge

It is important to be aware of the differences in water management approaches, language, and culture. It was found that differences in how water management is organised in different member states, leads to additional complexity in the implementation of unified strategies for litter monitoring. Also due to the linguistic barrier and difficulties in mutual understanding of the individual situation of one single partner, cross-border communication and cooperation can be difficult. Therefore, a key best practice would be the make use of a facilitator with knowledge about the main (cultural) differences in water management who can explain this in the beginning and help in mutual understanding on how to deal with these differences.

On a litter monitoring level, the monitoring by means of litter removal should contribute to preventive measures. The source of the plastic pollution should be analysed to be able to start te conversation with causing parties. Since we're talking about an interregional project, a unified cross-border strategy is needed such that generated results can be compared and combined.

Collaboration was found to be a key component for successful joint activities and measures. The contribution of citizens was experienced in helpful in several ways, as this led to increased data collection, awareness, and sharing knowledge. Additionally, it is valuable that the partners further explore the possibilities to collaborate with associated partners, local parties, and institutions inside the individual countries. This creates a trickle-down effect that has a positive impact on the entire problem of litter in the Meuse. The litter pollution problem asks for a long-term commitment since it can only be solved in the long run.

To further improve upon project management, **the project duration should be longer and structured by short-, medium- and long-term goals**. Consequently, the timeline of a project should be well aligned with the defined objectives. Within the project it is important that knowledge is well safeguarded in the organisation such that if e.g., a project member leaves the organisation, the important knowledge is still present within organisation.

Information management is crucial to make a cross-border dataset useful, transparent, and comparable. To make plastic monitoring activities reproducible and the data transparent, standardized measuring methodologies are needed for all involved partners. This is needed since data inconsistencies negatively influence the quality of the conclusions. Besides this, it is important that not only plastic fluxes are measured but also influencing parameters (e.g., wind direction or discharge) such that correlation between these measurements can be analysed. With respect to sharing data and information, it is from utmost importance that the method of information exchange is clearly communicated and well established at the start of the project.

A knowledge gain regarding the behaviour of plastic in the water is essential since the existing knowledge about this topic is scarce. Insight in this behaviour is required for further improvement in monitoring methods. Since the current methods are relatively time-consuming and arduous, **innovative technologies can help to automate and simplify monitoring**. This can e.g., be done cameras and Artificial Intelligence (AI).

For the future it is important that the best practices and lessons learned from this project are embedded into an interregional monitoring strategy. Developing a monitoring strategy is long-term effort that goes through several iterative cycles. Overall, to evaluate the effect of measures to reduce floating litter, one needs to **(1)** develop monitoring methods, **(2)** conduct baseline measurements, and **(3)** perform long-term monitoring of floating litter. After these steps it can be concluded how effective the implemented measure is. Before these steps are taken it is important that all participants mutually agree upon the desired result. Be clear on the results and extract the required data collection with monitoring programme from these goals.

Introduction

Litter pollution – How did we get here?

The past 70 years have seen a worldwide exponential increase in the production and consumption of products. In this period of time the plastic production increased from 2 to 381 million tons worldwide per year (Geyer, Jambeck, & Law, 2017). New materials such as plastic revolutionized our way of living. However, this leap forward also has a shadow side to it: a large portion of these products have ended up in the environment through improper waste disposal and littering. This so called litter pollution is now everywhere: large amounts of plastics have accumulated in our oceans (also known as the ‘plastic soup’), in our rivers, and on land. We even find microplastics, which mainly stem from litter that is broken down in the environment, in the food we consume and the water we drink.

Litter in rivers – A serious problem

Litter pollution is produced on land through mismanagement of waste and littering. Only a small fraction of litter pollution ends up in the famous ‘plastic soup’ in seas and oceans. Most litter is (temporarily) retained in rivers (Meijer, Emmerik, Ent, Schmidt, & Lebreton, 2021). Here it has a range of negative effects on nature and fauna, it can increase flood risk due to blockage of drainage systems, and cause economic damage (Van Emmerik & Schwarz, 2020) (Deloitte, 2019). Due to the longevity of the materials in our waste streams, the ubiquity and large volume of it, litter pollution has become one of the most significant and challenging environmental problems of our times.

Key knowledge required to effectively tackle the litter problem is currently lacking. For example, very little is known about the sources of litter pollution, how much litter is exactly in our rivers, and where hotspots of litter can be found. Such knowledge is key for the design of effective litter reduction, mitigation, and removal strategies. This knowledge can only be gained through effective monitoring of litter in our rivers.

Rivers run cross-border, litter pollution therefore is a cross-border problem as well which requires international cooperation to solve. Monitoring is one of the areas where international cooperation is needed the most. International standardized methods to monitor riverine litter are currently lacking. This leads to data gathered by different countries to often be incomparable with each other, hindering the design of effective solutions to the litter problem.

The LIVES project – Cross border cooperation to reduce litter pollution

The Litter Free Rivers and Streams (LIVES) project is a cross-border initiative with the aim of reducing the presence of litter in the catchment of the Meuse river through international cooperation. This project unites governments, water managers, and scientists from Germany, Belgium, and the Netherlands to jointly tackle the litter pollution. This is done on three fronts: 1) creating a shared understanding of the litter pollution problem through cross-border monitoring and data sharing, 2) implementation of measures aimed at reducing litter, and 3) creating institutional arrangements to anchor these changes in future policy.

Structure of the LIVES project

The LIVES project follows a layer-based approach, whereby the first two layers comprises six different work packages, namely: Management (WP M), Communication (WP C), Inventory Data Sharing (WP T1), Implementation of Measures (WP T2), Institutional Arrangements (WP T3) and First Level Control (WP T4). WP T1 consists of five building blocks in the form of a separate product. This report focuses on the ‘Inventory of best practices’ (third orange box) and the ‘Cross-border dataset’ (fourth orange box). The main objective is to give insight into the main lessons learned and draw recommendations for future cross border litter monitoring projects. It is important to mention that the ‘cross border dataset’ has an overlap with the ‘Open Access Data System’. It is therefore recommended to assess both these reports jointly.

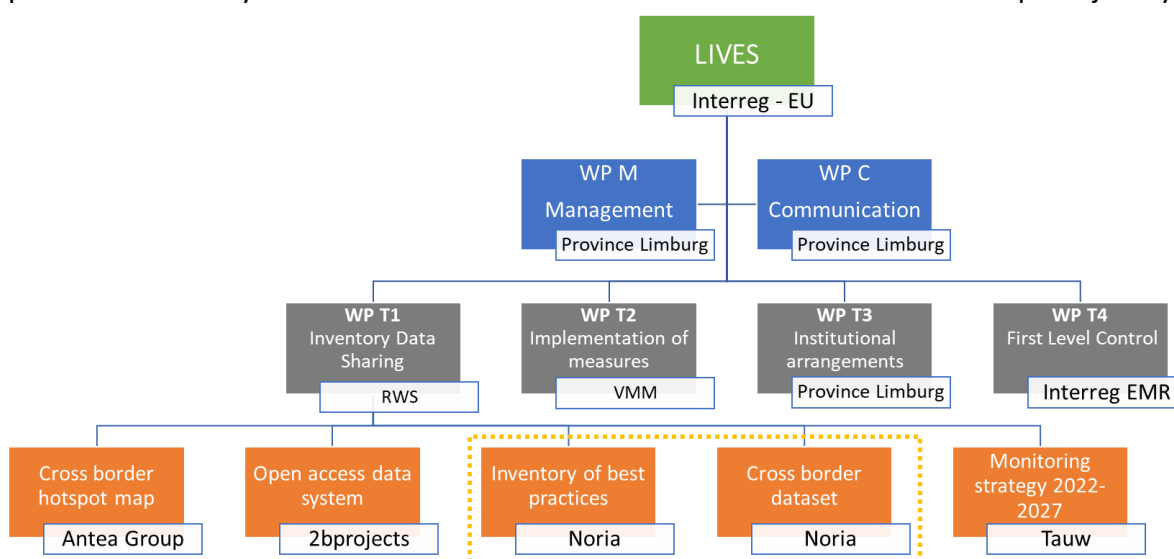


Figure 1 Structure of the LIVES project

Reading guide

The first chapter gives an overview of the best practices from the Interreg LIVES project, whereby the gained knowledge is summarized into seven main key messages. The second chapter is about cross border dataset which comprises three key messages. The third chapter provides an outlook on how to improve the building of a cross border dataset for litter monitoring with some practical advice.

1 Review on best practices

Chapter Summary: During this project interviews were held with the (associated) partners of the LIVES project. The full list with interviews can be found in Appendix A. These partners can be divided in three categories: water managing authority, educational institution, or garbage processor. The primary goal of the interviews was to gain insight regarding the best practices for monitoring from all involved partners. This gained knowledge was distilled into seven main key messages, which can be divided in three categories.

1. Political agenda and priorities,
2. Project management and collaboration,
3. Future innovative methods and knowledge.

Within every category the key message is mentioned and elaborated based on the information that was obtained from the interviews.

1.1. Political agenda priorities cultural differences

I. Take political, linguistic, and cultural differences seriously

The influence of differences in water management and language are an aspect that should not be underestimated during cross-border cooperation's like the Interreg LIVES projects.

This conclusion and recommendation were formulated with regards to several aspects mentioned by the partners.

Firstly, water management is organised in different ways in all member states. This results in organisational differences but also differences in tasks, roles, responsibilities, and authorisations regarding water management in the Netherlands, Germany, and Belgium. Due to these differences, the complexity of independently installing a litter monitoring system can vary significantly. Some partners for example need approval from a secondary government which is not directly involved in the Interreg project (Water Managing Authority, 2021).

Secondly, the level of urgency for the plastic pollution problem differs per country. For example, after the damage caused by European floods in July 2021, the German authorities are mainly focussing on future flood prevention measures rather than litter in the rivers. It was also mentioned that a project like Interreg LIVES has helped to place this topic higher on the political agenda. Sometimes it is good to start with the project and adjust methods and goals halfway.

A third element that should be taken seriously is the linguistic barrier which can hamper communication. This specifically comes forward when technical jargon is involved and it can e.g., become difficult for a German water manager to fully understand the Flemish colleague. Therefore, it would be very valuable that a bilingual translator is in attendance during these meetings, whereby the meeting summary could be made available in all the languages from the involved partners.

This underestimation results in insufficient attention for mutual understanding of the individual situation of one single partner, and thus suggestions that are not interregional applicable. If this interregional applicability is the main goal, the attention for these

differences must have high priority. Therefore, in the future interregional differences must be consciously included in the project management. This can be emphasized at the start of the project by explaining each other what lessons they have learned in earlier interregional projects. Subsequently, during the project several meetings can be organised in which a facilitator explains something about interregional differences and how this can be overcome in this project. After this general session the individual partners can explain how they experience the differences in their work within the project.

II. Monitoring by litter removal should contribute to preventive measures

Several partners, such as Waterschap Limburg and the Openbare Vlaamse Afvalstoffenmaatschappij mentioned during the interviews that they prefer prevention above recovery (Water Managing Authority and Garbage Processor, 2021). Subsequently, the question arises what the best preventive measures are. To find an answer to this question, the litter should be analysed in such a way that it gives insights regarding the main sources. Therefore, the litter should be removed for the sake of analysis such that preventive measures can be thought off.

Furthermore, one partner mentioned that the source should be analysed to be able to hold causing parties accountable in the future (Water Managing Authority, 2021). This way it will stimulate preventive measures or policies since in these cases there are concrete financial benefits in preventing plastic from entering the water. To gain this knowledge, the removed litter should be categorised based upon their potential source. If for all the potential sources the quantities of litter (number of items or weight) in rivers and streams are known, the authorities can select which source has highest priority to focus on. Nevertheless, litter will always be present in the water. This cannot fully be prevented and therefore removal activities are needed from e.g., infrastructures such as stews or pumping stations.

This results in the main conclusion that litter removal activities should lead to prevention, which lead to the advice to make a cross-border strategy for analysing litter in the water. This should be done with a universal method for all partners, such that generated results from individual analysis can be compared and combined. More practical suggestions for such a strategy can be read in chapter 3 of this report.

1.2. Importance of collaboration and project management

III. Collaboration is essential for successful joint activities and measures.

Involving citizens was experienced very helpful in several ways. First of all, helpful citizens give the government many extra hands with the removal of plastics. If the government facilitates the cleaning activities, there are many volunteers who like to help. The collected litter can subsequently be stored by the government and analysed to trace the origin. This is valuable input for preventive measures. Of course, this is only a 'nice add-on' for the governmental monitoring and should never form the core of a governmental monitoring program.

Secondly, involving the citizens leads to enhanced awareness of the problem and this way will help in preventing the problem from growing. A last important aspect is that the knowledge of citizens was very valuable since they know their immediate living environment and therefore the locations where plastic often accumulates.

Involvement of the youth is an objective that could be interesting to put on the agenda if prevention is the main objective. It was mentioned by educational partners (Educational institution, 2021) that the youth could be educated about the problem of plastic pollution. By participating in educational activities (e.g., cleaning the environment) and consequently becoming aware of the magnitude of the problem, this issue can be prevented from growing in the near future. Since plastic pollution is an omnipresent problem, knowledge institutions can have an interesting role by implementing modules related to this topic in their curriculums. One of the institutions mentioned that the LIVES project served as a steppingstone to further manifest this in their programme (Educational institution, 2021).

Next to a cross border approach, it is valuable that the partners further explore the possibilities to collaborate with associated partners, local parties, and institutions inside the individual countries with respect to litter monitoring and preventive measures. By not only keeping this problem as responsibility for governmental authorities, a trickle-down effect is created that has a positive impact on the entire problem of litter in the Meuse. This process actively creates and reinforces a positive feedback loop by increased involvement of local partners and citizens, leading to firstly a direct increase of the removed plastic from the catchment area of the Meuse but secondly growing awareness of this problem. By implication, the positive side effect of enhanced awareness has the potential to lead to more conscious choices concerning the disposal of plastic. It is a matter of keeping this problem present and making people aware of it. Several partners (Water Managing Authority, 2021) mentioned, that a good connection has been established with local partners, stakeholders and volunteers concerning this problem. There is large interest from multiple sides, to further bundle these efforts in the future by creating a collective approach. As stated by one of the partners (Water Managing Authority, 2021), the plastic pollution problem can only be solved in the long run, since this issue asks for a long-term commitment. To bundle information, it is therefore advised to conduct research on whether Citizen Science platforms can be utilized for this purpose. In this research attention should be, among other things, to aspect like quality, trustworthiness and added value. Citizen science will always be an add-on information to the independent information generated in governmental programmes. For now, it is advisable to start collaborating nationally, activate international knowledge and best practices, compare, disseminate, and harmonise methods and datasets to be able to stepwise build on more and more international collaboration. This is a lengthy and bottom-up process.

IV. Information management is crucial to make a cross-border dataset useful, transparent, and comparable.

An inventory of existing knowledge and the desired project goals that should be reached, should be established in the beginning of a project. A majority of the partners mentioned that the roadmap of attaining project goals, with respect to the monitoring, was not fully clear during the project. This leads to situations where partners have difficulties deciding what to do and therefore do not start, or different partner interpret the plan in a different way and start working on activities that lead to incomparable results. Therefore, it is important to start a project with a roadmap that contains clear steps, milestones, and time horizons.

A method of information exchange must be agreed upon at the start of the project. It was mentioned during the interviews (Water Managing Authority, 2021) that the international exchange of information is a complex process that should not be underestimated. This however does not only refer to an international level, but also a regional and local level, whereby the exchange of information can be unharmonized. It is important to involve information experts soon in the project to prevent problems from occurring later in the project or at the end. Such an information expert can also analyse the comparability of already existing datasets to figure out how well the existing methods or datasets can be exchanged.

Standardized measuring methodologies for monitoring plastic waste are needed to make the data and results comparable. From the analysis of the collected data, it became clear that the partners were measuring different aspects and therefore the comparison of the results was not possible. This will be explained in more detail in the next chapter but from this fact it can already be concluded that a unified measuring methodology is important in the beginning of a project. Another option that can be explored is the applicability of translation methods in between the different datasets. However, the expert opinion of people who often work with data from litter it seems very difficult to impossible translate these datasets into one overarching dataset. Consequently, more profound conclusions can be drawn that contribute to the establishment of future strategies. The Interreg LIVES project established a solid foundation for collaborative efforts and information exchange. If a solid measuring methodology can be made, this will ensure that the initially set goals will be reached.

Reproducibility and transparency of data is essential. The data that is gathered from partners or associated partners should be reproducible for every implemented monitoring method. This will harmonize methodologies and reduce the probability of errors. Lastly, if data is shared with partners, the data should be transparent, meaning that data that is shared should be self-explaining. This should be done with assistance of experts who have experience with cross-border datasets. This expert can then lead a session with all the partners, where the main goals of collecting data should be aligned. After the goals are clear, they can be made measurable with objective trees. The lowest layer of this tree is quantifiable and therefore usable to translate into required information and data. In a later stadium, tools like means-end diagrams can be used to agree upon the best measures to collect data.

V. Project management is an essential activity in cross-border cooperation projects.

The project duration should be longer and structured by short-, medium- and long-term goals. It became clear that within a project with this many participants who are from different countries, a good “project kick-off” is extremely important and should not be underestimated. Make people responsible for specific tasks such that they can focus on this task and make sure it is done with high quality standards. It is of importance to also set up short-, medium- and long-term goals. Short-term goals could comprise the agreement on the objectives, implementation of monitoring pilot projects, and setting up monitoring protocols. For the medium-term the goal could be to establish a first order of magnitude estimation of litter in each river component and its relative importance within the entire context. In the long run, the focus will remain on solution, guidelines and policy related goals supported by

long-term monitoring to identify trends and evaluate preventive measures. In a cross-border approach it is of importance that national and international baselines and agreements are established regarding to the monitoring protocols, activities, and strategies. A more in-depth description of these aspects can be found in Chapter 3.

Lastly, it is important to mention that the establishment of short-, medium-, and long-term goals does not only hold for this work package but also for other work packages from the entire Interreg LIVES project.

The timeline of a project needs to be well aligned with the stated objectives. From the interviews it appeared that the initial stated objectives were quite ambitious for the entire LIVES project and not in the best sequence. In the planning of a project proposal, it should be taken into account that project start takes time. After the proposal is submitted some time will pass by and submitting parties will continue with their daily job. When the proposal is approved, they need to make time for this new project and make a more detailed, realistic planning with all partners.

Safeguard the knowledge in your project. Information is a combination of different data on paper or digitally. People have knowledge in their head that is the result of combining information with their previously acquired knowledge. This is an important fact to be aware of in interregional projects like LIVES. To prevent knowledge from disappearing due to any event e.g., illness or job change, it is important to sufficiently share knowledge throughout the project. To safeguard the knowledge in an organisation it is important to have project-update presentation is a fixed frequency. You can e.g., organise lunch lectures in which one discipline gives an update about the last results. This can be summarised in visual management summaries which are easily accessible. The project update summaries should be self-explanatory to everyone who needs to get acquainted with the topic. Furthermore, in case of a job change, the responsible employee(s) should give an explanatory presentation about the project to the employee(s) taking over the project.

Smaller workgroups with clear work packages and deliverables result in tangible results and better insight in the progress. It was mentioned in several interviews (Water Managing Authority, 2021) that the time in between two meetings for the entire LIVES project was quite long and the goals that had to be reached in between were not clear. For this reason, it would be smart to use a more result-oriented approach with smaller sub-results. This way, the final goal 'at the end of a long distance' can be reached by having several smaller 'sprints'. Connected to creating smaller deliverables and work groups, a future best practice is the more frequent exchange of information and knowledge by e.g., meetings or small reports. In the project kick-off the partners should agree upon what information they would like to read during the project.

Project manager and Project leader both are important, but they have different skills. Small haziness's or indistinctness's should be identified quickly and solved. This can be done by a project leader who stands close to the project members and is familiar with the execution of tasks. A project manager is more responsible for the time management and takes care of the Key Performance Indicators (KPI's). If needed, this person can scale up if the preliminary results are not sufficient, whilst a project leader is more in the lead of the project. This person

knows everybody, speaks with project members in a high frequency and is the focal point of contact for smaller struggles during the project.

This project forms a solid foundation for a future follow-up. Across all work packages, the Interreg LIVES project was a successful project which stimulated cross-border cooperation involving the use of monitoring methods and the implementation of litter removal systems. It cannot be stressed enough that this project is one of a kind and it has truly paved the way for the reduction of plastic in the Meuse in the foreseeable future. Since something comparable has not been done before, an iterative approach is needed to optimize different aspects of such a project.

1.3. Future innovative methods and knowledge

VI. Future knowledge about the behaviour of plastic in water is essential

More knowledge about behaviour of plastics in the water is essential for the understanding how to improve monitoring methods. It was mentioned by the Province of Limburg, Wasserverband Eifel Rur and Vlaamse Milieumaatschappij (Water Managing Authority, 2021) that the level of knowledge about how plastic is floating through the rivers and canals is still scarce. This makes it difficult to comprehend if the current methods of litter removal and litter monitoring are the best methods. In the future this would be highly recommended to gain more insights by making models that predict the behaviour of floating plastics. However, this research field is in its infancy so this will take quite some time before it reaches the level that is needed to draw useful conclusions.

There were multiple suggestions given which could improve the knowledge level at locations where this is needed. The first and simplest option is to share knowledge regarding how to prepare a monitoring project, where to apply it, or what difficulties to be aware of. For example, the Dutch waterboard could make a short presentation or report about the lessons learned of installing litter trapping system in their streams. A second option would be to install and educate a small international committee with sufficient background knowledge and experience in the field of removing and monitoring litter. This committee can answer technical questions and perhaps proactively assist water managing authorities with the implementation of litter monitoring/removal systems.

VII. New or innovative technologies can help to automate and simplify monitoring efforts

There is additionally interest in a method for the automation of plastic monitoring if this would decrease the labour intensity and efficiency of current methods. Of course, it needs to be mentioned that a healthy balance should be found between these methods and cleaning activities, as these activities significantly contribute to the reduction of plastic in specific areas and lead to enhanced awareness creation. The automation would refer to e.g., the classification of found objects by means of the OSPAR analysis, since this is a relative intensive procedure. Due to the nature of this method, the partner mentioned that if this procedure

could be automated (e.g., image recognition), that monitoring could be set up on a larger scale. Currently, one partner uses cameras to monitor and control invasive animal species. It was mentioned that cameras could also be used as future monitoring tools, to continuously monitor e.g., plastic fluxes. Lastly, another partner collaborated with an Artificial Intelligence (AI) based institute to estimate the quantity of plastics with the help of drone images in the aftermath of the flooding events in the summer of 2021.

One Garbage processing organisation has experience with municipalities that implement remote sensing to monitor plastic on the shores of waterbodies. This is done by Unmanned Aerial Vehicles (UAVs) which offer the advantage, that they are cost-effective and efficient. The implementation of UAVs can be an interesting technology for the future to detect plastics not only on shores but also in the water. This insight could potentially be given by means of cameras on fixed poles, or poles on ships that are already performing inspections. If the images from such a camera are of sufficient quality, this can be translated into standardised pollution levels per square meter with usage of Artificial Intelligence models.

The Interreg LIVES project already helped the partners to start with monitoring activities. The partners indicated that more efforts could be put into the automation of plastic monitoring methods as future best practice. The deployment of monitoring systems is an iterative approach that needs to be optimized by trial and error which ultimately yields into the required knowledge. Due to these iterations and the infancy of the required technologies, this is a more yearly approach that must be properly managed from a governmental perspective. Since technology is rapidly advancing, these methods could potentially be embedded into the pool of future monitoring strategies.

2 How to improve on building a cross border dataset on litter monitoring

Chapter Summary: This chapter describes lessons regarding the building of an extensive cross-border dataset. Through a series of innovative pilots for cross-border litter monitoring in the Netherlands, Belgium, and Germany, a first version of a dataset could be established within this project (2bprojects, 2021). The Interreg LIVES project laid the foundation for these monitoring strategies and interviews with the involved partners yielded into learned lessons and best practices for the future. These will be described and bundled into key messages in the following section. It is important to mention that this chapter has high correlation with two other products within this project. These are the “Monitoring Strategy 2022-2027” written by Tauw and the “open access data system” made by 2bprojects (See Figure 1). Noria first collected data from the partners and subsequently analysed this data on outliers and other incorrect values. After this quick analysis we handed it over to 2bprojects in the shape that was useful form them. 2bprojects made a Proof of Concept for a potential future database (2bprojects, 2021) From the initial analysis and a conversation with 2bproject, the following three key messages can be distilled in two categories.

I. Shared data should be reliable, useful and the associated methods for data collection should be prepared together with the partners

Make a solid plan for registration of data. To come with valuable data that in the end can be translated into the required information, which was explained in chapter 1.2 part IV “Reproducibility and transparency of data is essential” it is important to first think about questions like; what data are needed, how this can be collected, how it can be stored and of course how we would like to visualise the information in the end. Before making a joint plan of how to collect data, the current methods can be used as input to make a jointly method. Every partner that collected data can make an elaborate description as to how the data was gathered and how it needs to be imported in the online database.

A uniform datasheet should be used amongst the involved partners to ensure harmonized data collection. As best practice, examples should be made that shows how to fill in these forms such that every individual working with these forms knows exactly how to fill it in the correct way. As the harmonization of methods is a crucial factor in data collection, it should be ensured that every partner measures the quantitative and/or qualitative data that is needed to answer the required objectives.

II. Data inconsistencies can be overcome by introducing unified methodologies and safety layers

Make sure data is correct and consistent. When gathering data, there is a phenomenon called data inconsistencies. Some databases with longer monitoring periods contain outliers which can be considered as one of the most found items from a waste classification analysis or a measurement error. An example from one of the datasets can be seen in Figure 2. This graph shows the number of items found from category C7, which represents coarse floating litter (e.g., objects such as lost wheel covers, Styrofoam, or isolation material). From the data it can be seen that in a period of eight months (March – October 2021) an outlier was present on the 15 September 2021. This is more than three times the previous highest amount of found items. Therefore, it becomes interesting to study the cause for this sudden increase in found plastic waste. Was there a flooding event? Did a construction site in the vicinity dump objects in the water? On basis of the data specific measures can be taken in order to prevent these sudden increases in waste fluxes. Data can be used as a powerful tool to detect outliers and potentially plastic emitters can be held liable by enforcement.

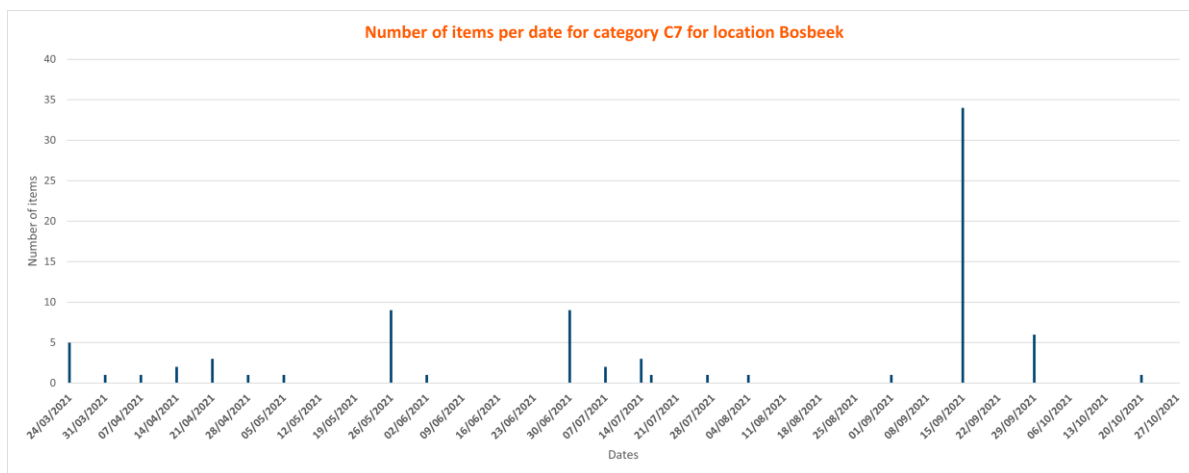


Figure 2 Overview of items per data found at location Bosbeek (Belgium)

Data check is important to build in the open access data system. For example, checks on outliers and invalid values should be located with a system or human inspection in order to keep the quality of the data high. If the quality of the data decreases, certain decision can be taken based on wrong data. This should be regarding the input data but also in terms of administration, meaning that the data needs to be transferred correctly to e.g., SharePoints. Data, which is registered with different devices or using software, this can result into wrong translation like wrong value in the wrong fields. This process would introduce an additional safety layer that potentially minimizes the probability of errors. An adequate scrutinization of these outliers is near to impossible if there is no transparency as to how the data was collected. This key message is mainly important for the report and product of 2bprojects.

III. Measuring potentially influencing parameters are as important as measuring plastic fluxes

Influencing parameters are equally important as measuring the plastic fluxes and should therefore be introduced as a best practice in the future. The fact that many variables influence the behaviour of plastic is put forward in a study from 2020 (Wendt-Potthoff, et al., 2020). Especially in rivers and lakes, many environmental factors influence plastic concentrations at the time of sampling activity. Therefore, the development of forecasting models that can predict the behaviour of plastic in our rivers is essential to be able to remove the litter with cost-effective methods. For data interpretation it is essential to not only provide the time of sampling and locations, but also data related to the ambient environmental conditions which could have an influence on the observed concentrations at a specific time and location, such as:

- Time and duration of the sampling (e.g., visual counting)
- Geographic location of the sampling site
- Precipitation during and prior to the sampling
- Wind direction during and before the sampling exercise
- Slope of the shore and degree of vegetation
- Discharge during and prior to sampling (rivers)

One partner (Water Managing Authority, 2021) mentioned that it was complex to establish a relationship between the measurements of litter concentrations and e.g., the discharge of a stream. In this specific project implementation of a monitoring campaign was set up for 6 weeks but the question arose how these findings could be extrapolated to for longer periods. Is there a simple linear relationship between the plastic flux and the discharge? Or does that behaviour differ for lower or higher discharges? These are potential questions that can be answered in the future if more parameters are measured following a refined monitoring strategy. This will ultimately yield more insights into the distribution and quantity of plastic flowing in the Meuse.

3 How the ‘lessons learned’ fit into existing frameworks for litter monitoring

This chapter provides a generic overview of key activities that are practical to perform within future monitoring strategies. This comprises a long-term approach (>5 years). The goal of this chapter is to give practical tips as to how future universal strategies can be made and implemented by governments of European countries.

3.1 Roadmap for a national macrolitter monitoring strategy in Dutch rivers.

To provide some practical suggestions as first step towards a long-term strategy, the insights from the interviews and the Rijkswaterstaat Roadmap for a national macro litter monitoring strategy in Dutch rivers (Emmerik & Vriend, 2021; Rijkswaterstaat, 2020) have been compared which lead so several conclusions listed in the end of this chapter. The roadmap consists of three subsequent levels, namely:

1. Develop monitoring methods
2. Conduct baseline measurements
3. Perform Long-term monitoring of floating litter

At each level specific questions can be answered that will be described in the following paragraphs. The more partners are involved, the higher the potential but also the higher the complexity of a project becomes. Especially in a cross-border approach with the involvement of three countries within the LIVES project, a common approach is needed to tackle this problem effectively.

In the short-term level (1-3 years), the focus should be on agreement upon the objectives, set-up of monitoring protocols and innovative sensing. Innovative sensing focuses on the method development for monitoring, testing and optimization. This includes developing the first method for consistent measurements of e.g., litter suspended in the water column. However, this can include projects related exploring the use of new technology (e.g., sonar, cameras with AI, or drones) to replace or complement existing methods. With respect to monitoring protocols, the tested and proven methods need to be evaluated to develop the measuring protocols. For harmonization purposes, the partners need to agree upon the objectives and monitoring methods that fit those objectives (e.g., units and metrics of plastic, how do you measure the plastic, mass balance or emissions into the ocean).

One crucial point that needs to be addressed in the process of establishing a monitoring protocol is the sharing of data amongst all

Example of monitoring strategy coupled with removal:

To evaluate the effect of a litter removal method, one needs to (1) develop monitoring methods that are suitable for collection of the required data, (2) conduct baseline measurements to know what the point of departure was, (3) implement the measure(s) in order to reduce the quantity of litter at the streams, or rivers, and subsequently (4) perform long-term monitoring of floating litter such that the effectiveness of the implemented measure(s) from step (3) can be measured.

involved partners. Hereby it is important, that the data is reproducible, of sufficient quality, and transparent. A more in-depth description of the exact data requirements can be found in the report of 2bprojects B.V. (2021). The activities in this level will deliver suitable monitoring tools and concrete protocols for the conduction of baseline measurements.

In the mid-term level (3-5 years), first baseline measurements should be performed to analyze later effects of measures and/or trends in the litter quantities. This is based upon the idea of analysing the gathered data according to several metrics (e.g., distribution of plastics, sources, material type, or norm values, or mass balance of plastic flux in the catchment). Parallely, a start can be made with the collection and integration of monitoring at local, national, and international level. This includes harmonizing monitoring protocols and sharing data with other partners. But it also includes integration of data from associated partners (e.g., citizen science, local contractors, or governments).

On the long term (>5 year) more high-level goals, such as e.g., the 2050 long term strategy for climate goals (European Union, 2020), should be formulated. the focus relates to all solution, guidelines, and policy related goals. These are supported by long-term monitoring efforts, to allow for reliable hotspot mapping, trend analyses, and evaluation of measures.

3.2 Result oriented data collection

To guarantee that all activities result in the desired result, the monitoring strategy should be initiated with the right process, namely starting with the end goal. To follow this process, it is advised to use a scheme like the RAKID model, the opposite to the DIKAR-model (Vries de, 2018) (Figure 3).

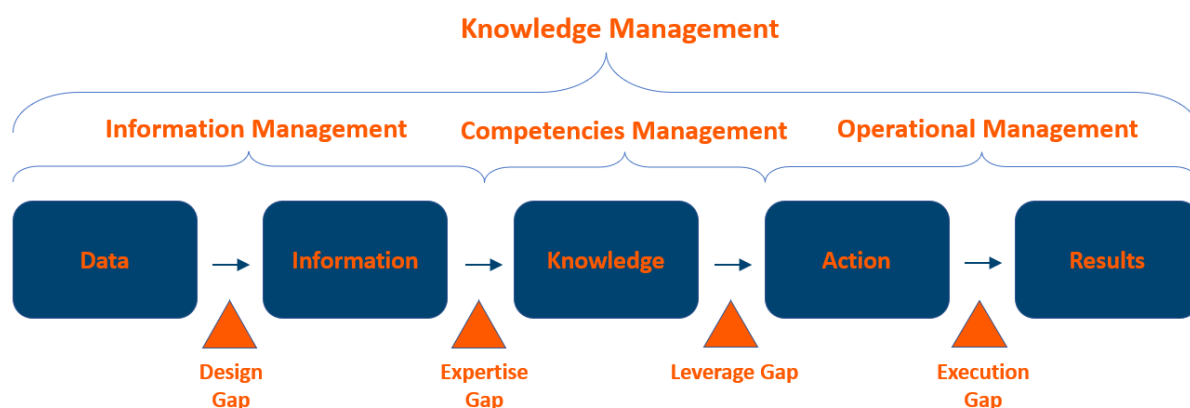


Figure 3 DIKAR model which should be used from right to left (RAKID) to reach the best results.

A common mistake in projects is that organisations start the data collection and then only start thinking about what they can do with the data. In this situation you often conclude that the data is not yet sufficient. Therefore, it is very important that in the beginning of the process, partners agree upon what the desired result should be at the end of a project. It is better to spend more time (e.g., a whole day) on coming to an agreement for the collective desired result that can be translated in the required information. This will ensure that the correct and required data is collected, aiding to fulfil the desired objective.

The RAKID approach can be used within the Rijkswaterstaat strategy. Firstly, the involved parties should agree upon the main strategy regarding the approach of the problem. For example, the desired result can either be on a more generic level (e.g., “plastic free water”) or on a more detailed level (e.g., “insight in the quantities of plastic in the water”) which can be followed by the installation of litter removal techniques or just monitoring the litter. The choice of a result can be translated into a desired insight and subsequently the required monitoring protocol. Two short examples will be given to illustrate how different goals/results lead to different protocols.



Figure 4 Example to illustrate project process with goal to remove litter from the water



If the main common goal (*result*) is to **remove plastic litter from the water as quick as possible**, this could be reached by the installation (*action*) of litter removal devices on those locations where the largest amount of litter passes by. In this case we need to know (*knowledge*) what locations are most suitable to remove the litter. Subsequently, *information* is needed about e.g., how much plastic per time unit is in the water, the accessibility of locations for trucks to reach the water, discharge, or flow velocity. Some information might already be available at a specific organization, other *data* must still be measured and translated into useful information.

Figure 5 Example process to illustrate project process with goal to prevent litter from entering the water.



If the main common goal (*result*) is to **prevent litter from entering the water**, then a suitable *action* could be to install more waste bins, entering a deposit on specific consumer goods, or oblige builders to take preventive measures regarding the spread of construction waste from their site. In this case we need to know (*knowledge*) the type of litter that is predominantly found in the water and what the most likely source is of the litter. Afterwards, *information* about quantities/distributions of different types of litter, a map with potential origin locations of litter or ideas of potential measures that can reduce these quantities, is needed. Some information might already be available at a specific organization, other *data* must still be measured and translated into useful information.

Both these cases result in different types of data collection and therefore will entail a different monitoring protocol.

3.3 Conclusions

The goal of this chapter was to give practical tips as to how future universal strategies can be made and implemented by European countries.

The main conclusion is that partners should first agree upon the desired results. To increase the chance that partners are on the same page it would be good write the ultimate results in the three levels that were also proposed in the Roadmap of Dutch macro litter monitoring. This refers to short-term (1-3 years), mid-term (3-5 years) and long-term results (> 5 years). Working out a plan regarding the collection of data and translation of data into valuable information is important. This results in knowledge, that is needed to take the right measures to reach the desired result of litter free rivers and streams.

To be able to generate trends, the measurements must be performed in different fixed moments during the year and in the same manner.

References

- 2bprojects B.V. (2021). *LIVES Open Access Data System - LOADS*. Maastricht. Retrieved December 2021
- Bronsveld, P., Hopener, E., & Kooter, I. (2021). *Advisory report inventory uniform measuring method for microplastic fibres from textiles*. Utrecht: TNO.
- Deloitte. (2019). *The price tag of plastic pollution - An economic assessment of river plastic*.
- Emmerik, T., & Vriend, P. (2021). *Roadmap Litter Monitoring in Dutch River*. Wageningen: Wageningen University .
- European Union. (2020). *2050 long-term strategy*. Retrieved from https://ec.europa.eu/clima/eu-action/climate-strategies-targets/2050-long-term-strategy_nl
- Geyer, R., Jambeck, J., & Law, K. (2017). Production, use, and fate of all plastics ever made. *Science Advances*, 3(7), e1700782.
- Jambeck, J., Geyer, R., Wilcox, C., Siegler, T., Perryman, M., Andrady, A., . . . Law, K. (2015). Plastic waste inputs from land into the ocean. *Science*, 768-771.
- Meijer, L. J., Emmerik, T. v., Ent, R. v., Schmidt, C., & Lebreton, L. (2021). More than 1000 rivers account for 80% of global riverine plastic emissions into the ocean. *Science Advances*, 1-13.
- Rijkswaterstaat. (2020). *Zwerfafval in en langs rivieren*. Retrieved januari 5, 2021, from <https://zwerfafval.rijkswaterstaat.nl/areaal/rivieren/>
- The Guardian. (2021, Dec 8). *Microplastics cause damage to human cells, study shows*. Retrieved from The Guardian: <https://www.theguardian.com/environment/2021/dec/08/microplastics-damage-human-cells-study-plastic>
- Van Emmerik, T., & Schwarz, A. (2020). Plastic debris in rivers. *Wiley Interdisciplinary Reviews: Water*.
- Vethaak, D. (2021, October 19). *ZonMw*. Retrieved from <https://www.zonmw.nl/en/news-and-funding/news/detail/item/momentum-structured-research-into-health-effects-of-microplastics/>
- Vries de, R. (2018, January 14). The importance of user analysis before the technical design of an instrument, which presents information to users from a different discipline. Delft.
- Wendt-Potthoff, K., Avellán, K., Emmerik, T., Hamester, M., Kirschke, M., Kitover, D., & Schmidt, C. (2020). *Monitoring Plastics in Rivers and Lakes: Guidelines for the Harmonization of Methodologies*. Nairobi: United Nations Environment Programme.
- Water Managing Authority, 2021. *Interview with one or more of the twelve water managing authorities that were involved in this project*.
- Educational institution, 2021. *Interview with one or more of the two educational institutions that were involved in this project*.
- Garbage processor, 2021 *Interview with the garbage processor that was involved in this project*.

Colofon

Client

Rijkswaterstaat in context of Interreg project “Litter free rivers and streams” (LIVES)

This project was supported by the Interreg V-A Euregio Meuse-Rhine program. The Lives project is being carried out within the context of Interreg V-A Euregio Meuse-Rhine, with 735.300 euro from the European Regional Development Fund

Published by

Noria Sustainable Innovators
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2627AN Delft

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06 – 248 560 70

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Date of publication

December 2021

Project-number

2021-RWS-004

Appendix A Table with interviewed partners

This table shows all dates when interviews with partners took place

Partner or associated partner	Category	Organisation	Noria sustainable Innovators	Antea Group	Tauw	2bprojects
Partner	Water managing authority	Provincie Limburg -NL	07-12-2021	07-12-2021	07-12-2021	06-12-2021
Associated Partner	n/a	IVN natuur educatie	07-12-2021	07-12-2021	07-12-2021	short conversation instead of full interview
Partner	Water managing authority	Rijkswaterstaat Zuid Nederland	16-11-2021		16-11-2021	
Partner	Water managing authority	Rijkswaterstaat Zuid Nederland	16-11-2021		16-11-2021	
Partner	Water managing authority	Rijkswaterstaat Zuid Nederland				02-12-2021
Partner	Water managing authority	Rijkswaterstaat Zuid Nederland	25-11-2021	24-11-2021		
Partner	Water managing authority	Vlaamse Waterweg		23-11-2021	23-11-2021	
Partner	Garbage processor	OVAM	24-11-2021	24-11-2021		
Partner	Water managing authority	Waterschap Limburg	30-11-2021	30-11-2021	30-11-2021	29-11-2021
Partner	Water managing authority	Waterschap Limburg	30-11-2021	30-11-2021	30-11-2021	29-11-2021
Partner	Water managing authority	Vlaamse Milieu Maatschappij	21-12-2021			
Partner	Water managing authority	Wasserverband Eifel Rur	26-11-2021		03-12-2021	short conversation instead of full interview
Partner	Educational institution	Open Universiteit Heerlen				
Partner	Educational institution	Zuyd Hoge School	02-12-2021			02-12-2021
Partner	Water managing authority	RWTH Aachen				
Partner	Water managing authority	RWTH Aachen				
Associated Partner	n/a	Regionaal Landschap Kempen en Maasland		08-12-2021		