LIFE Project Number

LIFE15 ENV/SE/000465

LIFE PROJECT NAME or Acronym

HG-RID-LIFE

Final (Technical) Report

Covering the project activities 01/09/2016 to 31/08/2019

Reporting Date

20/12/2019

Data Project

Project location:	Sweden
Project start date:	01/09/2016
Project end date:	31/08/2019
Total budget:	€1,701,112
EU contribution:	€1,019,766
(%) of eligible costs:	60.00%

Data Beneficiary

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2 List of key-words and abbreviations

Keyword or abbreviation	Comment or explanation
PMG	Project Management Group
SG	Steering Group
RG	Reference Group
EPS	External Project Secretariat
PTJ	Praktikertjänst AB
SRAB	Sweden Recycling AB
IVL	IVL Svenska Miljöinstitutet AB
PR1	Progress Report
MTR	Midterm Report
FR	Final Report

3 Executive summary

This Final Report presents the progresses achieved within the Hg-rid-LIFE project (project no: LIFE15 ENV/SE/000465) up to 31/08/2019. Given the positive start of the project and the good cooperation of the project partners, we are glad to conclude that our LIFE project has been a success. The set goals has been achieved as proposed in the project proposal.

3.1 Project objectives, key deliverables and outputs

The Hg-rid-LIFE project aimed at reducing the emissions of mercury (Hg) at dental clinics. This was done by a demonstration project for improving awareness and knowledge of existing installation techniques and maintenance routines for reducing emissions of mercury from amalgam separators. Furthermore, the project lead to an increased knowledge and competence regarding handling of waste containing mercury, management and procedures of amalgam separators, sanitation of mercury, and more. The project objectives were the following:

- Reduce mercury leakage from examined dental clinics.
- Clinics participating in the demonstration project with mercury levels in sewage waste from suction systems above 1,000 µg/l, will have their mercury levels reduced by 50 %.
- Remove sewage waste containing contamination corresponding to 100 kg mercury contaminated sludge.
- Increased knowledge and know-how on how to mitigate mercury leakage from dental facilities.
- Support the development of national and international guidelines for management of dental mercury by providing a draft proposal of guidelines.

The following key deliverables and outputs have been reached in the project:

Deliverable	**Scheduled Deliverable date (in GA or revised)**	**Actual Deliverable date**
E 1.1.2 List of members in Reference group, PR1	30/10/2016	Completed 31/10/2016
E 1.1.1. List of members of Steering Group, Project Management Group and Action leaders, PR1	30/10/2016	Completed 31/10/2016
E 1.2.1 Risk management plan, PR1	30/10/2016	Completed 31/10/2016
D 1.2.3 Stakeholder Analysis, PR1	31/10/2016	Completed 31/10/2016
D 1.1.1 Networking plan, PR1	31/10/2016	Completed 31/10/2016
D 1.2.1 Dissemination and Communication plan, PR1	31/10/2016	Completed 31/10/2016
C 1.1.1 Evaluation plan, PR1	30/11/2016	Completed 30/11/2016
B 2.1.1 Inventory of laws and recommendations on mercury management in Swedish dental facilities, PR1	31/01/2017	Completed 31/01/2017
C 1.1.2 Monitor and measure of LIFE Project Performance Indicators, PR1	31/01/2017	Completed 31/01/2017
B2.1.2 Survey of knowledge about mercury management in Swedish dental facilities, MTR	31/03/2017	Completed 31/03/2017

B 2.3.1 Report on laws and recommendations on dental mercury management in the EU, MTR	31/01/2018	Completed 31/01/2018
B 1.1.1 Development and testing of selection criteria, MTR	28/02/2018	Completed 28/02/2018
B1.1.2 Guidelines for optimal and efficient maintenance and use of amalgam separators, MTR	28/02/2018	Completed 28/02/2018
B1.2.1 Validation methods for performed decontaminations, MTR	28/02/2018	Completed 28/02/2018
B1.2.2 Reducing mercury leaks from decontaminated pipes by chemical treatment, MTR	28/02/2018	Completed 28/02/2018
B1.3.1 Methods and equipment for sampling mercury concentrations, MTR	28/02/2018	Completed 28/02/2018
B 2.1.3 Recommendations for improved routines at dental facilities in Sweden, MTR	28/02/2018 (revised, EASME letter of 19/04/2017)	Completed 28/02/2018
B 2.2.1 Training material and checklist, MTR	28/02/2018 (revised, EASME letter of 19/04/2017)	Completed 28/02/2018
C 1.1.2 Monitor and measure of LIFE Project Performance Indicators, MTR	28/02/2018	Completed 28/02/2018
C 1.3.1 Preliminary evaluation results and recommendations, MTR	28/02/2018	Completed 28/02/2018
B 2.3.2 Survey/overview of knowledge about mercury management in European dental facilities, MTR	31/03/2018	Completed 31/03/2018
D 2.1.1 Report on dental facilities experiences of mercury-control in Sweden	30/06/2018	Completed 15/08/2019
B 2.2.2 Web based tool	30/11/2018	Completed 10/11/2018
B1.4.1 Improved decontamination methods for sub-optimal pipe dimensions	31/08/2019	Completed 31/08/2019
B1.5.1 Decontamination of pipe systems with poor access	31/08/2019	Completed 31/08/2019
B 2.2.3 Web based tool evaluation report, including monitoring of the uptake of the web based tool and results as defined in the indicator table	31/08/2019	Completed 31/08/2019
B 2.3.3 Monitoring and measuring EU outreach, including number of practitioners reached by the webinar	31/08/2019	Completed 31/08/2019
B 2.3.4 Evaluation of EU-outreach through visits on project webpage	31/08/2019	Completed 31/08/2019
C 1.1.2 Monitor and measure of LIFE Project Performance Indicators	31/08/2019	Completed 31/08/2019
C 1.4.1 Assessment of the socio-economic impact of the project actions on the local economy and population	31/08/2019	Completed 31/08/2019
C 1.5.1 Final Results, Conclusions and Recommendations	31/08/2019	Completed 31/08/2019
C 1.6.1 Life Cycle Assessment (Technical and LCA report)	31/08/2019 (revised, EASME letter of 19/04/2017)	Completed 31/08/2019
D 1.2.2 Dissemination report	31/08/2019	Completed 31/08/2019
D 2.3.1 Proposal of input to development of national guidelines	31/08/2019	Completed 31/08/2019
D 2.4.1 Business strategy, developed by SRAB	31/08/2019	Completed 31/08/2019

Layman's report	31/08/2019	Completed 29/08/2019
E 4.1.1 After-LIFE report	31/08/2019	Completed 31/08/2019
E 2.1.1 Audit report	30/11/2019	Not relevant
Milestone	**Scheduled Milestone date (in GA or revised)**	**Actual Milestone date**
Kick-off and first PMG/SG-meeting	31/10/2016	Completed 14/12/2016
Reporting Scheme with specific milestones for each Action developed	30/11/2016	Completed 30/11/2016
Project webpage launched	31/12/2016	Completed 16/11/2016
Internal reporting of Milestones	31/05/2017	Completed 30/09/2017
First process evaluation questionnaire conducted	31/05/2017	Completed 31/05/2017
All clinics in B1.1 screened	30/09/2017 (revised, EASME letter of 19/04/2017)	Completed 30/09/2017
50 % of clinics in B1.2 and B1.3 decontaminated	30/09/2017 (revised, EASME letter of 19/04/2017)	B1.2 completed 30/09/2017 (Except B1.3, see Section 3.3)
All clinics in B1.1, B1.2 and B1.3 decontaminated	28/02/2018 (Except B1.3, see Section 3.3)	Completed 31/12/2018 (Except B1.3, see Section 3.3)
Notice boards on at least 50 % of decontaminated clinics	28/02/2018	Completed 28/02/2018
Material for training seminars developed	28/02/2018 (revised, EASME letter of 19/04/2017)	Completed 28/02/2018
Internal reporting of Milestones	30/11/2018	Completed 30/11/2018
6 dialogue/networking meetings held with Swedish dental actors	30/11/2018	Completed 16/03/2018
4 dialogue meetings held with responsible authorities	30/11/2018	Completed 13/06/2019
Web based training tool finalized	30/11/2018	Completed 10/11/2019
4 national conferences/fairs visited	30/11/2018	Completed 17/11/2017
50 % of clinics in B1.4 and B1.5 decontaminated	31/12/2018 (revised, EASME letter of 10/08/2018)	31/12/2018
At least 50 % of training seminars performed	31/03/2019 (revised, EASME letter of 10/08/2018)	Completed 14/05/2019
All clinics in B1.4 and B1.5 decontaminated	31/05/2019 (revised, EASME letter of 10/08/2018)	Completed 31/05/2019
Second process evaluation questionnaire conducted	31/05/2019 (revised, EASME letter of 10/08/2018)	Completed 31/05/2019
2 EU conferences/fairs visited	30/06/2019 (revised, EASME letter of 21/01/2019)	Completed 11/04/2019
Webinar on dental mercury management in the EU	31/08/2019 (revised, EASME letter of 10/08/2018)	Completed 14/04/2019
All training seminars conducted	31/08/2019	Completed 14/06/2019
A total of at least 6 national conferences/fairs visited	31/08/2019	Completed 18/05/2018
A total of at least 4 EU conferences/fairs visited	31/08/2019	Completed 13/04/2019

Notice boards put up on at least 80 % of decontaminated clinics	31/08/2019	Completed 31/08/2019
Business plan adopted by Medentex	31/08/2019	Completed 31/08/2019
First educations (according to business strategy) performed	31/08/2019	To be completed once relevant policies etc are in place
Final Conference	31/08/2019	Completed 29/08/2019

3.2 General progress and achievements as compared to Grant Agreement

The "Hg-rid-LIFE" project has reached all major goals and the activities performed within the project has run according to the objectives in the updated application content and budget set out in our LIFE application. All Deliverables and Milestones that were due to be completed by this time (except B1.3 decontaminated) have all been completed in time, with no obstacles and good results. The project team members have had a good cooperation and have been deeply involved in the project. The project management has taken measures to fulfil the objectives and ensure a successful implementation of the project.

Action B1: *Demonstration of improved decontamination methods for dental amalgam* has mainly run according to plan, however with some delays. This action has been more time consuming than predicted. Logistic is a critical issue because of geographical distances in Sweden. Lack of time and interest from dentists to take part in the project also effected this action negatively at the start. However, in the end of March 2018, 531 of 600 dental facilities had been screened. 25 dental facilities declined screening and there were also 30 that were given a previous opportunity and declined. The reporting of the screenings and analyzing of the results was facilitated by using an electronical survey tool. In the end, 132 dental clinics were decontaminated, 372.25 kilos of mercury contaminated sludge and 21.15 kilos of pure mercury have been collected and handled as hazardous waste. The quantity of collected elemental mercury varied from 3 to 2,300 grams per clinic. New methods for decontaminations were also tested; filming, chemical treatment and new equipment for improved decontamination methods for sub-optimal pipe dimensions as well as pipe system with poor access.

Action B2: *Demonstration of best practice of mercury management in dental facilities – training of professionals* has run fully according to plan. An inventory of applicable rules and recommendations concerning dental mercury management in Sweden was drawn up. A survey was carried out at two different times, the first one during May in 2017 and the second one two years later, in May 2019. The survey was sent out to all dental practices in Praktikertjänst (around 1,000) and to environmental inspectors in all 290 municipalities. This was an activity for identifying the current knowledge and competence situation in Swedish dental facilities on how to mitigate mercury leakages from dental facilities. The purpose of sending out the survey on two different occasions is because it enables us to see if there has been an increase in knowledge etc. Recommendations for improved routines at dental facilities in Sweden has been developed. The draft of the guidelines has been discussed at several dialogue meetings. Training material in the shape of a checklist has been published. The dental organizations in the EU were contacted to take part in an electronical survey concerning the use of dental amalgam. A web-based tool aimed to provide guidance towards minimising emissions of mercury from dental amalgam has been developed. It contains short video clips, interactive articles, check lists etc with examples from dental care in Sweden. Webinars were arranged for International Association of Dental Students (IADS) and for dental nurses. Training seminars for dental

nurses and inspectors at local authorities were arranged in several cities in Sweden, with information about the project and the web-based tool. The students were asked some questions before and after the seminar. Most estimated their knowledge level concerning impact from mercury on the environment higher after the lecture.
Action C1: *Monitoring of the impact of the project actions* has run fully according to plan. An Evaluation Plan for the complete project was developed, covering both an environmental effect evaluation and process/technical evaluation. Project Performance Indicators have been monitored and measured according to the current status. A test measurement was performed to develop the methodology at a dental care facilities that will be closed down and during normal operation. The documentation of progress and process enabling reflection together with the collected data on success factors and barriers has laid the base for preliminary evaluation results and recommendations. The Hg measurement methodology and analyses developed for dental clinics in the project was used for a technical evaluation of the cleaning methodology used in the project. Different forms of Hg was also measured in the project such as Hg(0), Hg(II) and methyl mercury. During the latter period of the project, when measurement data were available, an economic evaluation (Deliverable C1.4.1 Assessment of the socio-economic impact of the project actions on the local economy and population) and an environmental analysis (Deliverable C1.6.1 Life Cycle Assessment) were conducted.

Action D1: *Communication and Dissemination* has run fully according to plan. A Dissemination and Communication plan and a Stakeholder Analysis were delivered. Networking was initiated by participation as an exhibitor at Swedental, the largest dental conference in the Nordic countries in the middle of November 2016. The project has participated in eleven national and five EU fairs and conferences. Communication about the project and the web-based training tool have been made through articles in internal and external channels, newsletter, surveys, digital notice boards etc.

Action D2: *Dialogue for better national management of dental mercury* has run according to plan. The draft of guidelines for mercury control (Deliverable B 2.1.3, Recommendations for improved routines at dental facilities in Sweden) was discussed at several dialogue meetings with dental teams, dental service technicians and environmental offices in the county's municipalities. The meetings resulted in many comments which were documented. 13 dialogue/networking meetings with Swedish dental actors including technicians and authorities have been held.

Action E1: *Project Management* has run according to plan. The project team consist of a Coordinating Beneficiary (Praktikertjänst AB) and two Associated Beneficiaries (Sweden Recycling AB and IVL Swedish Environmental Research Institute AB).

3.3 Identified deviations, problems and corrective actions taken in the period

Action E1
There have been changes in the upper management of Sweden Recycling which caused a delay in the process of signing the internal co-operation agreement between Praktikertjänst and Sweden Recycling. The General Manager of Sweden Recycling who signed the Associated Beneficiary Declaration and Mandate, left the company in the end of January 2017. The new management at Sweden Recycling therefore asked for an extension of the deadline of the Partnership Agreement until 01/04/2017. The agreement was finally signed by both parties on 26/02/2018.

Action B1
Action B1 became more time consuming than expected. The milestones "All clinics in B1.1 screened" and "50 % of clinics in B1.2 and B1.3 decontaminated" were postponed by four months. The original deadline on 05/2017 was thereby postponed to 09/2017 (approved by the EC).

Unfortunately, the decontaminations in task B1.3 experienced some limitations, mainly due to problems with the prototype for long term sampling of decontaminated mercury water. The prototype that Sweden Recycling developed was shown to have unexpected issues. Based on a safety assessment of the prototype made during the project period, the result of the assessment was that the prototype could not meet vital requirements (see Action B1). The consequence was that the prototype could not be used further in the project and action B1.3 could not being carried out. The decontaminations in action B1.3 were instead moved to actions B1.4 and B1.5 (approved by EASME). In the letter, EASME also asked to ensure that the number of decontaminated clinics should proportionally be increased by 20 clinics in actions B.1.4 and B.1.5. We confirm that this has been done considering the number of clinics with suitable selection criteria (pipe dimensions, clinics equipped with cleaning doors or drain system which have poor access).

At the same time, a method for mercury measurements at dental clinics was developed by IVL and a test measurement has also been performed at a dental care facility that will be closed down.

The actions related to decontaminations (B 1.2.1 and B 1.2.2) have also been more time consuming than predicted. Logistics has been a critical issue because of geographical distances in Sweden. In the application form the schedule was too optimistic. Lack of time and interest from dentist to take part in the project has also initially effected this action.

The milestones related to decontaminations in B1 were revised according to following:
- ✓ "All clinics in B1.1 screened" and "50 % of clinics in B1.2 and B1.3 decontaminated" postponed until 30/09/2017
- ✓ 50 % of clinics in B1.2 and B1.3 decontaminated: The decontaminations in action B1.3 were moved to actions B1.4 and B1.5.
- ✓ All clinics in B1.1, B1.2 and B1.3 decontaminated: The decontaminations in action B1.3 were moved to actions B1.4 and B1.5
- ✓ 50 % of clinics in B1.4 and B1.5 decontaminated: Postponed until 31/12/2018 (without affecting other actions negatively).
- ✓ All clinics in B1.4 and B1.5 decontaminated: Postponed until 31/05/2019, which affected implementation of the milestone "Second process evaluation questionnaire conducted" in action C1. The milestone was revised from 30/11/2018 to 31/05/2019 so that that the evaluations from decontaminations in action B1 could be used as input.

Action B2
"The Training material and checklist/brochure" (Deliverable B 2.2.1, MTR) was postponed from 31/05/2017 until 28/02/2018 (approved by the EC 19/04/2017 so it could be delivered at the same time as "Guidelines for optimal and efficient maintenance and use of amalgam separators" (Deliverable 1.1.2, MTR). This enabled higher quality in the training material and coordination between all actions regarding handling of waste containing mercury, management and procedures of amalgam separators, sanitation of mercury, and more. The milestone

"Material for training seminars developed" was subsequently also postponed until 28/02/2018. The milestone in B2 "At least 50% of training seminars performed" was postponed from 30/11/2018 to 31/03/2019. According to the original application the milestone in B2 "Webinar on dental mercury management in the EU" was to be held at the end of the project. This was a mistake in the proposal. The milestone date was therefore be corrected from 30/11/2018 to 31/08/2019.

Action C1
The Life Cycle Assessment (LCA) (Deliverable C 1.6.1) was, according to the project proposal, set to 31/12/2017. However, since the LCA is a part of the final evaluation and is synchronised with the Cost Benefit Analysis (Deliverable C 1.4.1), it was necessary to have the same deliverable time for the LCA as for the CBA (31/08/2019), which was approved by the EC 19/04/2017. The milestone "Second process evaluation questionnaire conducted" was revised from 30/11/2018 to 31/05/2019 so that the evaluations from the training seminars in action B2 and from decontaminations in action B1 could be used as input.

After these very logical changes to the project, no further delays or other problems were reported. All deliverables and other documentation were finished and delivered on time. The quality of the reports was also checked according to IVL's internal review procedure.

Action D1
The milestone in D1 "2 EU conferences/fairs visited" was postponed to 30/06/2019 so the web based training tool could be demonstrated there (original deliverable date 30/11/2018).

As approved by the EC on 19/04/2017, the following corrections of some misspell in the application form/**non-substantial changes** has been made (during the project period):

- ✓ The project aims to collect 100 kg mercury – the correct statement is 100 kg mercury contaminated sludge (p 11, 12, 14, 15 in the Application Form).
- ✓ The project will improve existing technology for reducing emissions of mercury from amalgam separators – the correct statement is that the project will improve awareness and knowledge of existing installation techniques and maintenance routines for reducing emissions of mercury from amalgam separators (p 11, 15). The project will test new technologies for decontamination of pipe systems in use – the correct statement is that the project will test new methods.
- ✓ There are two different figures in the application form regarding numbers of decontaminations – the correct statement is 125 decontaminated dental clinics (p 12).
- ✓ Milestone "At least 50 % of training seminars performed" has two different deadlines according to "B2´s Project Milestones" in the Application Form (p 28). The correct deadline is 30/11/2018 (p 38, 57).

4 Introduction

4.1 Description of background, problems and objectives (as foreseen in GA)

Environmental problem/issue addressed
According to the report "Study on the potential for reducing mercury pollution from dental amalgam and batteries", (BIO IntelligenceService, European Commission, 2012) dental amalgam is one of the main remaining uses of mercury in the EU. The demand for dental amalgam was still high in 2010 and corresponded to on average 75 tons of Hg per year in the EU. Around 25% of EU dental facilities are still not equipped with amalgam separators, also a significant proportion of separators are not adequately maintained, which can significantly reduce their mercury capture efficiency. COWI/Concorde (2008) estimates that if about 500 g of mercury is trapped in the piping of an average European dental clinic, even a conservative estimate would put the total at some 50-70 tons of mercury for the EU. BIO Intelligence Service estimates that about 45 t Hg per year from dental practices within the EU ends up in the clinics effluent. Hence, there is a substantial load of mercury ending up in the environment due to the present and historical use of dental amalgam.

Mercury is a persistent substance and highly toxic for humans, ecosystems and living species and poses a threat already at low exposure. The BIO Intelligence Service states that the current levels of mercury concentration in the EU are such that all the general population is exposed to mercury above the natural background level. Approximately more than 70% of the European ecosystem area is estimated to be at risk today due to mercury.

Outline the hypothesis to be demonstrated / verified by the project
The proposed project aims at reducing the emissions of mercury by demonstrating new and improved methods for decontamination of amalgam and mercury in the pipe systems of Swedish dental clinics. The project has potential to remove up to 50 percent of the mercury from the dental clinics taking part in the pilot project. In a first stage, the project aims at collecting 100 kg mercury contaminated sludg. The project focuses on following technological achievements:

- improving standards for sampling mercury concentration,
- improving methods for decontamination of pipe systems in use and
- improving installation techniques and maintenance routines for reducing emissions of mercury from amalgam separators

Pipes in older suction systems (from the time before amalgam separators were used) are usually built for flow of air instead of water. These pipes usually contain large amounts of amalgam sludge. This is due to sharp bends of the pipes and weak decline. Hence, a general problem arising during current decontamination action is accessing contaminated pipes. With current decontamination system this is done by cutting the amalgam contaminated pipes. It must be done by using cold methods to minimize the risk for inhalation of mercury vapours. These difficulties will be avoided by using the methods proposed in Hg-rid-LIFE.

Hence, the proposed methods for decontamination will enable decontamination of suction pipes that are impossible to reach today or is considered too expensive to decontaminate. With the current technique many of pipes are not properly cleaned but this will be accomplished with the proposed methods. Quantification of benefits of novel cutting edge technologies is hesitant. The potential benefit also depends on the condition of the suction systems since the constructions

of the systems vary a lot. In some cases all of the pipes are reachable where in other cases just 50% can be reached. The potential benefit of the project is however substantial since it enables the pipes with most sludge to be decontaminated.

Description of the technical / methodological solution

Sweden Recycling has a prototype that simplifies cleaning of suction pipes and enables cleaning of waste water pipes without the need for a cleaning door, but this prototype requires further development and testing during the project period. The new methods is more simplistic and flexible than existing, as well as more cost effective. This also means that it has potential to be adapted to most standards of dental clinics throughout Europe.

To develop remediation methods that produce better results with cleaner pipes and lower mercury levels, several operational decontamination cases will be performed where new methods and new equipment are tested.

In order to increase the efficiency of pipeline cleaning with suboptimal pipe dimensions, and long pipes, new equipment for decontamination (High pressure washer) will be tested. This type of equipment is already available on the market so Sweden Recycling has purchased a high pressure washer who has a capacity of 200 bar pressure and with a range of 40 meters. This equipment will be tested to develop new methods and evaluated in action B1.4.

In systems that include long pipe sections and sharp bends it can be very difficult to reach every surface. New methods must therefore be developed for cutting and repairing all dimensions of pipe. This work will be carried out in cooperation with pipe specialists.

Equipment and methods will be tested and developed that simultaneously perform high-pressure rinsing and collection of waste water at the same connection point. This method will make this type of remediation simpler even when there is a cleaning door as it will be both simpler and require fewer staff than conventional techniques. This method is also expected to make it easier to launch decontamination in other EU countries as it will make the decontamination of waste pipes after dry suction systems both simpler and cheaper.

Expected results and environmental benefits

- Development and demonstration of an improved effective, easy-to-apply and cost-effective methods for mercury decontamination.
- Drains of 600 dental care facilities screened for mercury.
- Dental care facilities decontaminated from mercury with improved methods for decontamination that will be developed in an agile way during the project.
- Sewage waste containing contamination corresponding to 100 kg of mercury contaminatedsludge removed from pipes in dental clinics, the improved method generally has potential to increase the volume of removed contaminated sludge with 25-50 percent.
- Reduced mercury leakage from examined dental clinics.
- In clinics where mercury levels exceed 1,000 μg/l in sewage waste from suction systems, mercury levels will be reduced by at least fifty percent. This will also reduce concentration of mercury in sewage waste (mud).
- Increased knowledge level and know-how on how to mitigate mercury leakage from dental facilities reached in dental teams, environmental officers, suppliers of dental equipment and dental technicians. The goal is to carry out at least 15 training seminars and in addition several international webinars.
- Web-based training tool developed regarding mercury management in dental facilities.

- Support the development of national and international guidelines for management of dental mercury by providing a draft proposals of guidelines based on results obtained in this project. The draft proposals will hereafter be used as internal guidelines for mercury management by the beneficiaries.

4.2 Expected longer term results (as anticipated at the start of the project)

Adequate handling of dental amalgam waste is necessary to achieve certain goals of EU legislation on water quality (Water Framework Directive (2000/60/EC), Decision 2001/2455/EC and Directive 2006/11/EC on dangerous substances and Directive 2008/105/EC on priority substances) where mercury is identified as a priority hazardous substance. Dental amalgam is one of the main remaining uses of mercury in the EU. About 20-30 tons of mercury from dental amalgam use ends up in soil, ground and surfaces water every year according to BIO Intelligence Service (2012). Through demonstrating improved methods for decontamination of amalgam and mercury in the pipe systems of Swedish dental clinics this project will increase possibilities to manage mercury at the source and prevent it from ending up in the nature were water bodies are a core recipient.

Furthermore, a goal of the project is to heavily decrease the concentration of mercury in the effluents from the dental clinics. The projects actions to demonstrate improved methods for sampling mercury concentration in effluents will clearly mitigate an emerging pollutants from wastewater treatment discharges.

The project has potential to remove up to 50 percent of the mercury from the dental clinics taking part in the project. In a first stage, the project aims at collecting 100 kg sludge of Hg. When applied at a larger number of dental care facilities throughout Europe, the additional reduction rate of mercury is expected to be very high and the project will lead to large environmental benefits. If the calculations are based on the situation in Sweden where around 300 grams of pure mercury is expected to be removed from a clinics pipeline in each decontamination activity, we predict that several tons of mercury per year can be recovered throughout the EU with this method in the future. COWI/Concorde (2008) estimates that if about 500 g of mercury is be trapped in the piping of an average European dental clinic, even a conservative estimate would put the total at some 50-70 tons of mercury for the EU. In five years after this project ends, the method is expected to reach 5% of all dental facilities, which implies 3 tons of mercury decontaminated from dental care facilities.

Applying methods for decontamination of amalgam and mercury in the pipe systems of dental clinics will imply potentially large environmental and health benefits. Hence, this project goes further than current measures applied within the EU to reduce the release of mercury. If the results of this pilot project are applied throughout Europe it will result in a major reduction of mercury leakage from dental care facilities, one of the main remaining sources of mercury in the EU.

The project will potentially imply a widened business sector due to new services developed. Increased activity in the business sectors related to decontamination as well as management of hazardous waste is probable. In general there will be a large economic gain for the EU if mercury contaminated sludge from water treatment plants no longer needs to be sent to landfills due to high mercury concentrations. Concerning future development of treatment costs, profits can be generated from improvements made to equipment and methods that reduce time required for decontamination. The staff costs compared with current methods will be halved.

5 Administrative part (Action E1)

Duration of the action:

Foreseen start date:	01/09/2016	**Actual start date:**	01/09/2016
Foreseen end date:	31/08/2019	**Actual end date:**	31/08/2019

OBJECTIVES:
The objective of this action was to ensure progress and quality of the project, that deadlines were met, activities as described in the application were conducted according to plan and to control that actions were executed within the budget frame.

Deliverables and Milestones:

Deliverable	**Scheduled Deliverable date (in GA or revised)**	**Actual Deliverable date**
E 1.1.2 List of members in Reference group, PR1	30/10/2016	Completed 31/10/2016
E 1.1.1. List of members of Steering Group, Project Management Group and Action leaders, PR1	30/10/2016	Completed 31/10/2016
E 1.2.1 Risk management plan, PR1	30/10/2016	Completed 31/10/2016
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Milestone	**Scheduled Milestone date (in GA or revised)**	**Actual Milestone date**
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Final Conference	31/08/2019	Completed 29/08/2019

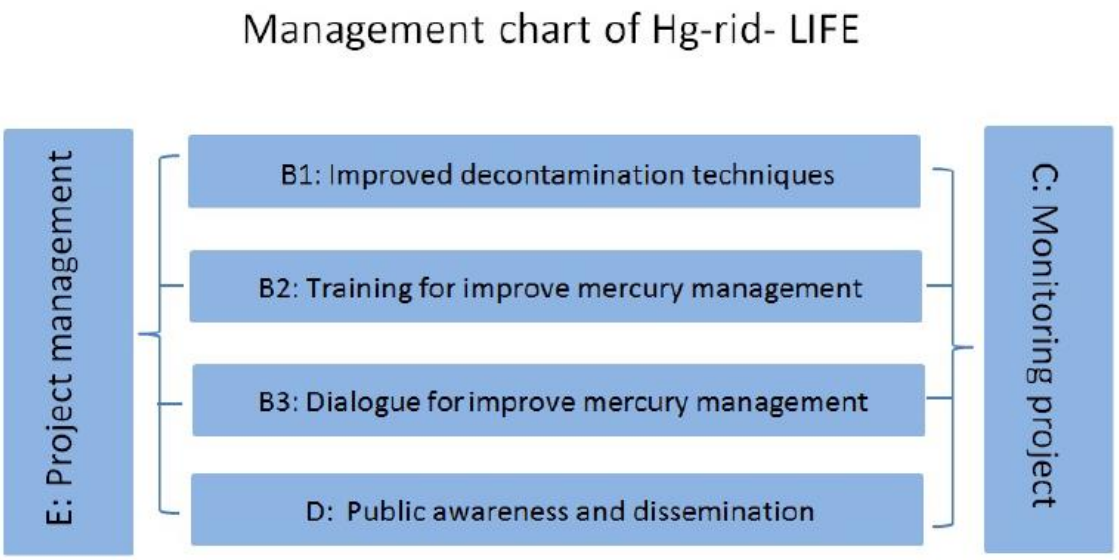
RESULTS:
No difficulties or problems have been detected during the project period. The project partners have had well defined roles and have been keen in achieving the goals of the project. The project work was focused on organizing the administrative, logistic and economic planning.

For more details on the progress, see RESULTS below.

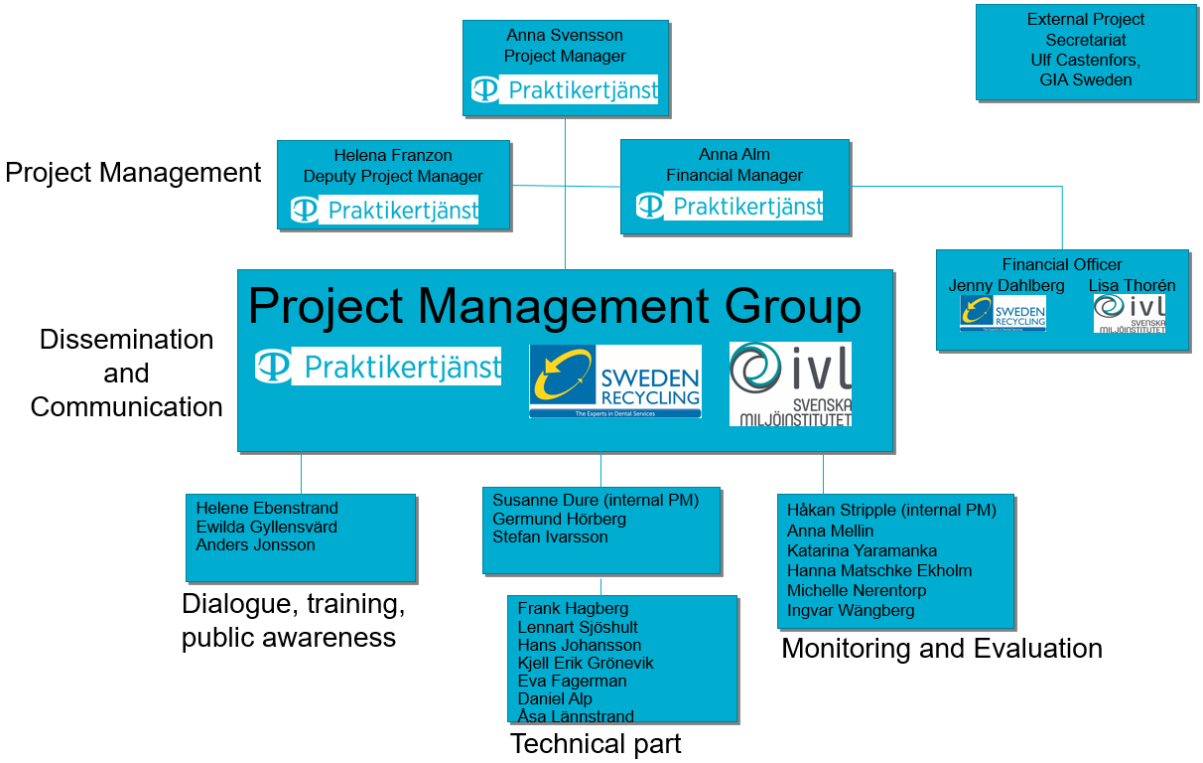
Sub-Action E.1.1 Project Management by Praktikertjänst (including project management process):

The Hg-rid-LIFE work plan was composed of four groups of actions, each with specific objectives and contents. All actions covered the whole project duration and ran in parallel, even if the technical action (B1) was more intense in the first year (screening of clinics) and the actions within Public awareness and dissemination of results (D) and Monitoring (C) was more intense in the end of the project period.

Groups of Actions and their interconnections:



The Project Organization (on 31/08/2019):



Project Management Group (PMG)

The project staff of the Project Management Group (PMG) was appointed in August 2016 (Deliverable E.1.1.1, PR1). The partnership had well defined roles for each of the project partners. In the end of August 2016, a preparatory meeting before the start of the project was organized with all members in the PMG. Deliverables and milestones of the project, deadlines and resources were then reviewed.

Meetings for the PMG have been organized once a month during September – December 2016 and then at least every quarter. An action plan related to the closest deliverables and milestones with responsibility for the actions has been created for each meeting, e-mailed to the PMG and reviewed the following meeting. All beneficiaries have had internal meetings between the PMG-meetings and were in close contact with each other. To facilitate the management the associated beneficiaries had internal project managers.

PMG from Sweden Recyling: Susanne Dure, Customer Support/Internal Project Manager, Anders Hallinder, Project Developer, Klas Broman, Quality Manager, Germund Hörberg, Project Developer

PMG from IVL: Cecilia Österman and Håkan Stripple, Evaluation Manager/Internal Project Manager

PMG from Praktikertjänst: Helene Ebenstrand, Project Administrator/Action Leader, Helena Franzon, Senior Advisor, Anna Svensson, Project Manager

Märta Tobiasson, student at Umeå University, Bachelor's program Environmental protection, Ulf Castenfors, External Project Secretariat, GIA Sweden AB

In the table below meetings within the PMG are presented. The table includes the date, location, agenda/subjects for discussion for the meetings.

Meeting No	Date	Location	Agenda/subjects for discussion for the meetings
1	23/08/2016	Head office Praktikertjänst, Stockholm	PMG-meeting. Start-up and project planning meeting. Deliveries and milestones. Resources. Upcoming meetings.
2	28/09/2016	Head office Praktikertjänst, Stockholm	PMG-meeting. Deliveries and milestones. Plan for screening of dental clinics. Education by Sweden Recycling.
3	26/10/2016	Head office Praktikertjänst, Stockholm	PMG-meeting. Deliveries and milestones.
4	13/12/2016	Head office Praktikertjänst, Stockholm	PMG-meeting. Deliveries and milestones. Information by consulted External Project Secretariat (EPS).
5	16/02/2017	Head office Praktikertjänst, Stockholm	PMG-meeting. Deliveries and milestones.
6	10/05/2017	Dental clinic Praktikertjänst, Gothenburg	PMG-meeting. Deliveries and milestones, tour at dental clinic.
7	07/09/2017	Head office Praktikertjänst, Stockholm	PMG-meeting. Workshop recommendations for improved routines at dental facilities in Sweden
8	30/11/2017	Head office Praktikertjänst, Stockholm	PMG-meeting. Deliveries and milestones.
9	20/02/2018	Head office Praktikertjänst, Stockholm	PMG-meeting. Deliveries and milestones.
10	24/04/2018	Head office Praktikertjänst, Stockholm	PMG-meeting. Deliveries and milestones.
11	04/09/2018	Head office Praktikertjänst, Stockholm	PMG-meeting. Deliveries and milestones.
12	13/11/2018	IVL Svenska Miljöinstitutet, Gothenburg	PMG-meeting. Deliveries and milestones. Lecture about mercury.
13	30/01/2019	Head office Praktikertjänst, Stockholm	PMG-meeting. Deliveries and milestones.
14	27/03/2019	Head office Praktikertjänst, Stockholm	PMG-meeting. Deliveries and milestones.
15	12/06/2019	Head office Praktikertjänst, Stockholm	PMG-meeting. Deliveries and milestones.

16	11/08/2019	Head office Praktikertjänst, Stockholm	PMG-meeting. Deliveries and milestones. Final Conference.
17	18/09/2019	Head office Praktikertjänst, Stockholm	PMG-meeting. Final Report.

Steering Group (SG):

The project staff of the Steering Group (SG) was appointed in August 2016 (Deliverable E.1.1.1, PR1). The SG-members has been Unit Director Dental Business at Praktikertjänst AB, General Manager at Sweden Recycling and Head of Research/expertise in mercury at IVL. The group has had yearly meetings, see below:

Meeting No	Date	Location	Agenda/subjects for discussion for the meetings
1	14/12/2016	Head office Praktikertjänst, Stockholm	Status of the project, decisions concerning any amendment issues.
2	08/05/2018	Head office Praktikertjänst, Stockholm	Status of the project, decisions concerning any amendment issues
3	06/05/2019	Head office Praktikertjänst, Stockholm	Status of the project, decisions concerning any amendment issues.

Reference Group (RG):

The members in the Reference Group have represented features that take responsibility for the entire chain, from "the handling of amalgam to clean water" - upstream work (stop dangerous substances at source) to the flourishing lakes and oceans in balance. Representatives from The Swedish Dental Association as well as Swedish authorities; The Swedish River Basin District Authorities, Swedish Environmental Protection Agency and Swedish Chemicals Agency have been engaged. Stockholm International Water Institute was also a member of the Reference Group. Nearly all of the members have been engaged in European working groups.

Meeting No	Date	Location	Agenda/subjects for discussion for the meetings
1	30/08/2016	Head office Praktikertjänst, Stockholm	Status of the project, dialouge.
2	12/09/2018	Head office Praktikertjänst, Stockholm	Status of the project, dialouge.
3	13/06/2019	Head office Praktikertjänst, Stockholm	Status of the project, dialogue.

External Project Secretariat (EPS):

In December 2016, an External Project Secretariat (EPS) according to best bid was contracted. The EPS has supported project management with the most important administrative and reporting issues, as well as ensuring high quality execution of the project, as the Coordinating Beneficiary never has coordinated this type of project before. The consulted EPS (GIA Sweden AB) has great experience from more than 35 successful projects in the LIFE Programme.

Communication with EASME and Regional Coordinator/Monitoring expert of NEEMO:

MTRs Inta Düce, Regional Coordinator/Monitoring expert of NEEMO, has visited the project four times, the first time in December 2016. Malgorzata Piecha, Project Adviser, European Commission, took part in the meeting in December 2018.

Meeting No	Date	Location	Agenda/subjects for discussion for the meetings
1	05/12/2016	Head office Praktikertjänst, Stockholm	Status of the project, technical and financial part.
2	10/04/2018	Head office Praktikertjänst, Stockholm	Status of the project, technical and financial part.

3	13/12/2018	Head office Praktikertjänst, Stockholm	Status of the project, technical and financial part.
4	24/10/2019	Head office Praktikertjänst, Stockholm	Status of the project, technical and financial part.

Please note that all questions in the EASME letter of 30/01/2017 were answered in the Progress Report (February 2017) and all questions in the EASME letter of 19/04/2017 were answered in the Mid Term Report (February 2018).

Meetings with the responsible of financial issues:

The responsible of the financial part of the project has had regular meetings with the External Project Secretariat (EPS) to ensure quality in the accounting.

Meeting No	Date	Location	Agenda/subjects for discussion for the meetings
1	10/02/2017	Head office Praktikertjänst, Stockholm	Financial workshop by consulted External Project Secretariat (EPS).
2	23/03/2017	Head office Praktikertjänst, Stockholm	Budget vs costs.
3	05/10/2017	Head office Praktikertjänst, Stockholm	Financial issues.
4	19/01/2018	Head office Praktikertjänst, Stockholm	Financial reporting Midterm Report.
5	05/02/2018	Head office Praktikertjänst, Stockholm	Financial reporting Midterm Report.
6	25/03/2019	Head office Praktikertjänst, Stockholm	Financial issues.
7	23/09/2019	Head office Praktikertjänst, Stockholm	Financial reporting Final Report

Workshop with technicians:

Two workshops with part of the PMG and the technicians were arranged on the 24th of November 2016 and on the 18th of December 2017. The aim of the meetings were to engage and educate the technicians in the project as they should perform screenings and decontaminations at the clinics.

Cooperation with university:

To ensure increased knowledge and competence regarding management of dental mercury to the environmental control functions, the project management started a cooperation with Umeå University. A student from the Bachelor's program Environmental protection has been a positive part of action B 2.1.2 Inventory and guidelines. As a part of the project, a thesis was written.

Sub-action E.1.2 – Risk management:

The risks and how to handle them has been analyzed in a risk management plan including an action plan drawn up with all the partners involved (Deliverable E 1.2.1, PR1). One of the top risks in the project was deemed to be weaknesses in financial reporting due to inexperience of LIFE-projects. However, with the support from MTRs Inta Düce, Regional coordinator/Monitoring expert of NEEMO, and the EPS this problem was minimised.

Sub-Action E.1.3 – Reporting and quality control:

As mentioned, the consulted EPS has supported the project management with the most important administrative and reporting issues, as well as ensuring high quality execution of the

project. To facilitate the participation and to ensure quality all project members used a file hosting service for document collaboration and co-authoring. To ensure the quality and environmental level of the project and for disseminating information the project management also established a Reference Group (Deliverable E 1.1.2, PR1).

Sub-Action E.2 –Audit Report:

Since the individual payment from the EU to each project beneficiary did not exceed a threshold of 750,000.00 EUR, the audit certificate for the financial statements was not required with the Final Report. This has been communicated to the project in EASME letter of 10/08/2018.

Sub-Action E.3 -Final Conference:

The Final Conference of Hg-rid-LIFE was held in the end of August 2019 at the same area as World Water Week, the annual focal point for the globe's water issues organized by Stockholm International Water Institute. The theme of our Final Conference was "Vision 2030: No emissions of mercury from dental clinics". The results of the project, the situation in the EU, the latest advances in mercury research and upcoming technology were presented. Approx 50 persons participated (dental organisations, service technicians, authorities etc). As the project is addressing to the Water Frame Directive and the aim is to minimise emission to the waste water, participating at World Water Week was a good final act of the project.

The project was also an exhibitor during the World Water Week, a fair for six days with over 4,000 experts, practitioners, decision-makers, business innovators and young professionals from 138 countries discussing water-related challenges.

Please note that the costs for the organisation of the Hg-rid-LIFE Final Conference were completely separated from the costs of the other joint event (World Water Week), i.e. only cost directly related to the Final Conference has been included in the project costs.

Sub-Action E.4 –After-LIFE Plan:

The main objectives of the After-LIFE Communication Plan are the following:

- ✓ To continue disseminating the project results to raise awareness and knowledge about how emissions of dental amalgam from dental clinics affect the environment and how to mimimise the emissions.

  Activities:
  - The web-based training tool regarding mercury management in dental facilities will still be active after the project and if possible further developed, hopefully with good examples from countries outside Sweden. Praktikertjänst will be responsible for the maintenance of it. It will be available for use two years after the project lifetime and will be available in 5 different languages (Swedish, English, German, French, Spanish) to maximize dissemination potential across Europe. The web-based tool will be continued to be disseminated, especially to dental students in Sweden and in the rest of the EU (dentists and dental nurses). More educated dental teams will motivate clinics applying methods that will minimize emissions of mercury from dental amalgam. Contacts established in the project, for example from fairs and conferences, will be reminded to visit the web-based tool and to spread it. Dental clinics in Praktikertjänst will be requested to use the web-based tool.
  - Dialogue with authorities communicating the results of the project, supporting the development of national legislation or guidance.

- Dissemination of the final results: Layman´s Report, Power Point presentations etc.
- Maintenance of the project web site and web-based training tool: Periodically updates, depending on the information available.
- The After-LIFE Report and Layman's report are also available on the project's website (www.praktikertjanst.se/life)

✓ Technology development

Activities:

- Develop the technology for amalgam separators to improve the effectiveness using reusable filter technology for removing toxic heavy metals from water. A prototype for a more efficient amalgam separator has been developed outside Hg-rid-LIFE. Atium, which is a Gothenburg-based startup company, is developing a new product where Atium's electrochemical filters complement today's amalgam separators to also capture water-soluble mercury ions. Atium's technology is based on research from Chalmers University of Technology. Today there are no amalgam separators that collect all the amalgam particles. The finest particles pass the separators. Zero emissions of mercury from dental clinics can be reality thanks to an electrochemical filter as a complement to amalgam separators. The prototype will be tested by dental clinics during 2020. A cooperation with Atium has been established during the project.

More information can be found in the deliverable E4.1.1 After-LIFE Report.

Expected/achieved results:

Expected results (quantitative targets)	Achieved results
4 Project Management Group-meetings per year	17 during 01/09/2016-31/08/2019
1 Steering Group--meeting per year	3 during 01/09/2016-31/08/2019
3 Reference Group-meetings during the project period	3 during the period 01/09/2016-31/08/2019

ISSUES and SOLUTIONS:

Staff changes:

Some staff changes have been made during the period. We are glad to conclude that despite these (many) personnel changes the project was not affected negatively.

6 Technical part

6.1 Progress per action (Actions B1-D2)

Action B1. Demonstration of improved decontamination techniques for dental amalgam

Duration of the action:

Foreseen start date:	01/09/2016	**Actual start date:**	01/09/2016
Foreseen end date:	31/08/2019	**Actual end date:**	31/08/2019

OBJECTIVES:

The goal of this action has been to develop methods that will reduce mercury emissions to an acceptable level in clinics that have high mercury emissions. References to "high levels of mercury" and "high mercury emissions" mean above 1000 µg/l.

Deliverables and Milestones:

Deliverable	**Scheduled Deliverable date (in GA or revised)**	**Actual Deliverable date**
B 1.1.1 Development and testing of selection criteria, MTR	28/02/2018	Completed 28/02/2018
B1.1.2 Guidelines for optimal and efficient maintenance and use of amalgam separators, MTR	28/02/2018	Completed 28/02/2018
B1.2.1 Validation methods for performed decontaminations, MTR	28/02/2018	Completed 28/02/2018
B1.2.2 Reducing mercury leaks from decontaminated pipes by chemical treatment, MTR	28/02/2018	Completed 28/02/2018
B1.3.1 Methods and equipment for sampling mercury concentrations, MTR	28/02/2018	Completed 28/02/2018
B1.4.1 Improved decontamination methods for sub-optimal pipe dimensions	31/08/2019	Completed 31/08/2019
B1.5.1 Decontamination of pipe systems with poor access	31/08/2019	Completed 31/08/2019
Milestone	**Scheduled Milestone date (in GA or revised)**	**Actual Milestone date**
All clinics in B1.1 screened	30/09/2017 (revised, EASME letter of 19/04/2017)	Completed 30/09/2017
50 % of clinics in B1.2 and B1.3 decontaminated	30/09/2017 (revised, EASME letter of 19/04/2017)	B1.2 completed 30/09/2017 (Except B1.3, see Sections 3.3 & 6.2)
50 % of clinics in B1.4 and B1.5 decontaminated	31/12/2018 (revised, EASME letter of 10/08/2018)	31/12/2018
All clinics in B1.1, B1.2 and B1.3 decontaminated	28/02/2018 (Except B1.3, see Sections 3.3 & 6.2)	Completed 31/12/2018 (Except B1.3, see Sections 3.3&6.2)
All clinics in B1.4 and B1.5 decontaminated, including clinics transmitted from B1.3.	31/05/2019 (revised, EASME letter of 10/08/2018)	Completed 31/05/2019

RESULTS:
The background, implementations and results of action B1 are described more in detail in Deliverables B1.1- B1.5.

Sub-action B1.1 Screening and development of selection criteria:
The purpose of this sub-action was to develop procedures and methods to identify and remediate high levels of mercury and to identify suitable trial subjects for decontaminations. In the end 531 dental facilities in Praktikertjänst were screened and selection criteria for decontamination necessary for each sub-action was developed.

This sub action began in early September 2016 with the development of a screening document. The document was first made as a case report form on paper. In late September 2016 the screening document was tested in the field on some clinics. The results of these tests were discussed and some changes to the document were decided.

The results from the screenings were initially documented in Excel. This way of working was not effective and the PMG decided to facilitate the reporting of the screenings and analysing of the results by using an electronical survey tool. Statistics could thereby easily be produced from the survey tool.

The screening has contained the following actions:
1. Inspection of suction systems and amalgam separators
2. Inspection of piping and sewers
3. Sampling for mercury analysis
4. Photographing and documentation of the pipe system and suction system construction

In the beginning of November 2016, the tool was tested in the field at some clinics. At first the tests were done by using cell phones. There were some technical problems during this test, for example saving and sending pictures. During late November 2016, the PMG decided to use tablets for the purpose of screening. When the technicians started using the tablets there was a problem sending the pictures together with the screening document. At the workshop with the technicians in November 2016, an updated version of the screening document was therefore created.

Documentation was made about:
- the manufactures of amalgam separators
- if the separators were correctly installed
- whether the amalgam separators were situated in the treatment chair (“dry system”) or if several treatment chairs were connected to one or more separators (central/”wet system”)
- the number of clinics with amalgam separator connected to the sink
- year when the suction system was installed
- access to cleaning hatch that simplify decontamination
- which material the pipes were made of
- size of the pipes in diameter
- mercury levels in sewage waste from suction systems

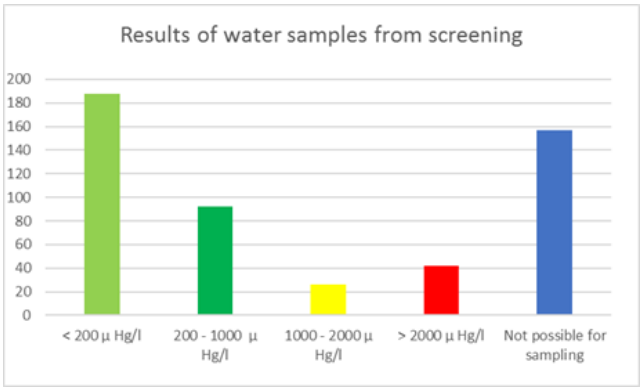
Screening became more time consuming than predicted. In the end of September 2017, screening of the dental clinics had been done according to the revised timetable. 531 of 600 facilities had been screened (in Praktikertjänst there are approx. 1,000 dental clinics at approx. 600 facilities). 25 facilities declined screening and there were also 30 facilities that had been

given a previous opportunity but declined. The results of the screenings carried out were highly sufficient in order to reach the original objective of the project. No more clinics were screened because the remaining numbers were so low and they were not expected to lead to added data and value to the project.

Results screening

The results from screening are presented in deliverable B 1.1.1 Development and testing of selection criteria. Some of the results:

- That a majority of the clinics had results of mercury levels in sewage waste from suction systems less than 200 µg/l. This could be an evidence of efficient maintenance and use of amalgam separators at the clinics because one objective in the project was that clinics participating in the demonstration project with mercury levels in sewage waste from suction systems above 1,000 µg/l, should have their mercury levels reduced by 50 %.
- The screening of amalgam separators and suction systems also showed that plastic is the most common material in the pipes (more than 90%) and that 70% of the facilities have pipes accessible from the treatment chair. These two aspects simplify cleaning of the pipes and will reduce mercury more efficiently.



Experience from screening was used to draw up selection criteria for choosing the 20 clinics for the first decontaminations. The following selection criteria were used:

- ✓ High concentrations of mercury (over 2, 500 micrograms/l)
- ✓ Suction systems installed in the 50´s or earlier
- ✓ The surrounding area in Växjö where Sweden Recycling is located for practical and environmental reasons when chemicals are to be tested on some of the sanitary facilities

Two clinics which were selected for decontamination did not accept the offer. This has been mentioned as a risk in the Risk Management Plan (Dental clinics not sufficiently aware of the effects of mercury contamination from their clinics to book time for mercury decontamination).

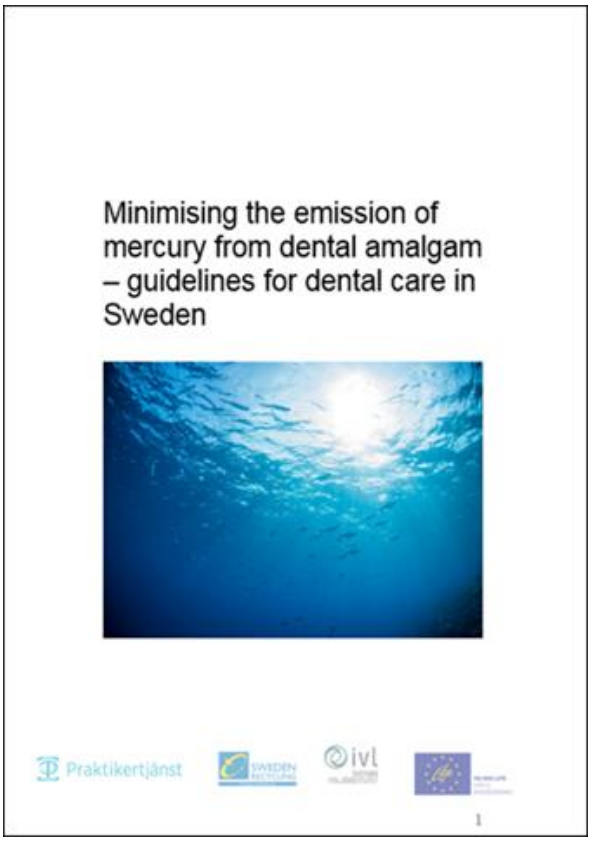
In this sub-action guidelines for optimal and efficient maintenance and use of amalgam separators were produced. Guidelines were developed by Sweden Recycling and Praktikertjänst; “Minimising the emissions of mercury from dental amalgam - guidelines for dental care in Sweden” (Deliverable B 1.1.2 Guidelines for optimal and efficient maintenance and use of amalgam separators, MTR). There are very few dental clinics that have zero emissions of mercury. The finest particles from removed amalgam fillings are not captured by separators. There is no amalgam separator on the market that capture 100% of the mercury. Proper maintenance therefore is important for minimising the emissions of dental amalgam.

The guidelines are applied by Praktikertjänst and will be possible to use as a basis for the development of national and possibly EU-wide guidelines for mercury management. Dental clinics and environmental authorities find guidelines for handling waste from dental amalgam, for example during patient treatment and daily routines for disinfection of the suction system

which affect the effectiveness of the amalgam separators. Dental service technicians find installation guidelines for suction system and requirements for amalgam separators.

Content:

- ✓ Requirements for dental amalgam separators
- ✓ Number of dental amalgam separators
- ✓ Installation of suction system
- ✓ Installation of wet suction system
- ✓ Installation of dry suction system
- ✓ Suction tubes
- ✓ Sink amalgam separators (amalgam separators connected to sinks)
- ✓ Disinfection
- ✓ Patient treatment routines
- ✓ Labelling
- ✓ Waste water sampling
- ✓ Cleaning and emptying of water locks and drains
- ✓ Upkeep of amalgam separator at dental practices
- ✓ Self Inspection
- ✓ Handling of amalgam waste
- ✓ Environmental maintenance service
- ✓ Records and transport documents
- ✓ Decontamination of pipe system
- ✓ Requirements on enterprises which carry out decontamination
- ✓ Incident Management (deviations and improvement proposals)
- ✓ Expertise



Guidelines for minimising emissions of mercury from dental amalgam

The guidelines are published on the project´s webbpage www.praktikertjanst.se/life and in the web-based tool www.hg-rid.eu.

Sub-action B1.2 Filming sewage pipelines and testing of new equipment and methods:
The purpose of this sub-action was to test new equipment and evaluation methods to validate the effectiveness of performed decontaminations.

Filming
All technicians that were involved in this part of the project were trained in the use of the pipe filming equipment. The training and demonstration was performed by a representative of the equipment supplier. The filming of selected clinics started in the second quarter of 2017 and ended in August 2017.

Clinics were selected for filming using the results of the scans in B1.1. Filming has been carried out both before the decontamination commences and after the completion of decontamination.

Results filming
The results of the filming showed that filming can be a useful tool partly to find clinics with a lot of sludge that are in great need of decontamination, but also for the control of the

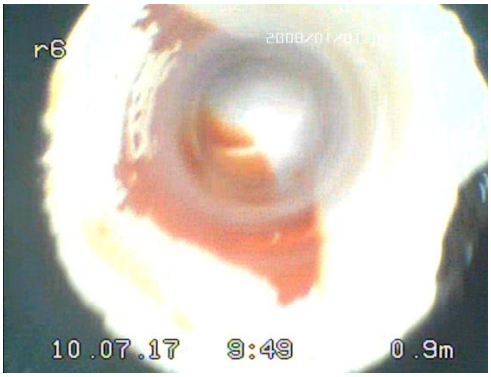
decontamination efficiency. When the video equipment indicates how far the tube system is in the camera all the time, you could use the film to locate where the remaining slurry pipe is located. If the high pressure hose is provided with markings for the length of the nozzle, it would be easy to perform additional flushing at the places where there is still sludge. This procedure could significantly improve the efficiency of the decontamination.

Films before and after decontamination have been published on the project´s webpage (www.praktikertjanst.se/life) The results were presented in deliverable B1.2.1 Validation methods for performed decontaminations, MTR.

Pipes with amalgam sludge

Pipes with amalgam sludge

Water lock with amalgam fillings



Filming before decontamination

Filming after decontamination

Films before and after decontamination have been published on the project´s webpage (www.praktikertjanst.se/life)

Chemical treatment

The sub-action also included testing chemical treatment of pipe systems to reduce mercury leaks of newly treated surfaces that have been contaminated with metallic mercury. The chemicals tested were sodium hypochlorite, potassium permanganate and sodium sulfide. These chemicals can bind metallic mercury so that it will not dissolve in water. Mercury levels before and after treatment were evaluated to determine the effectiveness of the chemicals. The chemicals were collected so that they did not reach the general sewage network.

Test of chemical treatment of pipe systems to reduce mercury leaks of newly treated surfaces started in second quarter of 2017 and ended in September 2017. Tests were been made in eight clinics.

Results chemical treatment
All chemicals had a positive impact on the results after 1, 3 and 6 months respectively. But best effect was found from sodium hypochlorite. As the other two chemicals had a greater risk of damaging sensitive flooring materials, it was concluded that treatment with sodium hypochlorite was preferable to the others and that further trials with this chemical should be carried out on future remediation to find out how to use it in the best possible way.

Results from chemical treatment were presented in Deliverable B1.2.2 Reducing mercury leaks from decontaminated pipes by chemical treatment, MTR.

Sub-action B1.3 Methods and equipment for sampling mercury concentration:
The purpose of this sub-action was to further develop current methods and new equipment for sampling and mercury analysis.

Result equipment for sampling mercury concentration
Unfortunately, the prototype developed within the project could not be tested at clinics due to important factors in the design that could not be secured and approved. Risk factors were leakage of contaminated mercury water and approval of the electrical safety requirements.

To ensure a product of this kind, the product had to be CE marked and approved for the correct application for which it was installed in. To achieve this required more resources in the form of a very long development of time and test procedure, and a budget that was significantly greater than that available in this project. This was something that had not been taken into account at the early stages of the project. The consequence was that the prototype could not be used further in the project and action B1.3 could not be carried out. The decontaminations in action B1.3 (20 clinics) were instead moved to actions B1.4 and B1.5.

However, a method for mercury measurements at dental clinics was developed by IVL and a test measurement has also been performed at a dental care facility that will be closed down in action C1. Different chemical forms of Hg such as Hg(0), Hg(II) and methylmercury were also measured/analysed for some samples. (See Sub-Action C1.2. Evaluating Impacts in the dental care facilities).

More standardized sampling methods for measuring mercury concentration in wastewater have been developed by Sweden Recycling to reduce error sources.

Sub-action B1.4 Development of improved decontamination methods for sub-optimal pipe dimensions:
The purpose of this sub-action was to develop methods that will break up more amalgam and reduce mercury levels to acceptable levels directly after operational decontamination.

Suitable trial subjects identified in B1.1 were to be used to develop and test methods and equipment for sub-optimal pipe dimensions, i.e:

- pipes too thick or too thin for existing decontamination equipment, and
- systems that include long pipe sections and sharp bends

In a system that includes long pipe sections and sharp bends it is difficult to reach every surface.

New methods must therefore be developed for cutting and repairing all dimensions of pipe.

The previous screenings (please see sub-action B1.1) showed that the number of clinics with suboptimal pipe dimensions were very small. Only three clinics had pipe systems more than 80 mm in diameter. Due to that, the selection criteria was changed to 50 mm.

In order to increase the efficiency of pipeline cleaning with suboptimal pipe dimensions, new equipment for decontamination (High pressure washer) was purchased and tested. This type of equipment is already available on the market, so Sweden Recycling purchased a high-pressure washer who has a capacity of 200 bar pressure and with a range of 40 meters. This equipment was tested to develop new methods and evaluated in action B1.4.

A method with high-pressure flushing with water where two sizes of high-pressure units were used. Manufacturing of peripheral equipment and coil hose/flush nozzles was made together with a company that specializes in equipment for high-pressure flushing. Thicker pipes require thicker connection nozzles and thinner pipes require smaller.

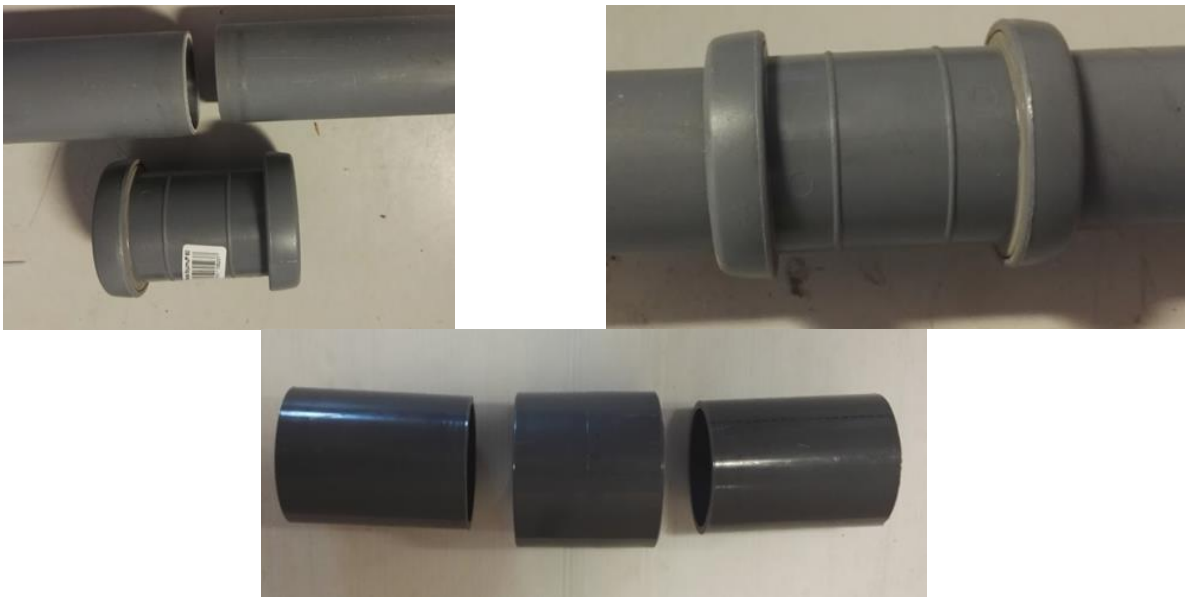
Tests with decontaminations from two directions (applies to wet systems) at the same facility were made to evaluate if there was a need to perform a second decontamination upstream. The second decontamination at the same facility was carried out immediately after the first or later. A more powerful high-pressure unit was used. Thicker pipes require more powerful high-pressure equipment. However, not all parts of the pipe system were even reached with this longer hose so a method by splitting pipes and then applying a sealing muffler between the piping was tested. A sleeve was inserted over one hole in one direction and then after flushing in the other direction. The hole was repaired with a suitable repair kit.

Results development of improved decontamination methods for sub-optimal pipe dimensions

A number of tests of different methods in different material were carried out in the project and they show that it is important to choose the right method for different types of materials, for example, it is not advisable to glue polypropylene material together, instead choose another joining method such as a joint sleeve. The same method performed on another material (polyvinyl chloride material) show that it works perfectly well. Tests also showed that choosing the right equipment to perform flushing is important, e.g. smaller pipe diameters and shorter pipe lengths require smaller equipment while larger pipe diameters and long pipe lengths require larger flushing equipment.

The results from tests with two decontaminations at the same clinic show that if the entire clinic's piping system can be accessed from the clinic and all the way downstream to the suction system, there is no need to perform a second decontamination upstream. This would only incur extra costs.

Not all parts of the pipe system were reached with this longer hose so tests have been performed by drilling a hole in the tube of a diameter large enough to insert flushing nozzle. A sleeve is inserted over one hole first in one direction and then after flushing in the other direction. The hole is repaired with a suitable repair kit. Testing showed that bonding with glue (TANGIT) in PVC plastic is a safe method for closing holes. The recommendation is to mark out all holes and subsequent repair on the property's pipe drawing.



Standard sleeve has been used to connect pieces of 50 mm pipes

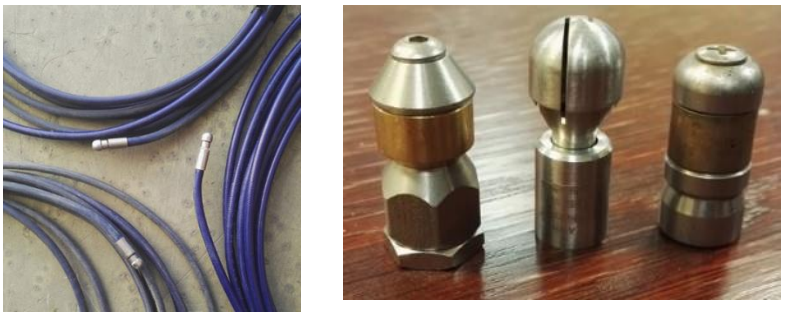
The results are presented in deliverable B1.4.1 Improved decontamination methods for sub-optimal pipe dimensions.

Sub-action B1.5 Development of methods for decontaminations with poor access:

The purpose of this sub-action was to develop simpler and cheaper methods for decontamination of pipe systems that do not have cleaning doors or which have poor access for other reason.

Equipment and methods were developed and tested that simultaneously perform high-pressure rinsing and collection of waste water at the same connection point.

Sewer pipes in the clinic's sewer system are often embedded in floor joists or have been laid in such a way that they are extremely difficult to clean using conventional techniques. There is also a problem if there is no cleaning hatch. The very high costs associated with this type of decontamination mean that the pipes are often ignored. For this reason, there is potential for significant environmental benefits if these pipes are finally decontaminated.



Flush nozzles in different dimensions and design tested

Two prototypes of nozzles were developed. In order to facilitate the assessment of the rewind water's clarity, a prototype was developed with a sight glass where it is possible to see the water flowing back. This prototype was used for pipe dimensions between 20 and 50 mm. When cleaning larger pipe dimensions, a prototype for dimensions between 50 mm and 120 mm was tested.

Prototype for larger pipe dimensions.

Prototype for larger pipe dimensions.

Results development of methods for decontaminations with poor access

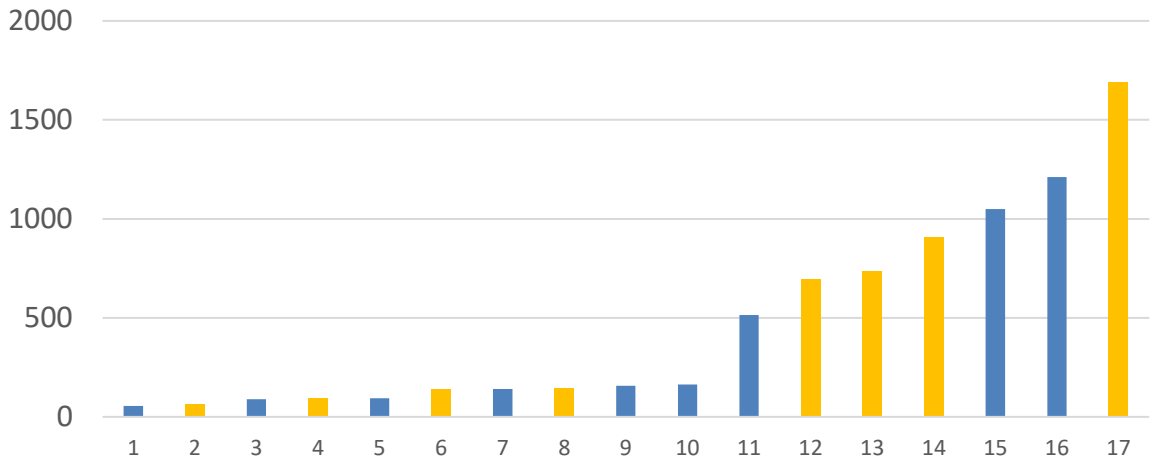
When cleaning larger pipe dimensions, another type of spray nozzle (prototype) was developed. The developed prototype enables the work on decontamination to be carried out from one and the same flush point.

However, evaluation of the values show that each decontamination of the clinic is unique because of the design of the piping system, hence any single factor that is decisive for the dissemination of data could not be demonstrated. See also "Other results from decontaminations" below. The results are presented in deliverable B1.5.1 Decontamination of pipe systems with poor access.

Other results from decontaminations

- Mercury concentrations in wastewater after decontamination at facilities with initial mercury concentrations above 1,000 µg/l reduce by about 50% using the new methods when comparing with on older decontamination methods.

- The results from the decontaminations in the project showed that there is no difference in collected amount of mercury whether the amalgam separator is situated in the treatment chair ("dry system") or if several treatment chairs are connected to one or more separators (central/"wet system"):

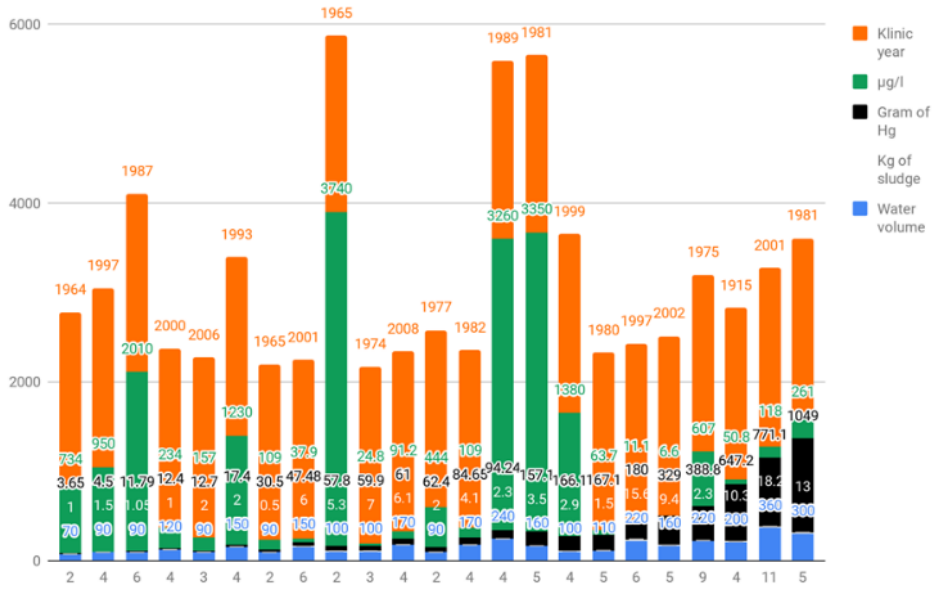


Results of 17 decontaminations, total amount of hg (g)
Blue = wet system, orange = dry system

- The results from the decontaminations also showed that there are no correlations of single decisive factors, e.g. why two clinics of the same size, age group do not show the same result of the amount of mercury collected. The amount of mercury varied from 3 grams to 2.3 kilograms per facility and the amount of sludge varied from 0.3 kilograms to 31.5 kilograms per facility.

  The conclusion is that clinics are differently designed and operated in different ways, in other words, there are very many parameters that have a decisive significance for the deviations that measurement data shows. Factors affecting are, for example: the suction system's capacity and flow, slope/fall on pipes, pipe dimensions, clinic's routines etc.

  Measurement data from a selation of clinics (23) shows the relationship between the number of units and consumed water, µg / l, the collected amount of kg of sludge and grams of mercury, and the year the clinic has been in operation. The results of the collected data presented in the diagram are that there is no single factor that is decisive for clinicians' differences in data.



Correlations of single decisive factors.

PERFORMANCE INDICATORS (if applicable)

Expected results (quantitative targets)	Achieved results (targets)
600 of PTJ's dental facilities screened	531 (55 rejected)
125 dental care clinics decontaminated from mercury with new and improved technology	132 dental clinics (76 dental facilities)
Mercury levels reduced by 50 % in clinics with initial mercury levels above 1,000 µg/l in sewage waste from suction systems	Decontamination of clinics with initial mercury levels above 1,000 µg/l reduces mercury levels with more than 50 %
Sewage waste removed that contain contamination corresponding to 100 kg of mercury contaminated sludge.	372.25 kg
Costs for sampling of mercury concentration reduced from EUR 5,000 to EUR 500	Prototype for sampling cannot be use (see chapter 3.3)
Staff costs for decontamination expected savings 400 EUR/year	Expected savings 400 EUR/year

ISSUES and MODIFICATIONS:
Because of initial technical problems and logistical delay, the screening became more time consuming than originally expected and the milestones "All clinics in B1.1 screened" and "50 % of clinics in B1.2 and B1.3 decontaminated" was therefore prolonged four months (approved by the EC date 19/04/2017). The original deadline on 05/2017 was postponed to 09/2017.

Among the first 20 dental clinics that were chosen for decontaminations, 18 accepted to be a part of the project. However, in the next group of 41 clinics that was invited only 10 accepted, mainly because the decontaminations would result in lack of income. Clinics need a long advance due to the loss of revenue and in combination with the foresight that is required for the logistical planning the action became more time consuming than expected. In addition, the results from the screening showed that not so many clinics corresponded to the selection criteria according to the application form (high mercury levels in sewage waste and suboptimal pipe dimensions). The number of clinics with suboptimal pipe dimensions was very small. Only three clinics had pipe systems more than 80 mm in diameter. The selection criteria in sub-action B1.4 was therefore changed to 50 mm.

The method in order to raise interest among clinics to take part in the project was changed from request by sending out letter to specific clinics corresponding to the initial selection criteria, to information on the intranet for all clinics in Praktikertjänst concerning the possibility to take part in the project. The lack of interest was highlighted as a risk in the Risk Management Plan (Deliverable E 1.2.1, PR1). Gladly, in the end, nearly 100 dental facilities made an interest notification.

The prototype in sub-action B1.3 could not be tested at clinics due to important factors in the design which could not be secured and approved. One of the requirements that could not be secured and controlled was how to ensure that leakage of decontaminated mercury water would not occur. The consequences of a possible leakage could entail high costs for the execution of property. This was approved/noted in the EASME letter of 10/08/2018.

Another important part that could not be assured according to the requirements was the electrical safety of the prototype. The prototype must be secured to wet areas and be able to make contact with water, if this requirement cannot be met the consequences could lead to personal injury.

To ensure a product of this kind, the product should be CE marked and approved for the correct application for which it will be installed in. To achieve this would have required more resources in the form of a very long development of time and test procedure, hence a budget that was significantly greater than that available in this project. This is something that was taken into account at the early stages of the project. The decontaminations in action B1.3 were therefore moved to actions B1.4 and B1.5 (approved by the EC).

However, a method for mercury measurements at dental clinics was developed by IVL. Different chemical forms of Hg such as Hg(0), Hg(II) and methylmercury were also measured/analysed for some samples. (See Sub-Action C1.2. Evaluating Impacts in the dental care facilities). More standardized sampling methods for measuring mercury concentration in wastewater have been developed by Sweden Recycling to reduce error sources.

The milestones related to decontaminations in B1 were revised according to following:

- ✓ 50 % of clinics in B1.2 and B1.3 decontaminated: B1.3 was cancelled and the decontaminations in action B1.3 were instead moved to actions B1.4 and B1.5.
- ✓ All clinics in B1.1, B1.2 and B1.3 decontaminated: B1.3 was cancelled and the decontaminations in action B1.3 were instead moved to actions B1.4 and B1.5.
- ✓ 50 % of clinics in B1.4 and B1.5 decontaminated: Postponed until 31/12/2018
- ✓ All clinics in B1.4 and B1.5 decontaminated: Postponed until 31/05/2019.

OUTSIDE LIFE and CONTINUATION AFTER PROJECT

The results of this action will be implemented and developed as methods for decontamination of pipe systems in dental clinics after the end of the project.

Action B2. Demonstrations of best practice of mercury management in dental facilities – training of professionals

Duration of the action:

Foreseen start date:	01/09/2016	**Actual start date:**	01/09/2016
Foreseen end date:	31/08/2019	**Actual end date:**	31/08/2019

OBJECTIVES:

This action aimed to demonstrate best practice routines and self-monitoring of dental mercury management to professionals at dental facilities in Sweden, including dental staff and management as well as suppliers, technicians, inspectors and other stakeholders to the project. This was accomplished through gathering information about laws and recommendations, surveys of current knowledge base at dental facilities and municipalities, and development of training materials for training seminars that were held and a web-based training tool. The project also aimed to look beyond the Swedish context however, and start a dialogue on improved mercury management in dental facilities with actors in the dental care area outside Sweden. The purpose of this dialogue was not to discuss the "ifs-and-buts" of amalgam, but how to safely take care of the waste generated from treating patients with dental amalgam.

Deliverables and Milestones:

Deliverable	**Scheduled Deliverable date (in GA or revised)**	**Actual Deliverable date**
B 2.1.1 Inventory of laws and recommendations on mercury management in Swedish dental facilities, PR1	31/01/2017	Completed 31/01/2017
B2.1.2 Survey of knowledge about mercury management in Swedish dental facilities , MTR	31/03/2017	Completed 31/03/2017
B 2.3.1 Report on laws and recommendations on dental mercury management in the EU, MTR	31/01/2018	Completed 31/01/2018
B 2.1.3 Recommendations for improved routines at dental facilities in Sweden, MTR	28/02/2018 (revised, EASME letter of 19/04/2017)	Completed 28/02/2018
B 2.2.1 Training material and checklist, MTR	28/02/2018 (revised, EASME letter of 19/04/2017)	Completed 28/02/2018
B 2.3.2 Survey/overview of knowledge about mercury management in European dental facilities, MTR	31/03/2018	Completed 31/03/2018
B 2.2.2 Web based training tool	30/11/2018	Completed 10/11/2018
B 2.2.3 Web based tool evaluation report, including monitoring of the uptake of the web based tool and results as defined in the indicator table	31/08/2019	Completed 31/08/2019
B 2.3.3 Monitoring and measuring EU outreach, including number of practitioners reached by the webinar	31/08/2019	Completed 31/08/2019
B 2.3.4 Evaluation of EU-outreach through visits on project webpage	31/08/2019	Completed 31/08/2019
Milestone	**Scheduled Milestone date (in GA or revised)**	**Actual Milestone date**
Material for training seminars developed	28/02/2018 (revised, EASME letter of 19/04/2017)	Completed 28/02/2018
Web based training tool finalized	30/11/2018	Completed 10/11/2019

At least 50 % of training seminars performed	31/03/2019 (revised, EASME letter of 10/08/2018)	Completed 14/05/2019
Webinar on dental mercury management in the EU	31/08/2019 (revised, EASME letter of 10/08/2018)	Completed 14/04/2019
All training seminars conducted	31/08/2019	Completed 14/06/2019

RESULTS:

Sub-Action B2.1 – Inventory and guidelines:

The purpose of this sub-action was to form the basis for the training of dental professionals,

An inventory of applicable rules and recommendations concerning dental mercury management in Sweden has been drawn up (Deliverable B 2.1.1 Inventory of laws and recommendations on mercury management in Swedish dental facilities, PR1) The inventory includes examples from different supervisory bodies. A survey for dental care services was sent to about 1200 operators in Praktikertjänst, in March 2017 of which about 400 responded (33 %). Of these, 96 % were dentists and 4 % dental nurses. A survey for environmental supervision departments was sent to all 290 municipalities in the country, of which 146 completed responses (50 %) were returned. (B2.1.2 Survey of knowledge about mercury management in Swedish dental facilities, MTR). The same questionnaire was sent to the same target groups in May 2019. Then, 67% of 863 operators and 31% of the supervisory bodies answered.

Recommendations for improved routines at dental facilities in Sweden (Deliverable B 2.1.3 Recommendations for improved routines at dental facilities in Sweden, MTR) were developed in cooperation with Praktikertjänst and Sweden Recycling. The draft of the guidelines was discussed at several dialogue meetings/workshops (see Action D1) with dental teams, dental service technicians and environmental offices in the county's municipalities. The meetings resulted in many comments which have been documented. The guidelines were updated with respect to comments. The guidelines will be revised continuously and published on the project´s webpage www.praktikertjanst.se/life and on www.hg-rid.eu after the project.

Sub-Action B2.2 – Training material:

The purpose of this sub-action was to develop training materials for routines concerning dental mercury management at dental facilities.

Training materials for routines concerning dental mercury management

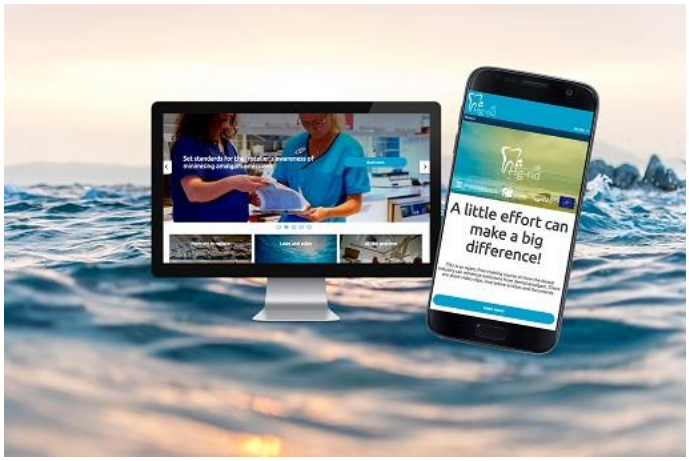
The Recommendations for improved routines at dental facilities in Sweden (see sub-action B 2.1) were a basis for the development of training material The guidelines have also been basis for developing training material in the shape of a checklist (Deliverable B 2.2.1 Training material and checklist, MTR) and for the web-based training tool (see below).

Web-based training tool

One of the main results of the project has been a web-based tool aimed to provide guidance towards minimizing emissions of mercury from dental amalgam: www.hg-rid.eu (including short video clips, interactive articles, check lists etc with examples from dental care in Sweden). (Deliverable B 2.2.2 Web based training tool.

The tool will help to prepare for the EU-regulations executed in 2018. The content is customized for dental teams, dental service technicians, and environmental maintenance service personnel and for local authorities.

The web-based training tool has been a success factor in the project. It has been perceived as user friendly by the ones that tried it. It helps the project reaching out in as easy way, not only in Sweden, but other countries in Europe as well. The training tool has been demonstrated at fairs, conferences and at training seminars for dental nurses and inspectors at local authorities.



In connection with use of the web-based tool, the participants evaluate how they can make use of the purpose of the training in their daily work and how it can be applied in their activities. A "Poll/Survey" appears in the portal after 3 minutes of activity. It has a simple question:

"Will you benefit from the information on this portal in your daily work? The scale for answers are: Strongly disagree 1 – Strongly agree 5. 60 persons have answered, 92% were promoters, and i.e. they gave a 4 or 5 on the five-grade scale.

An evaluation form regarding how the user can use the new knowledge in his/her daily work and how it will be applied in the user country/local dental facility is linked to the web-based tool. The users can voluntary sign up for a survey some months after the first use of the tool. About 30 persons have signed up, but just a few have answered the questionnaire. So far, there have been too few respondents to be statistically relevant It takes time to change habits and routines so it´s still too early to evaluate if clinics/dental services have committed to or applying the new tools/method.(Deliverable B 2.2.3 Web based tool evaluation report, including monitoring of the uptake of the web based tool and results as defined in the indicator table.)

Seminars

Dental nurses and inspectors at local authorities were invited for 15 training seminars in several cities in Sweden, with information about the project and the web-based tool. Three of the seminars were cancelled due to sickness and low attendance. 95% estimate their knowledge as very good or good after training. Initially, according to the application form, the training seminars should be directed to dental professionals, suppliers of equipment, service technicians and controllers. However, based on experiences from fairs and conferences this was changed because the interest was high among students and they lack this topic in their studies. Approx. 260 participants have been reached through the seminars.

Webinar on dental mercury management in the EU

A webinar was arranged for International Association of Dental Students (IADS). The organisation's objective is to improve research and dental education, with a focus on quality. The webinar was live but can also be watched on Youtube - https://www.youtube.com/watch?v=LefW9N6YrXQ and is available om the project´s webpage (www.praktikertjanst.se/life). A webinar was also held for dental nurses in Sundsvall.

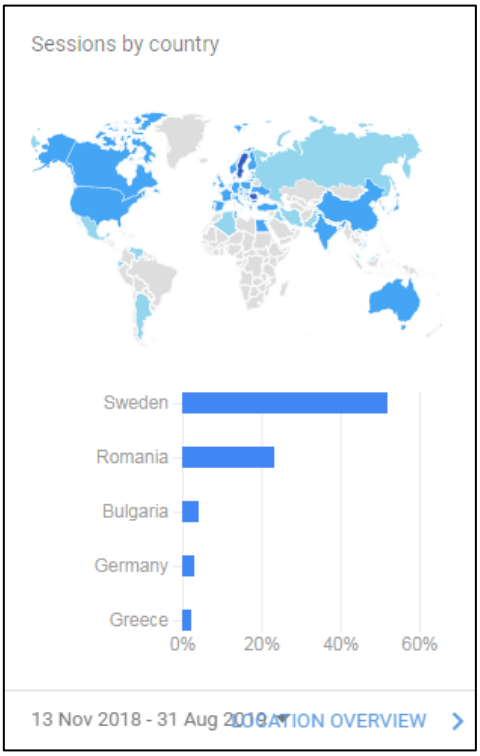
A request about the interest for arranging a similar seminar for Council of European Dentists (CED) and/or the dental organisations in the EU was sent to CED. CED spread the information and the link to the web-based tool and to the webinar arranged for IADS, but in the end did not accept the offer arranging a webinar.

Sub-Action B2.3 – EU outreach:
The purpose of this sub-action was to support development of European guidelines for dental mercury management and transferring knowledge to other European actors in the dental sector as Sweden is one of the countries that have come further than most.

A report on laws and recommendations on dental mercury management in the EU was made (Deliverable B 2.3.1 Report on laws and recommendations on dental mercury management in the EU). REGULATION (EU) 2017/852 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 17 May 2017 on mercury, and repealing Regulation (EC) No 1102/2008 was used in the report comparing the regulation with former facts and figures of the handling of dental amalgam waste.

A survey/overview of knowledge about mercury management in European dental facilities was made as a questionnaire (Deliverable B 2.3.2 Survey/overview of knowledge about mercury management in European dental facilities, MTR). However, it was more difficult than expected to spread the questionnaire in the EU. Council of European Dentists was not a possible way to go, probably because the issue is sensitive among European dentists. 29 of the national dental associations and chambers which are full members of the CED were therefore contacted to take part in the electronical survey. The results were anonymous, but only 16 dentists responded (4 of them came from United Kingdom, 3 from Spain, 1 from Czech Republic, 1 from France, 1 from Croatia, 1 from Germany, 1 from Latvia and 1 from Ireland, 4 of the respondents did not answer the question which country they came from).

The training tool has been demonstrated at EU-fairs and conferences. An advertisement about the web-based training with a link was available on Facebook for dental target groups within the EU during April-August 2019 and on the Facebook page of LIFE programme in May 2019. In August 2019 the share of users per country was as follows; Sweden (41%), Romania (30%), Bulgaria (6%), Greece (3%), United States (3%), Italy (2%), Germany (2%), Portugal (2%), Cyprus (2%).



Users of web-based training tool marked in blue on the map.

The webinar was live but can still be watched on Youtube and is available on the project´s webpage Live at the webinar was 80 participants (dental students). The number expect to increase as long it is online.

As the web-based training tool was launched in Swedish in November 2018 and in other languages in March 2019 it is still too early to evaluate the EU outreach.

An analysis of other European actors in the dental sector was done as part of the Networking plan (part of the Dissemination and Communication plan) in order to transfer knowledge (Deliverable D 1.1.1, PR1).

The project participated in five EU fairs and conferences (4 were foreseen) where the web-based training tool was demonstrated:

- International Dental Show (IDS) in Cologne, Germany, 12-16/03/2019
- Speaker´s Corner in Cologne, Germany, 15/03/2019 . A lecture was held during the fair IDS (mentioned above).
- Krakdent, Krakow, Poland, 11-13/04/2019
- The World Water Week, Stockholm, Sweden, 25-30/08/2019. The Final Conference was held in the end of August 2019 at the same area of this fair.
- Eat & Learn, a lunch-seminar at a dental clinic in Devon, England, 08/04/2019.

Other relevant contacts taken within the EU:

- CED, Council of European Dentists, a not-for-profit association which represents over 340,000 dentists across Europe. A member of the Reference Group has become a member of CED:s working group for dental material during the project period and has been the link to CED. Dental amalgam is one of the issues for this working group.

- Health Care Without Harm (HCWH) Europe, a non-profit European coalition of hospitals, healthcare systems, healthcare professionals, local authorities, research/academic institutions and environmental and health organisations. It currently has 142 members in 29 countries of the WHO European Region, including 20 Member States of the European Union. Contact has been established by Hg-rid-LIFE.

- European Center for Environmental Medicine, a nonprofit project engaged in establishing Environmental Medicine in Europe. Contact has been established through Health Care Without Harm (HCWH) Europe.

- Zero Mercury Working Group, (ZMWG) an international coalition of over 95 public interest environmental and health non-governmental organizations from more than 50 countries. ZMWG is a Working Group within European Environmental Bureau, Europe’s largest network of environmental citizens' organisations with 150 civil society organisations from more than 30 European countries. Zero Mercury Working Group was contacted by Praktikertjänst in early stage, during the work with the application form.

- VITO NV, an independent Flemish research organisation in the area of cleantech and sustainable development. The contact was established by VITO NV early in the project.

- Medentex, Bielefeld, Germany
  Medentex, the parent company to Sweden Recycling, is a globally operating company with headquarter in Bielefeld, Germany, specializing in disposal and recycling of hazardous dental waste. Medentex is specializing in collecting, transporting and recycling of dental waste, worldwide. The project visited Medentex in Bielefeld, Germany in June 2019 discussing the project and to see how the hazardous waste is handled. Medentex is an important link to dental clinics within the EU and has been in contact with environmental authorities in the EU concerning the mercury management.

Please see also more information in Action D1, Communication and Dissemination.

PERFORMANCE INDICATORS (if applicable)

Expected results (quantitative targets)	Achieved results
15 seminars offered in different Swedish cities.	12 (15 booked, 3 were cancelled)
5,000 users of web based training tool	3,244 visitors, 5,785 unique pageviews
300 surveys among Swedish dental facilities and local supervisory bodies regarding mercury management	2,437 surveys/1,066 respondents
4,000 clinics/dental services committed to or applying the new tools/methods	Too few respondents to be statistically relevant.

ISSUES and MODIFICATIONS:

As approved by the EC on 19/04/2017, "The Training material and checklist/brochure" (Deliverable B 2.2.1, MTR) was postponed from 31/05/2017 until 28/02/2018 so it could be delivered at the same time as "Guidelines for optimal and efficient maintenance and use of amalgam separators" (Deliverable B 1.1.2, MTR). This enabled a higher quality in the training material and coordination between all actions regarding handling of waste containing mercury, management and procedures of amalgam separators, sanitation of mercury, and more. All the training materials were then launched after the dialogue/networking meetings held with Swedish dental actors and responsible authorities (milestone 30/11/2018). These discussions were also a good input to the web based training tool (Deliverable B 2.2.2). The milestone "Material for training seminars developed" was thus postponed from 31/05/2017 until 28/02/2018.

The milestone in B2 "At least 50% of training seminars performed" was postponed from 30/11/2018 to 31/03/2019. The seminars were deemed to be more instructive if the web based training tool could be demonstrated at the same time (original deliverable date 30/11/2018). All training seminars were conducted earlier (31/05/2019 instead of 28/08/2019, according to plan) so that that the evaluations from the training seminars and from decontaminations in Action B1 could be used as input for the milestone "Second process evaluation questionnaire" conducted in action C1.

According to the original application, the milestone in B2 "Webinar on dental mercury management in the EU" was to be held at the end of the project. The milestone date was therefore corrected from 30/11/2018 to 31/08/2019 (end date of the project).

OUTSIDE LIFE and CONTINUATION AFTER PROJECT

The web-based training tool regarding mercury management in dental facilities will still be active after the project and if possible further developed, hopefully for with good examples from countries outside Sweden. Praktikertjänst will be responsible for the maintenance of it. It will be available for use two years after the project lifetime and will be will be available in 5 different languages (Swedish, English, German, French, Spanish) to maximize dissemination potential across Europe. The web-based tool will be continued to be disseminated, especially to dental students in Sweden and in the rest of the EU (dentists and dental nurses). More educated dental teams will motivate clinics applying methods that will minimize emissions of mercury from dental amalgam. Contacts established in the project, for example from fairs and conferences, will be reminded to visit the web-based tool and to spread it. Dental clinics in Praktikertjänst will be requested to use the web-based tool.

The guidelines "Minimising the emissions of mercury from dental amalgam - guidelines for dental care in Sweden" (Recommendations for improved routines at dental facilities in Sweden,

Deliverable B 1.1.2, MTR) will be revised continuously and published on the project´s web page www.praktikertjanst.se/life and on the web-based tool (www.hg-rid.eu) after the project. More training seminars at dental schools will also be held and the web-based training tool will be presented.

Action C1. Monitoring of the impact of the project actions

Duration of the action:

Foreseen start date:	01/09/2016	**Actual start date:**	01/09/2016
Foreseen end date:	31/08/2019	**Actual end date:**	31/08/2019

OBJECTIVES:

The objective of this action was to monitor and evaluate the effects of the decontamination and capacity building efforts of the project as well as the process. The evaluation included also the effects on the local level in the dental care facilities and the more overall effects of the entire project.

Deliverables and Milestones:

Deliverable	**Scheduled Deliverable date (in GA or revised)**	**Actual Deliverable date**
C 1.1.1 Evaluation plan, PR1	30/11/2016	Completed 30/11/2016
C 1.1.2 Monitor and measure of LIFE Project Performance Indicators, PR1	31/01/2017	Completed 31/01/2017
C 1.1.2 Monitor and measure of LIFE Project Performance Indicators, MTR	28/02/2018	Completed 28/02/2018
C 1.3.1 Preliminary evaluation results and recommendations, MTR	28/02/2018	Completed 28/02/2018
C 1.1.2 Monitor and measure of LIFE Project Performance Indicators (FR)	31/08/2019	Completed 31/08/2019
C 1.4.1 Assessment of the socio-economic impact of the project actions on the local economy and population	31/08/2019	Completed 31/08/2019
C 1.5.1 Final Results, Conclusions and Recommendations	31/08/2019	Completed 31/08/2019
C 1.6.1 Life Cycle Assessment	31/08/2019 (revised, EASME letter of 19/04/2017)	Completed 31/08/2019
Milestone	**Scheduled Milestone date (in GA or revised)**	**Actual Milestone date**
First process evaluation questionnaire conducted	31/05/2017	Completed 31/05/2017
Second process evaluation questionnaire conducted	31/05/2019 (revised, EASME letter of 10/08/2018)	Completed 31/05/2019

RESULTS:

Sub-Action C1.1 Monitoring and measuring project performance indicators:

The purpose of this sub-action was to monitor and evaluate the effects of the different actions in the project.

At the core of the Evaluation Plan (Deliverable C1.1.1, PR1), which was developed in the beginning of the project, lays the Project Performance Indicators (Deliverable C.1.1.2, PR1, MTR, FR). The Evaluation plan included a development and more detailed elaboration of the Project Performance Indicators. The aim of the evaluation plan was to ensure that the project partners share a mutual understanding of the data and information that are required for the project evaluation, and to ensure that once collected, this data was as useful as possible in to the results of the Hg-rid- LIFE project.

The Project Performance Indicators have been monitored three times (beginning, mid-term and end of project) and data collected with appropriate methods (planned and carried out by IVL,

Sweden Recycling and Praktikertjänst) in order to be able to continuously measure LIFE Project Performance Indicators and the impact of the project (effect evaluation) according to the Evaluation Plan. The work was coordinated and overseen by IVL. The progress on Project Performance Indicators is found in Deliverable C.1.1.2. Monitor and measure of LIFE Project Performance Indicators, PR1, MTR, FR.

A full table of the indicators can be found in the report (Deliverable C1.5.1 Final Results, Conclusions and Recommendations). The evaluation on usability of results have studied the following:

- The relevance, effectiveness and usability of training material
- Accessibility and relevance of information
- Usability and relevance of online training and workshops

The analysis has been done mainly through a qualitative analysis of different project activities, mainly through questionnaires, monitoring of dissemination activities and surveys with relevant stakeholders, such as dental teams, students in the dental sector, environmental inspectors etc.

The general conclusion is that the project results have been distributed and used by a wide range of stakeholders. What can be stated in the evaluation of relevance and usability of project activities and results are that the activities have created awareness and, in some cases, increased knowledge about safe management on mercury waste and mercury's effect on the environment.

The web-based tool was essential for the project objectives and helped the project to reach out. The tool made the information more accessible and enabled people from all over the world to educate themselves on this issue in an effective and user-friendly way.

Sub-Action C1.2. Evaluating Impacts in the dental care facilities:

The purpose of this sub-action was to make a technical evaluation of the mercury (amalgam) cleaning system at the dental care facilities and other technical aspects of using mercury.

The full results from this sub-action is included in the LCA-report (Deliverable C1.6.1 Environmental and Technical Evaluation with Life Cycle Assessment).

Detection of mercury in dental care facilities as well as measurements of mercury flows and concentration have been important task in this sub-action. Technical evaluation of continuous mercury cleaning equipment as well as temporary mercury cleaning actions have also been important tasks. Measurement data from this task have also been used in other sub-actions such as C1.6 (LCA environment) and C1.4 (CBA economic).

A method for mercury measurements at dental clinics was developed and a test measurement has also been performed at a dental care facility that will be closed down. Different chemical forms of mercury such as Hg(0), Hg(II) and methylmercury were also measured/analysed for some samples. In principle, amalgam from the dental activities will be captured in the amalgam separator. However, amalgam will also be trapped in the waste water piping from the dental chairs since the separators not collect the finest particles of amalgam. This amalgam will be collected during the temporary cleaning activities (decontamination). The design of the piping system has been found to be very important for how much amalgam that will be trapped in the dental facilities. Some of the amalgam particles will thus proceed beyond the amalgam separator and also mercury dissolved in the water phase will pass the separator. An airflow from

the vacuum system to the recipient will also contain some mercury. The mercury-sludge from the decontamination process will be collected and sent to Germany for processing and final deposition of the mercury. The overall results from the system are presented in sub-action C1.6 (LCA environment).

Analysis results of water samples showed that small amalgam particles and dissolved mercury species pass the amalgam separator filters and are discharged to wastewater. Of total mercury measured in water samples, 4 percent was in its oxidised form as Hg(II), which probably origins from the oxidation of amalgam particles in the water, 0.5 percent as dissolved gaseous mercury (DGM) and 0.05 % was as the bio accumulative form methylmercury (MeHg). DGM and MeHg is generally formed by certain bacteria. Although MeHg and DGM concentrations were low, the finding of MeHg and DGM in the samples indicates a potential in-situ formation in the enclosed pipe systems of dental clinics. Built-up dental amalgam stuck in the pipe system of a dental clinic can dissolve and release small amounts of mercury into the passing water. Dissolved mercury species can pass the amalgam separators and are therefore leaking into the environment. The removal and cleaning of the pipes by decontamination could lower the risk of the formation of dissolved mercury species, and thus lower the environmental burden of mercury.

This verifies that the project actions enforce achievement of goals of EU legislation on water quality (Water Framework Directive (2000/60/EC), Decision 2001/2455/EC and Directive 2006/11/EC on dangerous substances and Directive 2008/105/EC on priority substances) where mercury is identified as a priority hazardous substance and is in line with the Community Strategy Concerning Mercury.

Sub-Action C1.3 Process evaluations:
The purpose of this sub-action was to describe the effects on the local level in the dental care facilities and the more overall effects of the whole project.

The process evaluation assessed the implementation of mercury mitigation solutions and addresses the project operations regarding allocation of resources (time, personnel and money). Initial results from this sub-action were presented in Deliverable "C 1.3.1 Preliminary evaluation results and recommendations", MTR.

The project process has been affected by a number of factors. The main factor which seems to have affected all activities through a snowball effect has been the initial "marketing" of this project, i.e. to anchor the project, the screenings and decontamination process with the dental facilities and reach an understanding on what was supposed to happen. On the positive side, there have been a large commitment within the project management group and also among the different actors when they fully understand the purpose of the project.

For the monitoring of the process, the project has followed the common structure of continuous documentation of progress, as well as a process enabling reflection, of the project actions among project partners. This has been carried out regularly at project meetings. Communication between project members was provided an important source of evaluation where the process has been discussed and documented.

A first process evaluation questionnaire (Milestone 05/2017) was carried out in connection to the survey of the knowledge situation in Swedish dental facilities regarding project objectives. Correlation analyses were performed on data based on results from two different surveys.

Multivariate analysis and specifically the methods PCA (Principal Component Analysis) and PLS (Partial Least Squares regression) were used in the evaluation. The data set were quite challenging as there were many qualitative parameters in the survey and hence the conclusions from the analysis were thus difficult to interpret and not that clear. Some interesting patterns were although recognized in the PCA and also some correlations were useful for further discussions. A usability assessment of the training materials and information was also performed.

In the evaluation, dialogue/network meetings have been held with Swedish dental actors and responsible authorities (milestone 20/11/2018). This has also been a base for the evaluation of training material usability as outlined in the Evaluation Plan.

Implementation of actions and use of resources

In general, the activities within the project have been implemented with good results and according to ambition and plan. However, some activities have been altered after circumstances.

One significant barrier for implementation of the initial activities were the delays in screening the clinics (Action B1.1). This was due to various reasons regarding planning and organizational aspects but also some unforeseen aspects such as difficulties getting clinics interested in paying for the decontamination (read more under "barriers").

Regarding the reference group in the project, they have been used as support and as experts during the process but not overly involved or active. They have met three times during the year and most work have been done during the meetings, as for example discussing the proposal for national guidelines. The majority within the reference group although think that their knowledge and expertise has come to good use and that the combination of different fields of expertise has enabled fruitful discussions and perspectives to the issues need resolving.

The project team is glad to conclude that the project has succeeded with the goal and what was considered important from the beginning: mercury sludge has been reduced from dental clinics and the awareness of mercury waste has increased (also see project effects and usability of results).

Sub-Action C1.4 Assessment of the socio-economic impact of the project actions on the local economy and population:

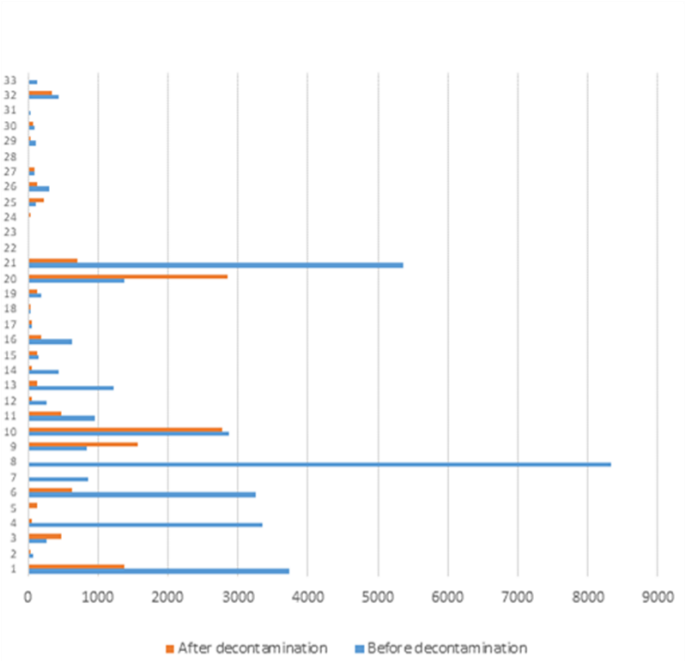
The purpose of this sub-action was to evaluate the costs and benefits to society of the project.

The full results from this sub-action are presented in Deliverable "C 1.4.1 Assessment of the socio-economic impact of the project actions on the local economy and population".

This report presents the assessment of socio-economic impacts of the mercury abatement measures adapted in the Hg-rid-LIFE project on mercury decontamination of dental care facilities. The two abatement measures have been decontamination of pipes, and the use of amalgam separators. The aim of the measures was to reduce the mercury discharge to the environment through the facilities wastewater.

In conclusion: On an European level, building an efficient system for mercury waste handling and final disposal, which is needed for the dental clinics to comply with EU‘s recently implemented regulation on the mandatory use of amalgam separators, will not only decrease mercury discharge but also provide job opportunities enhancing the local and regional market.

One of the projects' measurable objectives is 50% reduction of mercury concentrations in the wastewater from dental clinics with the initial concentration above 1,000 µg/l. The available data where this applied imply that this objective was achieved for major part of the facilities.



Mercury in wastewater, samples before and after decontaminations, µg/l

Sub-Action C1.5 Conclusions and recommendations:
The purpose of this sub-action was to present qualitative and quantitative final results and outcomes from the projects.

The full results from this sub-action are presented in Deliverable "C1.5.1 Final Results, Conclusions and Recommendations".

A. Environmental and technical aspects
As previously described, most of the amalgam is separated by the amalgam separator, which is placed either directly in the dentist's chair (dry system) or at the end of the sewage-pipe system in the building, usually in the basement (wet system). However, the separation of amalgam in the separator is not complete since very fine-grained amalgam from e.g. drilling and grinding as well as dissolved mercury in the aqueous phase follow the wastewater into the main sewage system, as the separator is based on sedimentation and lacks e.g. an absolute filter for removal of particles and carbon filters to separate dissolved mercury in the aqueous phase. In the LCA models, a purification rate of 98.6 % has been assumed for the separator (best possible efficiency).

The mercury decontamination process itself or the disposal and final storage of mercury only contributes to a minor part of the total emissions of mercury. However, it should be noted that the project did not have access to direct emission data from the mercury sludge and separator processing but were estimated based on mercury concentrations in outgoing air and water.
From the above conditions, one can conclude that the total mercury emissions could be reduced by an improved filtering technique on outgoing water and air from the dental clinics. The discharge of mercury otherwise passes through the sewage system to the sewage treatment plant where it can be discharged with outgoing water or end up in the sewage sludge.

The amount of amalgam that accumulates in the dental clinic's sewage pipe system depends on several different factors and can therefore vary greatly between different clinics. Aspects affecting the accumulation of amalgam in the pipelines can e.g. be; the slope of the pipe system, the water flow in the pipes, the material and surface structure of the conduits, biogenic growth in the conduits etc. This condition is also shown by the varying amounts of amalgam obtained from the various mercury decontaminations. The design of the clinics' sewage pipe systems is therefore an important aspect for the decontamination, and in the long term it might be conceivable to design the pipe systems in such a way that recurring mercury remedies can be minimized and most of the amalgam can be captured in the separator.

Conclusions

Air measurements showed diverse air mercury concentrations in different dental facilities. IVL conclude that the mercury concentration depends on too many factors (such as; type of facility, age of facility, number of chairs, type of ventilation system etc.) to be able to generalize how much handling of dental amalgam contributes to the indoor mercury concentrations at dental clinics. At no clinic has harmful mercury levels been observed, even during decontamination when the levels increased significantly. Air concentrations dropped quickly after the decontamination, which shows a quick recovery back to background indoor levels, possibly thanks to good ventilation.

IVL water sampling and analysis are not comparable with SRAB's and Medentex techniques, which made direct comparison unsuitable. Although, results from this study showed that small amalgam particles and dissolved mercury species pass the filters of the amalgam separator and are discharged to wastewater. All visited clinics were different and had different set-up of the vacuum system. Water was sampled at different clinics, at different times of the day as random samples. This is not the best way to achieve representative samples. Therefore, no conclusions regarding the total amount of emitted mercury into water should be drawn from results of this study.

Recommendations

Based on experiences gained during this study, IVL here present some recommendations for improving the handling and collection of mercury from dental clinics.

It has been shown that small amalgam particles can pass the amalgam separator and be discharged to the waste water. Therefore, a development of more efficient filters is recommended. Also, dissolved mercury species in water can pass the amalgam separator. A development of a technique to capture dissolved mercury species in water is needed to supplement the separators, which with present technique mainly captures bigger particles.

The emissions of mercury to air, through the vacuum system, can easily be reduced by using an active coal filter. Active coal absorbs and collects gaseous mercury and is thus cleaning the exhaust gases from mercury. The technique is cheap and reliable and is easy to install.

A well-functioning ventilation system is important to ensure good air quality and low indoor mercury levels for staff and patients at dental clinics.

B. Economic aspects

Within the project, we have estimated benefits and costs of two possible abatement measures to remove mercury from dental care facilities' wastewater; 1. Decontaminations (compared to the reference scenario) and 2. Use of amalgam separators (compared to the hypothetical scenario where amalgam separators are not used). The focus of the project was on

decontaminations; the results from 68 decontaminations have been used in the assessment of the socio-economic impacts of this procedure. For amalgam separators, analysis is based on much less detailed data – mainly average values. The main findings for both technologies are summarized in the table below.

Technology and time horizon	Range	All 68 decontaminations	One decontamination of a clinic	All amalgam separators at a clinic	One amalgam separator
		10 years	10 years	10 years	1 year
Costs of removed Hg, €2018/kg	Min	1700	1700	13 300	13 800
	Mean	17 300	17 300	13 300	13 800
	Max	1 208 100	1 208 100	13 300	13 800
Net benefits, Euro	Min	-349 200	-9400	-10 100	-400
	Mean	392 700	5800	18 100	660
	Max	1 399 400	199 600	56 570	2080
Benefit-to-cost ratio	Min	0.0013	-0.00004	0.0015	0.0014
	Mean	2.1	2.4	2.8	2.7
	Max	5.0	51	6.5	6.3

Table: Results of the analyses

The results of our study can be with a certain cautiousness extrapolated to a **European level**. If decontaminations are performed in additional 6,000 clinics in Europe, the total net benefit would amount to 35 million Euro. If 25 % of all the clinics in Europe (42,500 is assumed to lack amalgam separators of 17, 000), would install separators, this will result in the additional net benefit of 75 million Euro. These estimates are associated with additional uncertainties regarding the total number of clinics in Europe, average number of amalgam separators per clinic, and percentage of amalgam separators already installed before the new regulation entered into force.

Based on the data, assessments and results presented in the report, there are a few topics in need of discussion. Our results indicate that both conducting decontaminations and using amalgam separators result in social welfare increase. However, the results depend on amount of mercury removed and on valuation of mercury's impact: if at least one of these values is below a certain break-even point (140 g mercury and 17,300 Euro/kg mercury, respectively), no net benefit is generated.

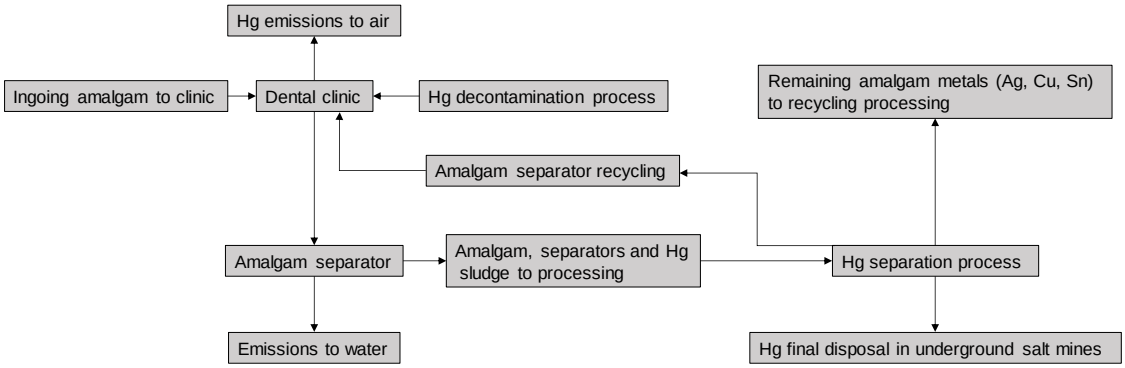
On **an EU level**, discharge of mercury to wastewater from dental facilities is expected to be decreasing in the coming years, due to larger number of amalgam separators installed after January 1st, 2019. Trends for decontaminations are harder to predict due to the missing regulation on that issue. The common problem for both measures though is seemingly underdeveloped infrastructure for handling mercury-containing waste. Not in all European countries the whole logistics chain of waste transport and proper handling is in place, which poses difficulties in following the legislative requirements by dental clinics. Building an efficient system for mercury waste handling and final disposal would not only decrease mercury discharge but also provide job opportunities enhancing the local and regional market.

Considering uncertainties in the results on the benefits-cost ratio and cost-efficiency of the considered mercury abatement options (due to high variation in valuation of benefits and removed amounts of mercury), we would highlight that more studies are needed, especially regarding decontamination, which seems to be an under-researched area compared to amalgam separators. This in order to verify the findings from our study.

Sub-Action C1.6 Assessment of the technical system for mercury reduction:
The purpose of this sub-action was to make an environmental assessment of the mercury reduction system including the flow of mercury. The assessment was performed with a system perspective and with a Life Cycle Assessment (LCA) methodology.

The full results from this sub-action are presented in Deliverable "C 1.6.1 Life Cycle Assessment".

An LCA model was developed covering the entire system of a dental clinic, including the mercury cleaning process and the final storage of collected mercury. A schematic picture of the technical system is shown in Figure A below.



Schematic picture over the technical system for Hg separation at dental clinics in Sweden.

The Life Cycle Assessment (LCA) was performed in order to evaluate the environmental benefits of the decontamination process and the use of amalgam separators at dental care facilities. A system perspective was created in order to get an understanding of the system, the emissions and the probable recipients of mercury emissions. Data for the assessment were collected during several study visits at dental care facilities, where air and water concentrations of mercury were measured. The results from the LCA indicated that current mercury cleaning methods have a major improvement on environmental indicators (global warming potential, eutrophication and acidification potential, photochemical oxidants) and reduce the risk of mercury toxification (human toxicity, terrestrial ecotoxicity, marine aquatic ecotoxicity and freshwater aquatic ecotoxicity).

In addition, different forms of mercury have been analyzed in water samples at several dental clinics during the decontamination process. This information together with other process information has been used in the LCA model.

Nine environmental impact categories have been evaluated in the study. The results are divided into the dental clinic, the mercury decontamination process, and the mercury sludge and final storage of mercury in closed underground salt mines. Three different scenarios have been evaluated:

- **Scenario 1:** Mercury handling with mercury decontamination, mercury processing and final mercury storage, representing the main handling system of today in Sweden.
- **Scenario 2:** Mercury handling with only amalgam separation and final storage of amalgam in Sweden.
- **Scenario 3:** Reference case with no mercury or amalgam handling. The amalgam from the dental clinics will go directly to the recipient.

ISSUES and SOLUTIONS:
The Milestone ”Second process evaluation questionnaire conducted” was revised from 30/11/2018 to 31/05/2019 so that that the evaluations from the training seminars in action B2 and from decontaminations in action B1 could be used as input.

Action D1. Communication and Dissemination

Duration of the action:

Foreseen start date:	01/09/2016	**Actual start date:**	01/09/2016
Foreseen end date:	31/08/2019	**Actual end date:**	31/08/2019

OBJECTIVES:
Communication and Dissemination has been important ways for increasing knowledge and know-how on how to mitigate mercury leakage from dental facilities. Existing communication channels and networks were utilized as much as possible to spread results and lessons learned.

Deliverables and Milestones:

Deliverable	**Scheduled Deliverable date (in application)**	**Actual Deliverable date**
D 1.2.3 Stakeholder Analysis, PR1	31/10/2016	Completed 31/10/2016
D 1.1.1 Networking plan, PR1	31/10/2016	Completed 31/10/2016
D 1.2.1 Dissemination and Communication plan, PR1	31/10/2016	Completed 31/10/2016
D 1.2.2 Dissemination report	31/08/2019	Completed 31/08/2019
Layman's report	31/08/2019	Completed 29/08/2019
Milestone	**Scheduled Milestone date (in application)**	**Actual Milestone date**
Project webpage launched	31/12/2016	Completed 16/11/2016
Notice boards on at least 50 % of decontaminated clinics	28/02/2018	Completed 28/02/2018
4 national conferences/fairs visited	30/11/2018	Completed 17/11/2017
2 EU conferences/fairs visited	30/06/2019 (revised, EASME letter of 21/01/2019)	Completed 11/04/2019
A total of at least 6 national conferences/fairs visited	31/08/2019	Completed 18/05/2018
A total of at least 4 EU conferences/fairs visited	31/08/2019	Completed 13/04/2019
Notice boards put up on at least 80 % of decontaminated clinics	31/08/2019	Completed 31/08/2019

RESULTS:
The full results from this action are presented in the report "D 1.2.2 Dissemination report".

One of the objectives of the project has been to increase the competence of different actors and to achieve a consensus. We can already assess that the available results have given greater expertise and consensus among various actors such as dental staff, dental service technicians, and environmental inspectors. Now there is an awareness and a higher interest to work with green dental care.

Quotes from dentists:
"I receive feedback on what may need to be rectified and perhaps the decontamination of my pipes. It's great."

"I was really pleased when I was told about the project. During decontamination, more than 0.5 kilograms of elemental mercury were collected. It's comforting to know that this was taken care of in a good way."

"The whole process was super easy and professional. The decontamination only took up a few hours of the day. When it was finished we could take care of our patients immediately. No supplementary work was needed."

Quotes from inspectors:
"It was very interesting and rewarding day!"

"Thank you for a fruitful meeting!"

Sub-Action D1.1 – Networking with other projects:

The purpose of this sub-action was to find other Swedish and EU projects and initiatives with shared objectives and goals during the project lifetime to exchange experiences.

A Networking plan (Deliverable D 1.1.1, PR1) was completed in the beginning of the project.

In May 2017, the project was invited to and participated as speaker at a LIFE Information Day at the Swedish Environmental Protection Agency on how to initiate and launch a LIFE project. During this meeting the project met a number of other ongoing and possible future Swedish LIFE-projects.

The project has also been networking with other non-Swedish LIFE-projects. The LIFE-project ”Building LIFE capacities in Lithuania” with representatives from Environmental Projects Management Agency under the Ministry of Environment of the Republic of Lithuania visited the project in Stockholm on May 14, 2019.

Networking with other projects was mainly sought in connection with conferences, seminars and other events related to dental or environmental issues.

See below some of the conferences etc that were attended by the project:

Swedental, Stockholm, 16-18/11/2016
Praktikertjänst, Sweden Recycling and Medentex from Germany (Sweden Recycling is a part of the German Medentex group) were exhibitors at Swedental, the largest dental conference in the Nordic countries with over 10,000 visitors. The conference was an opportunity to network with other dental care companies, technicians etc.

Swedental, Stockholm, 15-17/11/2017

Praktikertjänst and Sweden Recycling participated at Swedental. One activity in the stand was a digital questionnaire in order to get comments on the draft of national guidelines (Deliverable B 2.1.3, MTR). The respondents of the survey obtained a water bottle with the LIFE-logotype. A slideshow about the project was also presented.

Swedental, Gothenburgh, 14-16/11/2018

In 2018 the project had an own booth, demonstrating the web-based tool. Especially students showed interest and the coming seminars were therefore organized for this target group.

International Dental Show (IDS) in Cologne, Germany, 12-16/03/2019

More than 160,000 trade visitors from 166 countries participated. Hg-rid-LIFE-project was the only environmental project at the entire fair. Many of the visitors had not reflected that drilling out old amalgam fillings and amalgam in the pipe system could be an environmental problem. The project established a contact with a Polish company selling amalgam separators in Poland, run by a Polish dentist. This contact has supported the dissemination of the web-based tool in Poland.

Krakdent, Krakow, Poland, 11-13/04/2019

Krakdent is a dental fair with approx.16,000 visitors from Poland, the Czech Republic, Slovenia etc. According to the organization Health Care Without Harm there is still a high demand for dental amalgam in Poland, as amalgam is the only dental material refunded by the public health system. Despite the requirements set up by the EU regulation only a few percent of the dental practices have installed the amalgam separators.

The World Water Week, Stockholm, Sweden, 25-30/08/2019

Participating at World Water Week was a possibility to communicate the project and the web-based tool for experts, practitioners, decision-makers, business innovators and young professionals from a range of sectors and countries. Over 4,000 individuals and around 570 convening organizations from 138 countries came to network, exchange ideas, foster new thinking and develop solutions to the most pressing water-related challenges.

Miljöbalksdagarna, Stockholm, Sweden, 4-5/04/2019

This conference and fair is arranged every year by the Swedish Environmental Protection Agency (also a member of the Reference Group in the project). About 600 conferees, most of them inspectors from local supervisory bodies, participated. The conference and fair were a good opportunity to have a dialogue.

Eat & Learn, Devon, England, 08/04/2019

The project visited Pure Dental Centre, a dental clinic with five dentists and 12 dental hygienists/other dental staff. During an "Eat and learn", a lecture about the project was held, which was much appreciated.

Praktikertjänsts Tandvårdskongress Stockholm, 11-12/04 2019

During a conference for dental clinics in Praktikertjänst, the Hg-rid-LIFE-project was exhibitor during two days.

Tandsköterskeförbundets Yrkeskonferens, Stockholm, Sweden, 31/01/2019

The project was exhibitor at the yearly conference for approx 300 dental nurses. Because the dental nurses often are responsible for the issues concerning amalgam separators it was an opportunity to inform about the free web-based tool.

Speaker´s Corner, IDS, Köln, Germany, 15/03/2019

A lecture about the project with the headline "Mercury Management of Dental Care Facilities" was held at Speaker´s Corner 15/03/2018 at IDS in Köln, Germany.

Sweden Recycling, Växjö, Sweden

Two visits at Sweden Recycling in Växjö have been arranged, in November 2016 and in December 2017, to learn more about how waste from dental amalgam is collected and handled and to have a dialogue with the environmental service technicians performing the screenings and decontaminations in the project.

Medentex, 17-18/06/2019

The Hg-Rid-LIFE project visited Medentex in Bielefeld, Germany to discuss the results of the project, the outreach of the project in the EU and to see how the hazardous waste from amalgam separators and decontaminations is handled. The amalgam waste collected by Sweden Recycling at dental clinics in Sweden is transported to Medentex in Bielefeld. Medentex is specializing in collecting, transporting and recycling of dental waste, worldwide.

Final Conference, 29/08/2019

The Hg-rid-LIFE final conference was held at the same area as World Water Week, the annual focal point for the globe's water issues organized by Stockholm International Water Institute.

About 50 persons from dental clinics, service technicians, local authorities, the Swedish Environmental Protection Agency and the Swedish Chemicals Agency participated.

As the project is addressing the Water Frame Directive and the aim is to minimize emission to the waste water, participating at the renowned World Water Week was a good final of the project. The theme of our Final Conference was "Vision 2030: No emissions of mercury from dental clinics". The results of the project, the situation in the EU, the latest advances in mercury research and upcoming technology were presented.

The project was also an exhibitor at World Water Week, a six-day fair. The participants at the final conference had access to the fair area after the conference.

Sub-Action D1.2 – Dissemination planning and development of the dissemination pack:
The purpose of this sub-action was to effective dissemination of the project result to respective target groups.

A Dissemination and Communication plan (Deliverables D1.2.1, PR1) and a Stakeholder Analysis (Deliverable D1.2.3, PR1) were completed in the beginning of the project. The Dissemination and Communication plan was then revised every year. The main message in the communication has been "Together we make the dental care greener".

Website: The project Web page (http://www.praktikertjanst.se/Life) was launched in November 2016. The number of visits have been regularly monitored. The goal for visits on the web-site was set very high in the application (300 000 visitors at the end of the project) and will not been able to reach. This goal will be modified, please see chapter 7. In August 2019, the number of visitors were 8 945.

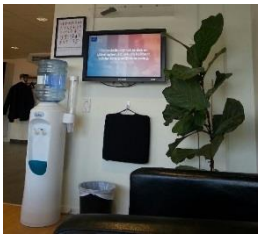
Logotype: A logotype for the project was launched in May 2017.

Facebook: In June2017 the project started a page on Facebook: https://www.facebook.com/hgridlife

An advertisement about the web-based training with a link was available on Facebook for dental target groups within the EU during April-August 2019.

An information about Hg-rid-LIFE and the web-based training tool was posted on the Facebook page of LIFE programme in May 2019.

Notice Boards (Digital): Digital Notice Boards for patients at dental clinics are common. About 154 dental clinics in Praktikertjänst have TV screens in the waiting rooms and/or treatment rooms with the possibility to show information to the patients. This is why Notice Boards didn't have to be purchased in the project. Information about the project has instead been incorporated in existing slideshows for the Digital Notice Boards.



Flyers: When the screening took place the dental clinics received a flyer with "Thank you for your contributions to make dental care greener!" with information about the project. The flyer was also disseminated at the dental conference Swedental in November 2016, in the beginning of the project.

Roll-ups: A roll-up in Swedish has been used at national fairs and conferences etc, the first time at the dental conference Swedental in 2016. The message is "Together we make dental care greener". A roll-up in English communicating the web-based training tool has been used at EU fairs. The roll-ups were also placed at the head office at Praktikertjänst.

Slideshows: Slideshows communicating the objectives and results of the project have been used at fairs. Quotes from dentists expressing about the benefits of the project have been part of the slideshows.

Letters: An internal letter was produced early in the project to the dental clinics in Praktikertjänst (about 600) to communicate the project and inform about the coming screenings. The dental clinics also received a flyer with information about when the screenings were expected to take place. Feed-back from the screenings were sent by e-mail to the clinics using a template that communicated the status of the amalgam separators and the suction system.

Diplomas: The 76 dental facilities/132 dental clinics having the drain system decontaminated from mercury in the project have received diplomas with information about Hg-rid-LIFE.

Leaflets: In order to communicate the web-based training tool, leaflets have been distributed at fairs and conferences. The leaflet has been available both in Swedish and English.

Articles in journals: A large number of articles and press releases have been published during the project period, please see examples below and the Dissemination Report.

Communication about the project has been done to the public by an article in a waiting room journal distributed to all the 2,000 dental and health care clinics in Praktikertjänst.

The journal Tandläkartidningen (The Journal of the Swedish Dental Association) published two multipage articles about decontamination in May 2017 and March 2018 where the Hg-rid-LIFE was communicated. The Journal of the Swedish Dental Association is published by the The Swedish Dental Association (SDA), who organizes all dentists in Sweden.

Give Away: A water bottle with the LIFE-logotype was used as a Give Away at the dental fair Swedental 2017 and 2018.

Layman´s Report: A Layman´s Report has been produced and published in Swedish and English.

Newsletter: A newsletter was published in November 2017, both in a Swedish and English version.

Other communication channels
In the annual reports for Praktikertjänst 2016, 2017 and 2018, the project has been described.


NEWSLETTER
2017
Hg-rid

PERFORMANCE INDICATORS (if applicable)

Expected results (quantitative targets)	Achieved results (targets)
300,000 visitors on the project website	8,945 visits, 6,463 unique pageviews
>100 dental care facilities with digital project notice boards	154
600,000 reached with information on project digital notice boards (general public)	4,400,000
6 national conferences/fairs visited	11
4 EU conferences/fairs visited	5

ISSUES and MODIFICATIONS:
The milestone in D1 “2 EU conferences/fairs visited” was postponed to 30/06/2019 so that the web based training tool could be demonstrated.

OUTSIDE LIFE and CONTINUATION AFTER PROJECT
The web based training tool (milestone 30/11/2018) in the project will be an action to spread the knowledge outside the framework of the LIFE project. Nearly all of the members in the Reference Group are engaged in European working groups and will continue to communicate the project and the web-based training tool. The project will also maintain all the contacts established during fairs and conferences.

Action D2. Dialogue for better national management of dental mercury

Duration of the action:

Foreseen start date:	01/04/2017	**Actual start date:**	01/04/2017
Foreseen end date:	31/08/2019	**Actual end date:**	31/08/2019

OBJECTIVES:

The aim of this action was to initiate a dialogue for a better coherence of dental mercury control at a national level. The activities within this action relied heavily on the input and interest from controlling authorities and other dental actors, as responsibility for dental mercury control lies outside of PTJ:s areas of expertise. Nonetheless, it has been noted that the quality of the controls differs significantly between municipalities in Sweden, and thus there is potential to improve coherence and increase knowledge at dental facilities to take responsibility for their dental mercury waste.

Deliverables and Milestones:

Deliverable	**Scheduled Deliverable date (in application)**	**Actual Deliverable date**
D 2.1.1 Report on dental facilities experiences of mercury-control in Sweden	30/06/2018	Completed 15/08/2019
D 2.3.1 Proposal of input to development of national guidelines	31/08/2019	Completed 31/08/2019
D 2.4.1 Business strategy, developed by SRAB	31/08/2019	Completed 31/08/2019
Milestone	**Scheduled Milestone date (in application)**	**Actual Milestone date**
6 dialogue/networking meetings held with Swedish dental actors	30/11/2018	Completed 16/03/2018
4 dialogue meetings held with responsible authorities	30/11/2018	Completed 13/06/2019
Business plan adopted by Medentex	31/08/2019	Completed 31/08/2019
First educations (according to business strategy) performed	31/08/2019	To be completed once relevant policies etc are in place

RESULTS:

Sub-Action D2.1 – Inventory and dialogue with dental actors and associations in Sweden:

The purpose of this sub-action was to support the dialogue among public and private dental actors in Sweden.

The guidelines developed by Praktikertjänst and Sweden Recycling for management of dental amalgam (see sub-action B2.1) were discussed at seven dialogue meetings/workshops hosted by Praktikertjänst with dental teams, service technicians and inspectors from the local authorities. The guidelines were then updated with respect to comments. Totally 220 persons participated in the meetings.

Comparing the surveys sent to dental clinics in May 2017 and in May 2019 resulted in the Deliverable D 2.1.1 Report on dental facilities experiences of mercury-control in Sweden.

The general difference between the two occasions were not that significant but in overall, they estimated their knowledge higher in 2017 than in 2019. For environmental inspectors about 18 percent estimated their knowledge as very good in 2017 but only 13 percent in 2019. About 61 percent estimated their knowledge as good year 2017, in year 2019 this increased to 67 percent. The same trend can be seen regarding the dental staff; 35 percent in 2017 estimated their knowledge as very good compared to 32 percent in 2019. The comments from the survey in 2017 shows that many know that mercury is harmful to the environment but not in what way.

The results on how they estimate their knowledge about safe managing of mercury at dental facilities showed that the knowledge seem to have somewhat deteriorated among environmental inspectors, fewer consider themselves to have very good knowledge in 2019 while more considered themselves to have good knowledge in 2019. Further, more answered that their knowledge is very bad in 2019 than 2017.

There is a significant decrease in answer frequency in 2019 than 2017 but the result of the survey can still be an indication on the state of the knowledge.

Dialogue Meeting 15/02/2018

Dialogue Meeting/Workshop 14/11/2017

The guidelines have been discussed at following meetings with dental actors and responsible authorities:

Dialouge Meeting	**Target Group**	**Number of participants**
Swedish Dental Service organizations, 14/11/2017	Environmental responsibles in dental teams	25
Swedental, 15-17/11/2017	Dental teams	51
Technicians at Sweden Recycling 18/12/2017	Technicians	10
Dental teams in Praktikertjänst 02/02/2018	Dental nurses	8
Dental Hygiene Association 15/02/2018	Dental teams and dental technicians	25
Municipalities 16/03/2018	Inspectors	8
Service technicians at Plandent 18/05/2018	Service technicians	12

Other Dialouge Meetings:

Dialouge Meeting	**Target Group**	**Number of participants**
Privattandläkardagen (organisation for private dentists in Sweden)	Dentists in sweden.	60
Swedental (the largest dental conference in the Nordic countries) 15/11/2018, two sessions	Dental teams	15

See also “D 1.2.2 Dissemination report”.

Sub-Action D2.2 – Dialogue with responsible authorities:
The purpose of this sub-action was to start a dialogue with responsible authorities for environmental improvements through potentially developing a draft for national guidelines.

The Swedish Environmental Protection Agency informed the inspectors at the county's municipalities about the project and asked for interest in participation in a dialogue group. Almost 10 inspectors reported interest. An invitation for a dialogue meeting was sent out and four municipalities participated at a dialogue meeting 16/03/2018. In June 2019, a seminar for the county's municipalities was arranged to inform about the web-based training tool.

Representatives from Swedish authorities have been members in the Reference Group; The Swedish River Basin District Authorities, Swedish Environmental Protection Agency and Swedish Chemicals Agency have all been engaged. In the National plan of Dental amalgam phase out published by Swedish Chemicals Agency, the Hg-rid-LIFE-project is mentioned.

Sub-Action D2.3 – Draft proposal of input to improved national guidelines:
The purpose of this sub-action was to form of a draft proposal of input to development of national guidelines on dental mercury control at dental facilities.

Initially, recommendations for improved routines at dental facilities in Sweden (Deliverable B2.1.3, MTR) were developed in cooperation with Praktikertjänst and Sweden Recycling. The draft of the guidelines were then discussed at several dialogue meetings with dental teams, dental technicians and environmental offices in the county's municipalities. The meetings resulted in many comments which were documented and the guidelines were updated with respect to the comments. The guidelines are presented in the web-based training tool.

Based on the Guidelines, the work lead to the Deliverable "D2.3.1 Proposal of input to development of national guidelines".

Sub-Action D2.4 – Develop business strategy:
The purpose of this sub-action was to spread and remain knowledge gained after the project has ended and to facilitate the possible replication in other regions.

According to the business plan developed by Sweden Recycling and adopted by Medentex all operations, products and tools are in place and already adjusted to the size of the current markets. At the moment, no other company is delivering the full operational chain or is experienced in pipe cleaning activities/decontaminations, except the organisation in Sweden (Sweden Recycling). Decontamination business is not existing outside Sweden.

Once necessary new EU and national legislation requiring decontaminations is in place, Medentex can start to build up the scalable organisation with the help of a best practice handbook, which has already been developed. The implementation phase will start immediately after the new legislation and the regulations are in place. The first effects will become visible in the countries where the organisation already provides dental services: Germany, Austria, the Netherlands, UK and Ireland. All relevant needs for transport, storage and treatment are in place. The first technician teams are available and training for further sales and technician staff is already planned theoretically.

PERFORMANCE INDICATORS (if applicable)

Expected results (quantitative targets)	Achieved results (targets)
1 draft proposal of improved guidelines provided	1
1 Business strategy/plan developed and adopted	1
10 dialogue/networking meetings held with Swedish dental actors and responsible authorities	13

ISSUES and MODIFICATIONS:

The milestone "First educations (according to business strategy) performed" has not been completed. When the legislation about decontamination is in place training of technicians (online based), with a Service Manager on-site, will start during an introduction year to build up the organisation. The deliverable D 2.1.1 Report on dental facilities experiences of mercury-control in Sweden was postponed from 30/06/2018. The reason was that the survey sent to dental clinics in May 2017 should be sent once again, in the end of the project (May 2019) to compare the results concerning awareness and knowledge.

OUTSIDE LIFE and CONTINUATION AFTER PROJECT

The guidelines for mercury decontamination in dental clinics in Sweden, developed within the project, are expected to initiate or inspire to national or EU-wide guidelines. The guidelines will be revised continuously and published on the project´s web page www.praktikertjanst.se/life and on www.hg-rid.eu after the project.

The Business strategy, developed by SRAB, will facilitate the possible replication in other regions after the project.

6.2 Main deviations, problems and corrective actions implemented

Overall, the Hg-rid-LIFE project has run according to plan and without any major hinders. However, some minor delays have occurred and some technical issues have been handled (all with full information communicated to and approved by Neemo and EASME), see below:

Action E1

There were early on changes in the upper management of Sweden Recycling which have caused a delay in the process of signing the internal co-operation agreement between Praktikertjänst and Sweden Recycling. The General Manager, who signed the Associated Beneficiary Declaration and Mandate for Sweden Recycling, left the company in the end of January 2017. The new management at Sweden Recycling therefore asked for an extension of the deadline of the Partnership Agreement until 1st of April 2017. The agreement was finally signed by both parties on 26/02/2018.

Action B1

Due to some initial technical and logistical problems as well as limited interest from dental clinics that was solved, sub-action B1 became more time consuming than expected and the milestones "All clinics in B1.1 screened" and "50 % of clinics in B1.2 and B1.3 decontaminated" were postponed by four months. The original deadline on 05/2017 was thereby postponed to 09/2017.

After having developed a prototype for long term sampling of decontaminated mercury water, Sweden Recycling made a safety assessment of the prototype. The result of the assessment was that the prototype unfortunately could not meet the requirements. The consequence was that the prototype could not be used in the project and action B1.3 could not be carried out. The decontaminations in action B1.3 were instead moved to actions B1.4 and B1.5.

Overall, the action related to decontaminations (Action B1) became more time consuming than predicted. Logistics became a critical issue because of geographical distances in Sweden. In the application form the time schedule was too optimistic. Lack of time and interest from dentist to take part in the project did also initially effect this action negatively. Clinics need a long advance due to the loss of revenue and in combination with the foresight that is required for the logistical planning the action became more time consuming than expected. The method in order to raise interest among clinics to take part in the project was therefore changed from request by sending out letter to specific clinics to information on the intranet for all clinics in Praktikertjänst concerning the possibility to take part in the project. Gladly, nearly 100 clinics made an interest notification and the necessary decontaminations could in the end be concluded successfully.

The milestones related to decontaminations in B1 were revised according to following:

- ✓ "All clinics in B1.1 screened" and "50 % of clinics in B1.2 and B1.3 decontaminated" postponed until 30/09/2017
- ✓ 50 % of clinics in B1.2 and B1.3 decontaminated: B1.3 was cancelled and the decontaminations in action B1.3 were instead moved to actions B1.4 and B1.5.
- ✓ All clinics in B1.1, B1.2 and B1.3 decontaminated: B1.3 was cancelled and the decontaminations in action B1.3 were instead moved to actions B1.4 and B1.5.
- ✓ 50 % of clinics in B1.4 and B1.5 decontaminated: Postponed until 31/12/2018.
- ✓ All clinics in B1.4 and B1.5 decontaminated - Postponed until 31/05/2019.

Action B2

"The Training material and checklist/brochure" (Deliverable B 2.2.1, MTR) was postponed from 31/05/2017 until 28/02/2018 so it could be delivered at the same time as "Guidelines for optimal and efficient maintenance" (Deliverable B 1.1.2, MTR) and use of amalgam separators. This enabled higher quality in the training material and coordination between all actions regarding handling of waste containing mercury, management and procedures of amalgam separators, sanitation of mercury, and more. All the training materials were then launched after the milestone dialogue/networking meetings held with Swedish dental actors and responsible authorities (30/11/2018). These discussions were also a good input to the web-based training tool. The milestone "Material for training seminars developed" was subsequently also postponed until 28/02/2018.

The milestone "At least 50 % of training seminars performed" had two different deadlines according to "B2´s Project Milestones" in the Application Form (p 28). The correct deadline should be 30/11/2018 (p 38, 57), which was corrected.

The milestone "At least 50% of training seminars performed" was also postponed from 30/11/2018 to 31/03/2019. The reason being that the seminars would be more instructive if the web-based training tool could also be demonstrated. All training seminars were conducted by 31/05/2019 (instead of 28/08/2019), so that that the evaluations from the training seminars in Action B2 could be used as input for the milestone "Second process evaluation questionnaire" conducted in C1.

According to the application form, the milestone in B2 "Webinar on dental mercury management in the EU" was originally to be held at the end of the project. The milestone date was therefore corrected from 30/11/2018 to 31/08/2019 (approved by EC).

Action C1

The Life Cycle Assessment (LCA) (Deliverable C 1.6.1) was, according to the project proposal, set to be delivered on 31/12/2017. However, as the LCA was a vital part of the final evaluation and had to be synchronised with the Cost Benefit Analysis (Deliverable C 1.4.1), It was necessary to have the same deliverable time for the LCA as for the CBA (i.e. 31/08/2019).

The milestone "Second process evaluation questionnaire conducted" was revised from 30/11/2018 to 31/05/2019 so that that the evaluations from the training seminars in action B2 and from decontaminations in action B1 could be used as input.

Action D1

The milestone in D1 "2 EU conferences/fairs visited" was postponed to 30/06/2019 so the web based training tool could be demonstrated (original deliverable date 30/11/2018).

All changes mentioned above did not negatively affect the project and the overall timetable in the project, hence the project could end successfully on 31/08/2019 according to original plan.

As approved by the EC, the following corrections of some misspell in the application form/**non-substantial changes** has also been made:

- ✓ The project aims to collect 100 kg mercury – the correct statement is 100 kg mercury contaminated sludge (p 11, 12, 14, 15 in the Application Form).

- ✓ The project will improve existing technology for reducing emissions of mercury from amalgam separators – the correct statement is that the project will improve awareness and knowledge of existing installation techniques and maintenance routines for reducing emissions of mercury from amalgam separators (p 11, 15). The project will test new technologies for decontamination of pipe systems in use – the correct statement is that the project will test new methods.
- ✓ There are two different figures in the application form regarding numbers of decontaminations – the correct statement is 125 decontaminated dental clinics (p 12).

6.3 Evaluation of Project Implementation

Methodology applied, results of actions conducted and the cost-efficiency of actions

We are glad to report that our LIFE project has mainly run according to plan and the methodology applied has been a success. The results of the actions conducted are largely in line with the GA and the cost-efficiency has been high, resulting in total eligible project costs of only 80% of budgeted costs. No major issues have delayed or hindered the project and we hence consider the project a success.

New and improved methods for decontamination has been developed in an agile way during the project. Facts have been collected using qualitative and quantitative methods. The results have been analysed by researchers and various methods have been used, eg correlational analysis.

The main factors affecting the project results and outcome can be concluded to communication and commitment. The commitment has been crucial for how the project has worked and for reaching the project objectives. All involved have been committed to the subject and the success of the project. Furthermore, the team has been very capable, which has strengthened the project, for example during the decontamination when the technicians at Sweden Recycling was able to answer questions not always within their ordinary activities. The high number of dental clinics within Praktikertjänst further helped the project to reach its goals.

Even though there have been some obstacles during the project, the main goals are reached. Initially the project planned for 600 screenings and decontaminations in 125 clinics. In the end, 530 clinics were screened, and 76 dental facilities/132 dental clinics were decontaminated. Some changes have been made, for example that the automatic sampling machine was not developed and some shifts in the timetable. The project has collected mercury from dental clinics and reduced emissions from clinics, but foremost developed methods for more effective decontaminations and increased knowledge and awareness of the issue.

In the beginning of the project there were some difficulties getting clinics to participate in the project and carry out decontaminations. However, the commitment within the project group has been great and the web training tool has worked as a platform about information concerning mercury in the environment and mercury waste management in dental care. The project has further helped involved actors to get a common view on mercury waste management.

The results of surveys show no clear result of increased knowledge among dental staff and environmental inspectors but could indicate an increase in awareness. Students participating in seminars thought the web training tool will be a useful tool in their upcoming career.

Users of the web training tool thought it was easy to use and increased their knowledge about the subject and the movie clips was informative. Thus, training material is of relevance, given in an efficient way and have a high usability.

Comparing the results achieved against objectives

Action	Foreseen in the revised proposal	Achieved (visible)	Evaluation
B1	**Objective** Reduce mercury leakage from examined dental clinics. **Expected results** Development and demonstration of a new and improved effective, easy-to-apply and cost-effective technology for mercury decontamination. Drains of 600 dental care facilities screened for mercury.	New and improved methods for mercury decontamination have been developed; filming, use of chemicals and new methods for decontamination of pipes with poor access or suboptimal pipe dimensions. Screenings of 531 dental facilities were performed to collect data on amalgam separators, suction system, mercury levels in wastewater, pipe systems etc (55 rejected). The results were used to identify suitable trial subjects.	The results of the screening show that a majority of the clinics have results of mercury levels in sewage waste from suction systems less than 200 µg/l. This could be an evidence of efficient maintenance and use of amalgam separators at the clinics. The clinics received feed-back with the results and, where applicable, recommendations what to be rectified to reduce mercury emissions from amalgam separators. The result showed that filming can be a useful tool partly to find clinics with a lot of sludge that are in great need of decontamination, but also for the control of the decontamination efficiency. The new methods developed will break up more amalgam and reduce mercury levels. A prototype that simplifies cleaning of suction pipes and enables cleaning of waste water pipes without the need for a cleaning door was used and improved successfully. A prototype for cleaning larger pipe dimensions was developed which to increase efficiency when decontaminating. In order to increase the efficiency of pipeline cleaning with suboptimal pipe dimensions, new equipment for decontamination (High pressure washer) was purchased and tested.
B1	**Objectives:** Clinics participating in the demonstration project with mercury levels in sewage waste from suction systems above 1,000 µg/l, will have their mercury levels reduced by 50%. **Expected results:** In clinics where mercury levels exceed 1,000 µg/l in sewage waste from suction systems, mercury levels will be reduced by at least fifty percent. This	Clinics with initial mercury levels above 1,000 µg/l reduced mercury levels with more than 50 % after decontamination.	The results of the screening show that a majority of the clinics have results of mercury levels in sewage waste from suction systems less than 200 µg/l. This could be an evidence of efficient maintenance and use of amalgam separators at the clinics. Decontamination of the drain system will reduce high mercury levels.

	will also reduce concentration of mercury in sewage waste (mud).		
B1	**Objectives:** Remove sewage waste containing contamination corresponding to 100 kg of mercury contaminated sludge. **Expected results:** Sewage waste containing contamination corresponding to 100 kg of mercury contaminated sludge removed from pipes in dental clinics, the new technology generally has potential to increase the volume of removed contaminated sludge with 25-50 percent. 125 dental clinics decontaminated from mercury with a new and improved technology for decontamination that will be developed in an agile way during the project.	132 dental clinics /76 dental facilities were decontaminated from mercury. 372.25 kg mercury contaminated sludge and 21.15 kg mercury collected and handled as hazardous waste after decontaminations. The new methods developed for decontamination is estimated to increase efficiency by about 50% when comparing with on older decontamination method.	The amount of mercury from decontamination varied from 3 grams to 2.3 kilograms per facility. The high variation of mercury removed indicates that decontamination reduce mercury emissions to wastewater, but the amount is impossible to predict because the pipe system in dental clinics is unique. The slope of the pipe system, the water flow in the pipes, the material and surface structure of the conduits, biogenic growth in the conduits etc will affect the result. Tests of different methods in different material have been carried out in the project and show that it is important to choose the right method for different types of material.
B2	**Objectives:** Increased knowledge and know-how on how to mitigate mercury leakage from dental facilities. **Expected results:** Increased knowledge level and know-how on how to mitigate mercury leakage from dental facilities reached in dental teams, environmental officers, suppliers of dental equipment and dental technicians. The goal is to carry out at least 15 training seminars and in addition several international webinars. Web-based training tool developed regarding mercury management in dental facilities	12 training seminars (15 booked, 3 were cancelled). A total of 260 people participating. A webinar was arranged for International Association of Dental Students (IADS). A user-friendly web-based training tool developed.	Training seminars for dental nurses and inspectors at local authorities were arranged in several cities in Sweden, with information about the project and the web-based tool. According to the application form, the training seminars should be directed to dental professionals, suppliers of equipment, service technicians and controllers. However, based on experiences from fairs and conferences this was changed because the interest was high among students and they lack this topic in their studies. The original stakeholders were reached during fairs and conferences. The students participating in the seminars were asked if they thought the web-based tools would help them increase awareness and knowledge to reduce emissions from mercury in the future. The majority thought that it will help to great, or some, extent. The web-based training tool has been a success factor in the project. It has been perceived as user friendly by the ones that tried it. It helps the project reaching out in as easy way, not only in Sweden, but other countries in Europe as well. The training tool has been demonstrated at fairs,

			conferences and at training seminars for dental nurses and inspectors at local authorities. In August 2019 the share of users per country was as follows; Sweden (41%), Romania (30%), Bulgaria (6%), Greece (3%), United States (3%), Italy (2%), Germany (2%), Portugal (2%), Cyprus (2%).
B2 D2	**Objectives:** Support the development of national and international guidelines for management of dental mercury by providing a draft proposal of guidelines. **Expected results:** Support the development of national and international guidelines for management of dental mercury by providing a draft proposals of guidelines based on results obtained in this project. The draft proposals will hereafter be used as internal guidelines for mercury management by the beneficiaries.	Guidelines for optimal and efficient maintenance and use of amalgam separators has been developed by Sweden Recycling and Praktikertjänst; "Minimising the emissions of mercury from dental amalgam - guidelines for dental care in Sweden". The guidelines are applied by Praktikertjänst and Sweden Recycling as internal guidelines for mercury management and will support the development of national and international guidelines.	The work with the guidelines has supported consensus among dental clinics and supervisory bodies regarding mercury management. The guidelines have been discussed at several dialogue meetings with dental teams, dental service technicians and environmental offices in the county's municipalities. The meetings resulted in many comments which were documented.

Long term results

The new methods for decontaminations developed will break up more amalgam and reduce mercury levels. If the calculations are based on the situation in Sweden where around 300 grams of pure mercury is expected to be removed from a clinic´s pipeline in each decontamination activity, 39-63 tonnes of mercury per year can be recovered throughout the EU in the future. The estimation is based on 130,000-210,000 dental clinics in the EU. With the same estimations 636 - 1 026 tonnes of amalgam sludge can be recovered. In addition to mercury the sludge contains heavy metals such as silver, tin and copper so this will also be an environmental benefit.

The web-based tool will be continued to be disseminated, especially to dental students in the EU (dentists and dental nurses). More educated dental teams will hopefully motivate clinics applying methods that will minimize emissions of mercury from dental amalgam. If and when regulations for decontamination and control of the compliance of the regulation about the use of dental amalgam are in place, there will be legal requirements to apply the described methods.

One activity after the project is to have dialogue with authorities and NGO´s communicating the results of the project, supporting the development of national legislation or guidance.

Project results immediately visible and results becoming apparent after a certain time period

The following results have already been demonstrated in the project (see table above, Achieved results). The following results will only start to become to be apparent from the year 2019/2020:

- The technology for amalgam separators to improve the effectiveness using reusable filter technology for removing toxic heavy metals from water will be developed. A prototype for a more efficient amalgam separator has been developed outside LIFE. Atium, which is a Gothenburg-based startup company, is developing a new product where Atium's electrochemical filters complement today's amalgam separators to also capture water-soluble mercury ions. Atium's technology is based on research from Chalmers University of Technology. Today there are no amalgam separators that collect all the amalgam particles. The finest particles pass the separators. Zero emissions of mercury from dental clinics can be reality thanks to an electrochemical filter as a complement to amalgam separators. The prototype will be tested by dental clinics during 2020. Atium and the Hg-rid-LIFE-project established contact during the project period.
- New and improved methods for mercury decontamination will be used by Sweden Recycling in order to simplify decontaminations of pipes with poor access or suboptimal pipe dimensions.
- Staff costs for more difficult decontaminations will be reduced.
- More standardized sampling methods for measuring mercury concentration in wastewater to reduce error sources have already been implemented by Sweden Recycling.
- More seminars at schools for dental nurses about minimising emissions of mercury from dental amalgam and communicating the web-based training tool. Three more seminars are already booked.
- More dissemination about the project. An article in Germany will be published in December 2019. In Sweden an article will be published in an environmental magazine. In March 2020 a lecture about the project will be held at a conference for Quality managers in Sweden.

Results from project amendment (if applicable)

Not applicable (no amendment needed).

Replication and effectiveness of dissemination activities

Numerous communication and networking activities were carried out during the entire project to disseminate the project´s result and increase awareness and knowledge among stakeholders how to minimize emissions of mercury from dental amalgam. Using different channels have facilitated the effectiveness of dissemination. Considerable efforts and economic means have been invested in these dissemination activities and we consider them a large success.

The project has been communicated through several channels:

- ✓ Web-based training tool
- ✓ Information to dental clinics within Praktikertjänst (intranet, flyers, letters)
- ✓ Participation in ~~dental~~ fairs and ~~-~~conferences for dental clinics, local supervisory bodies, researches etc
- ✓ Web page
- ✓ Digital Notice Boards for patients
- ✓ Facebook
- ✓ Newsletter, articles
- ✓ Dialogue meetings with dental clinics, environmental responsible at dental clinics, dental service technicians and the county's municipalities.

In order to assess the effectiveness of the project actions, a series of indicators have been monitored along all the project lifespan. As far as dissemination actions are concerned, we can quote the following indicators with related value referred to the reporting period:

Expected results (quantitative targets)	Achieved results (targets)
300,000 visitors on the project website	8,945 visitors, 6,463 unique pageviews
>100 dental care facilities with digital project notice boards	154
600,000 reached with information on project digital notice boards (general public)	4,400,000
6 national conferences/fairs visited	11
4 EU conferences/fairs visited	5

For more detailed information, please see Action D1 and Deliverable D1.2.2 Dissemination Report.

Policy impact

The following Hg-rid-LIFE project achievements have supported legislation (regional, national, EU):

EU legislation on water quality (Water Framework Directive (2000/60/EC)

Added value of the project: Reducing emissions of mercury, a priority hazardous substance, by mercury management and decontaminations in dental clinics. New methods of decontaminations will result in more collected mercury. A contribution to good water status.

Community Strategy Concerning Mercury (COM/2005/0020)

Added value of the project: Guidelines handling dental amalgam as hazardous waste, described in the web-based training tool. The guidelines can support the developement of national legislation. Mercury management and decontaminations in dental clinics mercury emissions will be reduced and protect people against exposure.

EU Priority Substances Directive (2013/39/EU)

Added value of the project: Reducing emissions of mercury, a priority hazardous substance, by mercury management and decontaminations in dental clinics.

Mercury Discharges Directive (82/176/EEC)

Added value of the project: Minimizing mercury to end up in the environment, to the soil, by mercury management and decontaminations in dental clinics. New methods of decontaminations will result in more collected mercury.

Mercury Directive (84/156/EEC)

Added value of the project: Limit values and quality targets for mercury emissions by mercury management and decontaminations in dental clinics.

Waste Framework Directive (Directive 2008/98/EC)

Added value of the project: Guidelines for handling amalgam as hazardous waste by reducing the emissions from dental clinics by the source (mercury management, guidelines, web-based tool).

The REGULATION (EU) 2017/852 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 17 May 2017 on mercury, and repealing Regulation (EC) No 1102/2008

Added value of the project: Guidelines for mercury management and handling amalgam as hazardous waste by reducing the emissions from dental clinics by the source (mercury

management, guidelines, web-based tool), raised awareness and knowledge.

The Minamata Convention on Mercury
Added value of the project: Minimizing mercury to end up in the environment, to the soil, by mercury management and decontaminations in dental clinics. New methods of decontaminations will result in more collected mercury.

Finally, on a regional level the project has supported consensus among supervisory bodies. Municipalities and county boards have the direct responsibility for environmental supervision. The interpretation of the law has varied among the 290 municipalities.

After the project started a new regulation about the use of dental amalgam entered into force; REGULATION (EU) 2017/852 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 17 May 2017 on mercury, and repealing Regulation (EC) No 1102/2008**.** According to this regulation each Member State shall, by 1 July 2019, set out a national plan concerning the measures it intends to implement to phase down the use of dental amalgam.

Member States shall make their national plans publicly available on the internet and shall transmit them to the Commission within one month of their adoption. The results of this project will support the implementation of the new regulation in the Member States.

The restriction of use of mercury in EU will lead to decrease in environment mercury release. But some of the most important ways to decrease the mercury release are to:

- 100 % of EU dental practices equipped with amalgam separators installed in the right way for best effect.
- 100 % adequately maintained
- Increased knowledge and consensus between dentist teams and regulation authorities

The HG-rid-LIFE project has focused on all those areas and the results will hopefully be a help in the work with reducing the emissions of mercury at dental clinics. It is always easier to get attention when a dentist speaks to another dentist, Sweden and Praktikertjänst will here be the best practice.

A summary of the main success factors and barriers:
The most important thing in the project has been the common goal to reduce mercury emission from dental facilities. Everyone in the project team and stakeholders connected to it have believed in the positive effects of the project and have supported the work to reduce mercury in the environment.

Technical enablers which helped the project were the new nozzles the technicians used with the high-pressure water and more powerful units as well as preparing the pipes with chemicals. The learning process regarding the decontaminations resulted in high-pressure water only from above and from one direction.

An important aspect which has enabled the project process to reach its objectives is the Reference Group which has had representation from three of the relevant national authorities for the dental community. The possibility to gain approval for the work in the project as well as to spread the results has been of big importance to the project. A member of the Reference Group has become a member of CED:s working group for dental material (Council of European Dentists) during the project period and has been the link to CED. Dental amalgam is one of the

issues for this working group. CED is a not-for-profit association which represents over 340,000 dentists across Europe.

Unfortunately, it has been more difficult than expected to spread the results in the EU. Council of European Dentists was not a possible way to go, probably because the issue is sensitive among European dentists. A barrier for reaching out with project results beyond Sweden to international connections is that there is no natural platform that enables communication regarding these questions on an EU level. It is therefore difficult to reach out to other actors operating in European countries.

According to the regulation of the European Parliament and of the Council of Mercury, dental practitioners shall ensure that their amalgam waste is handled and collected by an authorized waste management establishment or undertaking. It is problematic in countries where there are limited infrastructures. This problem has been confirmed from dentists outside Sweden during the project. Hence, waste management establishment must be ensured. A chain is only as strong as its weakest links. In many countries outside of Sweden the fundamental needs for dental waste disposal are not 100% clear now.

Policy developments that resulted from project activities:
On a national level the project has supported the National plan of Dental amalgam phase out published by Swedish Chemicals Agency. The Hg-rid-LIFE-project is mentioned in the plan. Each Member State shall, by 1 July 2019, set out a national plan concerning the measures it intends to implement to phase down the use of dental amalgam.

How the Hg-rid-LIFE project delivered on results foreseen in GA Form B3:
All deliverables and milestones have been achieved except for milestone "First educations (according to business strategy). When the legislation about decontamination is in place training of technicians (online based), with a Service Manager on-site, will start during an introduction year to build up the organisation.

A prototype for sampling mercury could unfortunately not be tested at clinics due to important factors in the design that could not be secured and approved. Risk factors were leakage of contaminated mercury water and approval of the electrical safety requirements. However, more standardized sampling methods for measuring mercury concentration in wastewater have been developed to reduce error sources.

6.4 Analysis of benefits

Environmental benefits

Direct / quantitative environmental benefits
The Hg-rid-LIFE project had the potential to reduce total emission of mercury by 50 percent at the source, i.e. the number of dental clinics in the case study with an effluent concentration of mercury over 1,000 µg/l would be reduced by 50 percent.

In the end, the following quantitative benefits were reached in the project:

Expected results (quantitative targets)	Achieved results
600 of PTJs dental facilities screened	531 (55 rejected) dental facilities screened
125 dental care clinics decontaminated from mercury with new and improved technology	76 dental facilities/132 dental clinics decontaminated
Mercury levels reduced by 50% in clinics with initial mercury levels above 1,000 µg/l in sewage waste from suction systems	Decontamination of clinics with initial mercury levels above 1,000 µg/l reduced mercury levels with more than 50%
Sewage waste removed that contain contamination corresponding to 100 kg of mercury contaminated sludge.	372.25 kg mercury contaminated sludge removed

Qualitative environmental benefits

Through the successful demonstration of new and improved techniques for decontamination of amalgam and mercury in the pipe systems as well as improved guidelines for mercury management of Swedish dental clinics, the Hg-rid-LIFE project will increase possibilities to manage mercury at the source and prevent it from ending up in the nature were water bodies are a core recipient.

The Hg-rid-LIFE project has also improved awareness and knowledge of existing installation techniques and maintenance routines for reducing emissions of mercury from amalgam separators, which will be of use for the whole EU, as well as the improving of standards for sampling mercury concentration in water. The improving of standards together with draft guidelines for mercury will serve as input for developing green procurement standards for decontamination actions for managing mercury within the EU.

The Hg-rid-LIFE project will also support the development of national legislation or guidance from national authorities (local municipalities and The Swedish Environmental Protection Agency) since one of the major results has been to use data obtained from the project to develop draft guidelines for mercury decontamination. The guidelines will mainly be applied in the actions of Praktikertjänst, but will also be possible to use as a basis for the development of national or even EU-wide guidelines for mercury decontamination. Thus, this will be an important action to implement EU regulations into national legislation to managed mercury.

According to a study by BIO Intelligence Service (2012) it is estimated that having 95% of mercury in dental effluents captured in 100% of dental facilities instead of 70% of mercury captured in 75% of dental facilities (situation in 2012) would result in approximately 7 t/year of avoided mercury releases to urban WWTP:s in the EU. This would represent a 30% reduction of the mercury load (p 85). The impact will be more significant in those Member States where only a small proportion of dental clinics are equipped with amalgam separators (i.e. Bulgaria, Estonia, Spain, Greece, Hungary, Ireland, Lithuania, Luxemburg, Poland, Romania, Slovakia). This study was made before the new regulation concerning mercury entered into force 1 January 2018. If all mercury-containing waste is treated as hazardous waste, emissions to air corresponding to approximately 7 t/year will be avoided, 2t/year to water and 11 t/year to soil and groundwater.

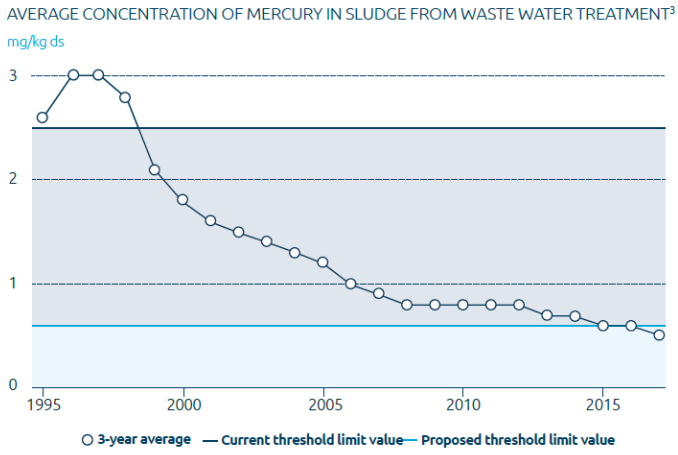
Long term environmental benefits:

Through demonstrating improved methods for decontamination of amalgam and mercury in the pipe systems of Swedish dental clinics, this project will increase possibilities to manage mercury at the source and prevent it from ending up in the nature where water bodies are a core recipient. If the calculations are based on the situation in Sweden where around 300 grams of pure mercury is expected to be removed from a clinic´s pipeline in each decontamination

activity, 39-63 tonnes of mercury per year can be recovered throughout the EU in the future. The estimation is based on 130,000-210,000 dental clinics in the EU.

In general, there will be a large economic gain for the EU if sludge from water treatment plants no longer needs to be sent to landfills due to high mercury concentrations. A lower mercury content of dental effluents entering wastewater treatment plants will reduce the need for municipalities to invest in expensive mercury abatement devices in sewage sludge incineration plants. It may also increase the possibilities of using sewage sludge for agricultural purposes. Proper maintenance of the amalgam separators, capturing and treating all mercury in dental waste as hazardous waste reduces the emissions of mercury at the source. If all mercury-containing waste is treated as hazardous waste, emissions to soil, groundwater and air corresponding to approximately 11 t/year to soil and groundwater, 7 t/year to air and 2t/year to water will be avoided. The example below shows how the concentration of mercury in sludge gradually can decrease, partly because of the decontaminations.

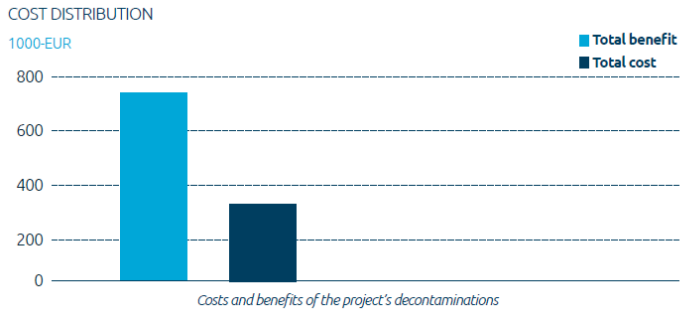
The figure shows how the average concentration of mercury in sludge from waste water treatment plants in Stockholm, Sweden from 1995 to 2017 has decreased. In 1998 the treatment plants in Stockholm, Sweden, received contribution for decontamination of dental clinics. The concentration is presented in mg/kg dry substance. The current limit for mercury in sludge to be spread on agricultural land is 2.5 mg/kg dry substance. This limit is proposed to be changed to 0.6 mg/kg dry substance. Approximately 90 % of the mercury is estimated to originate from dental amalgam.



Economic benefits

The socio-economic analysis of the decontamination conducted within the Hg-rid-LIFE-project indicates a benefit-cost ratio of approximately 2. That is, the value of the estimated health and environmental benefits of the project due to removed mercury are 2 times higher than the cost of the decontaminations.

The total estimated costs and benefits from the main analysis are presented in the figure (based on 68 decontaminations).



Costs and benefits of the project's decontaminations

Since amalgam has been banned in Sweden since 2009, it can be presumed that decontaminations are more profitable in socio-economic terms in the countries where amalgam still is used and where pipe systems never have been decontaminated when extrapolating results from Sweden to other countries. Please see Deliverable C 1.4.1 Assessment of the socio-economic impact of the project actions on the local economy and population.

The Life Cycle Assessment (Deliverable C 1.6.1. shows that all toxicity values (Human toxicity, Terrestrial ecotoxicity, Marine aquatic ecotoxicity and Freshwater aquatic ecotoxicity) indicate major improvements when mercury cleaning methods are used. Even the use of only an amalgam separator provides major improvements. High values are obtained for Marine aquatic ecotoxicity where the toxicity factors for are also high. However, a good explanation for these high values compared to the other toxicity values have not really been able to find.

Through demonstrating improved methods for decontamination of amalgam and mercury in the pipe systems of Swedish dental clinics, this project will increase possibilities to manage mercury at the source and prevent it from ending up in the nature where water bodies are a core recipient. If the calculations are based on the situation in Sweden where around 300 grams of pure mercury is expected to be removed from a clinic´s pipeline in each decontamination activity, 39-63 tonnes of mercury per year can be recovered throughout the EU in the future (the estimation is based on 130,000-210,000 dental clinics in the EU. The market volume in EU is estimated at 378 million euro).

No increase in the number of full time equivalents have been created yet. Because of the big differences between dental clinics when it comes to size and drain system it´s difficult to predict the need for staff in the future.

If the technology for amalgam separators with reusable filter technology for removing toxic heavy metals from water can be used there will be big business opportunities for the startup company Atium (please see Sub-Action E.4 –After-LIFE Plan). A prototype will be tested by dental clinics during 2020.

Impacts on waste management companies
The Hg-rid-LIFE project results are expected to lead to positive impacts on European waste management companies in a number of ways:

What is a cost for dentists is also an additional revenue for waste management companies regarding the maintenance of amalgam separators and/or the collection and treatment of dental amalgam waste. The waste management costs for dental clinics is estimated to increase from EUR 5 to 32 million per year (20% correspond to maintenance works and 80% to waste collection and treatment), according to BIO Intelligence Service (2012). The economic impact on the waste management companies is therefore expected to be very positive. Hopefully, based on the success of the Hg-rid-LIFE project, Sweden Recycling will be deemed best practice and will be able to guide and support other waste management companies in EU.

In many countries outside of Sweden the fundamental needs for dental waste disposal are not 100% clear now. This problem has been confirmed from dentists outside Sweden during the project. However, it is our belief that the project will enable a widened business sector due to new services developed. Increased future activity in the business sectors related to decontamination as well as management of hazardous waste is highly probable (e.g. by SRAB, Medentex etc).

In general, it is expected that there will be a large economic gain for the EU if sludge from water treatment plants no longer need to be sent to landfills due to high mercury concentrations. Concerning future development of treatment costs, profits can be generated from improvements

made to equipment and methods that reduce time required for decontamination. The staff costs compared with current methods could be reduced by 50%.

Based on information provided from BIO Intelligence Service (2012) it is estimated that approximately 25 % of EU dental practices are still not equipped with amalgam separators. If 100% of the dental clinics in EU should be equipped with amalgam separators, the economic impacts will be high. Assuming an average number of 2,1 dentists per clinic (*COWI/Concorde (2008) Options for reducing mercury use in products and applications, and the fate of mercury already circulating in Society, Report for the EU commission*), the estimate is approximately 34,200 additional dental clinics across the EU will have to install a separator.

By applying the costs of EUR 150 to 750/year that have been identified in the "*Study on the potential for reducing mercury pollution from dental amalgam and batteries, Final report 11 Juli 2012 (European Commission)"*, it is estimated that installation and maintenance of separators in these additional clinics will represent a total revenue in the range of EUR 5 to 26 million per year (also including amalgam sludge treatment). Hence, this means a potentially attractive market opportunity for the waste management companies.

Sweden Recycling is situated in a sparsely populated area of Sweden. The Hg-rid-LIFE project has enforced the development of know-how in the area and will in the long run boost connected business sectors to develop associated services.

The demonstration project was carried out at dental facilities of Praktikertjänst across Sweden. This means that knowledge has been spread geographically over Sweden, and the results have, through dissemination and communication also been spread to large parts of the EU.

Impacts on EU citizens
The project results are expected to lead to positive impacts on EU citizens in a number of ways:

A lower mercury content of dental effluents entering WWTP's will reduce the need for municipalities to invest in expensive mercury abatement devices in sewage sludge incineration plants, according to BIO Intelligence Service (2012). It may also increase the possibilities of using sewage sludge for agricultural purposes. This will have a positive economic effect on municipalities and on local taxpayers. It will also reduce the environmental costs associated with the management of mercury pollution from dental amalgam.

Impacts on public authorities
The project results are also expected to have positive impacts on public authorities: Increased activities for public authorities towards dental clinics would result in approximately 1 million EUR/year of labour cost assuming that each inspection would take 4 hours and that 10% of dental clinics in the Member States will be inspected each year. Some revenues could also be generated which may partly offset the labor costs.

Social benefits

Employment
The project will potentially imply a widened business sector due to new services developed such as environmental maintenance service. A study for the EU Commission estimated that a full implementation of EU waste legislation would increase the annual turnover of the EU waste management sector and recycling by EUR 42 billion and create over 400,000 jobs.

If 100% of the dental clinics in EU are equipped with amalgam separators, the social impacts will be high. It is expected to have a positive impact in terms of job creation in companies that are involved in the manufacturing, installation and maintenance of amalgam separators as well as in companies specializing in the collection and treatment of mercury containing waste.

A full implementation of EU waste legislation would increase the annual turnover of the EU waste management sector and recycling by EUR 42 billion and create over 400,000 jobs.

Public health and safety
It is roughly estimated that avoiding air emissions of 7 t mercury/year will avoid health damage costs in the range of EUR 35 to 140 million per year, related to IQ loss of between EUR 5,000 to 20,000 per kg mercury emitted to air (BIO Intelligence Service (2012)).

Replicability, transferability, cooperation
The knowledge gained from the Hg-rid-LIFE project can easily be used to reduce mercury emissions in other European countries (i.e. a high likelihood of replication). COWI/Concorde (2008) estimates that if about 500 g of mercury is being trapped in the piping of an average European dental clinic, even a conservative estimate would put the total at some 50-70 tons of mercury for the EU. This implies that the Hg-rid-LIFE project has great potential to improve the technology to remove mercury leakage.

Sweden Recycling's mother company, Medentex in Germany, which has similar activities to Sweden Recycling, has begun decontamination activities and surveys of mercury emissions within the proposed project period. Medentex has an accredited laboratory for mercury analysis. The knowledge we have gained from the Hg-rid-LIFE project will be used by Medentex to start up similar activities in Germany (and other EU countries) if and when necessary EU legislation is in place, requiring dental clinics to decontaminate. If the results of this demonstration project are applied throughout Europe it will be possible to deal with one of the main remaining sources of mercury in the EU.

The potential for replication of the technique is high, but the knowledge by the operator is important. Decontamination of dental clinics is a delicate task. If underestimated, it will end in a disaster.

Best Practice lessons
The demonstrated methods for decontamination (filming, use of chemicals and new methods for decontamination of pipes with poor access or suboptimal pipe dimensions) will enable decontamination of suction pipes that are impossible to reach today or is considered too expensive to decontaminate. With the current "best practice" technique, many of pipes are not properly cleaned, but this will be accomplished with the methods demonstrated in Hg-rid-LIFE. The benefits of the project are substantial since it enables the pipes with most sludge to be decontaminated.

Innovation and demonstration value
The Hg-rid-LIFE project aimed at reducing emissions of mercury at the source. Through demonstrating developed methods for decontamination of amalgam and mercury in the pipe systems of Swedish dental clinics, a first step has been taken towards less mitigation of mercury also in the EU.

Based on the results of the project, a more effective method for mercury decontamination is now ready for implementation in Europe. The project has also improved awareness and knowledge of existing installation techniques and maintenance routines for reducing emissions of mercury from amalgam separators, which will be of use for the whole EU. The improving of standards for sampling mercury concentration in water together with draft guidelines for mercury will serve as input for developing green procurement standards for decontamination actions for managing mercury within the EU.

The project managed to remove up to 50 percent of the mercury from the dental clinics taking part in the pilot project. The project results included the following technological achievements:

- improving standards for sampling mercury concentration
- developing methods for decontamination of pipe systems in use and
- improving awareness and knowledge of existing installation technology for reducing emissions of mercury from amalgam separators

Pipes in older suction systems (from the time before amalgam separators were used) are usually built for flow of air instead of water. These pipes usually contain large amounts of amalgam sludge. This is due to sharp bends of the pipes and weak decline. Hence, a general problem arising during current decontamination action is accessing contaminated pipes. These difficulties will be avoided by using the methods developed in Hg-rid-LIFE.

Hence, the demonstrated methods for decontamination (filming, use of chemicals and new methods for decontamination of pipes with poor access or suboptimal pipe dimensions) will enable decontamination of suction pipes that are impossible to reach today or is considered too expensive to decontaminate. With the current technique, many of pipes are not properly cleaned, but this will be accomplished with the methods demonstrated in Hg-rid-LIFE. The benefits of the project are substantial since it enables the pipes with most sludge to be decontaminated.

The web-based training tool is available free of charge in five languages and has also a clear demonstration value.

Policy implications

Adequate handling of dental amalgam waste is necessary to achieve certain goals of EU legislation on water quality (Water Framework Directive (2000/60/EC), Decision 2001/2455/EC and Directive 2006/11/EC on dangerous substances and Directive 2008/105/EC on priority substances) where mercury is identified as a priority hazardous substance.

The Hg-rid-LIFE project has delivered a decisive and crucial contribution to the implementation of the water management principles of the EU, by reducing the emissions of mercury at the source. Actions to manage dental amalgam waste and to manage the use of amalgam are key to implement the Community Strategy Concerning Mercury. Thus, the final results of the Hg-rid-LIFE project are in line with goals of the Water Framework Directive and the Environmental Quality Standards Directive under the Water Framework Directive as well as the Community Strategy Concerning Mercury.

The project results will also assist the EU in achieving the Environmental objectives set by the EC concerning minimization of environmental impact from economic activities.

The implementation of the Hg-rid-LIFE project was facilitated by a new regulation concerning mercury which entered into force 1 January 2018 (REGULATION (EU) 2017/852 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 17 May 2017 on mercury, and repealing Regulation (EC) No 1102/20089. The long term effects is dependent on regulation for decontamination and on control of the compliance of the regulation about the use of dental amalgam.

To follow the implementation of the regulation about the requirements to publish a national action plan, phase-out dental amalgam use in vulnerable groups, and enforce the mandatory use of amalgam separators to remove amalgam particles from dental waste, a series of interactive maps to monitor Member States' progress has been released; EU Mercury Regulation https://noharm-europe.org/mercury-tracker?mc_cid=8ecad0c628&mc_eid=c2392b8e2e

Decontamination of pipes in dental clinics is an effective method for reducing the leakage of mercury from dental clinics, in addition to amalgam separators and correct handling of amalgam waste. However, to ensure the environmental benefits, regulations must be implemented.

Possible barriers for implementation can be:

- ✓ it can be misinterpreted that promoting best practices in waste management could be picked up by the authorities as strategy to deal with amalgam'
- ✓ lack of control of the compliance of the regulation
- ✓ obscure legal situation - who is responsible for contaminations in the drain system?
- ✓ dentists think it´s too expensive

7 Key Project-level Indicator

Key indicator	State-of-play end of project	Achieved result	State-of-play after 3 years
Ecological status – water pollutants (mercury removed from sludge)	less than 1,000 µg/l in the effluent	less than 1,000 µg/l in the effluent	less than 1,000 µg/l in the effluent
Waste management (mercury contaminated sludge)	100 kg	372.25 kg	900 kg (modified to 636 kg)
No of clinics committed to or applying the new tools/methods	4,000	too early to evaluate	10,000
Supervisory/enforcement bodies involved	6	12	20
Implication of NGO	12	7	20
Website (visits)	300,000	8 945	400,000 (modified to 15 000 visits)
Web-based training tool (users)	5,000	3,244	6,500
Digital notice boards (no of general public)	600,000	4,400,000	700,000 (8,800,000 contacts are estimated to be reached)
Surveys regarding awareness of the environmental/climate problem	300	2,437 persons (1,066 respondents)	300 (modified to 2,437 persons)
Training and network (no of individuals trained)	5,000	above 5,000	6,500
Full-time equivalents	8	0	30
Running costs/year (€)	591,826	452,000	0
Capital cost (equipment, €)	- 4,500	0	- 5,000
Expected savings (staff costs, €/year)	- 400	-400	- 400
Payback time (year)	-1	7.3	0
Continuated transfer of tehnology and know-how	1,000	1,000	6,000

Analytical comparison with the targets at the beginning of the project

Ecological status – water pollutants (mercury removed from sludge)

Achieved results: One of the projects' measurable objectives is 50% reduction of mercury concentrations in the wastewater from dental clinics with the initial concentration above 1000 µg/l. Evaluation of decontamination effects via mercury concentrations in wastewater shows that this objective was achieved for major part of the facilities (i.e less than 1000 µg/l). Please see also Action C1 and Deliverable C 1.4.1 Assessment of the socio-economic impact of the project actions on the local economy and population.

State-of-play after 3 years: Improved mercury management is important to achieve levels less than 1000 µg/l in the effluent. The legal requirements about installing amalgam separators will be important in reaching this goal. The web-based training tool with instructions for proper handling of amalgam waste can be a support. If and when regulation for decontamination and control of the compliance of the regulation about the use of dental amalgam are in place, this goal is realistic.

Waste management (mercury contaminated sludge)

Achieved results: A total of 372.25 kg mercury contaminated sludge and 21.15 kg mercury have been collected from 76 dental facilities/132 dental clinics, i.e. almost four times more than predicted as the goal was 100 kg.

State-of-play after 3 years: Based on the situation in Sweden, we estimate that 636 - 1,026 tonnes of amalgam sludge can be recovered in the EU (estimation is based on 130,000-210,000 dental clinics in the EU). However, regulation for decontamination must be in place first to make this happen.

No of clinics committed to or applying the new tools/methods

Achieved results: As the web-based training tool was launched in Swedish in November 2018 and in other languages in March 2019, it´s still too early to evaluate if clinics/dental services have committed to or applying the new tools/method. It takes time to change habits and routines. The users of the web-based training tool can voluntary sign up for a survey some months after the first use of the tool. About 30 persons have signed up, but just a few have answered the questionnaire.

State-of-play after 3 years: More educated dental teams will hopefully motivate clinics applying methods that will minimize emissions of mercury from dental amalgam. The goal of 10,000 clinics committed to or applying the new tools/methods could be reached if regulations for decontamination and control of the compliance of the regulation about the use of dental amalgam are in place.

Supervisory/enforcement bodies involved

Achieved results: 12 supervisory/enforcement bodies have been involved in working groups in the project, participated in dialogue meetings, training seminars and in the Final Conference. Representatives from Swedish authorities; The Swedish River Basin District Authorities, Swedish Environmental Protection Agency and Swedish Chemicals Agency have been members of the Reference Group. Supervisory/enforcement bodies on regional level has also been involved in the project.

State-of-play after 3 years: One activity after the project is to have dialogue with authorities communicating the results of the project, supporting the development of national legislation or guidance. The goal of involving 20 supervisory/enforcement bodies should be reached.

Implication of NGO

Achieved results: Seven (7) NGO:s, on both national and EU levels, have been involved in the project. Beyond this, each dental organization in the EU (28) has been contacted with information about the project, a request to take part in an electronical survey and with information about the web-based training tool. However, it was more difficult than expected to get response from the European dental organizations.

State-of-play after 3 years: One activity after the project is to have dialogue with NGO´s communicating the results of the project, supporting the development of national legislation or guidance. The goal of involving 20 supervisory/enforcement bodies should be possible to reach.

Website (visits)

Achieved results: The website has complemented the web-based training tool, which is one of the main results of the project. The goal for visits on the web-site was set very high in the application and has not been able to reach within the project period. Total visitors on the project website have been 8,945, unique pageviews have been 6,463. Beyond Sweden, there have been visitors from Croatia, Greece, Poland, Germany, Czechia, United States, Romania, Malta, Philippines, Venezuela etc. The project has also a Facebook page as a digital channel.

State-of-play after 3 years: Praktikertjänst will continue to maintain the project web site. The goal for visits on the web-site was set very high in the application (400,000 visitors) and will not been able to reach. Hence, this goal has been modified to 15,000 visits.

Web-based training tool (users)

Achieved results: The web-based training tool has been a large success factor in the project. It was launched in Swedish in November 2018 and in other languages in March 2019. The number of users during the project period was 3,244 and the number of unique page views was 5,785. The tool has been perceived as user friendly by the ones that tried it. It has helped the project reaching out in an easy way, not only in Sweden, but also to other countries in Europe as well. The training tool has been demonstrated at fairs, conferences and at training seminars for dental nurses and inspectors at local authorities. An advertisement about the web-based training with a link was available on Facebook for dental target groups within the EU during April-August 2019 and on the Facebook page of LIFE programme in May 2019. In August 2019 the share of users per country was as follows; Sweden (41%), Romania (30%), Bulgaria (6%), Greece (3%), United States (3%), Italy (2%), Germany (2%), Portugal (2%), Cyprus (2%).

State-of-play after 3 years: The web-based tool will be continued to be disseminated, especially to dental students in Sweden and in the rest of the EU (dentists and dental nurses), so we expect it will be possible to reach the goal of 6,500 users. More educated dental teams will motivate clinics applying methods that will minimize emissions of mercury from dental amalgam. Contacts established in the project, for example from fairs and conferences, will also be reminded to visit the web-based tool and to spread it. Dental clinics in Praktikertjänst will be requested to use the web-based tool.

Digital notice boards (no of general public)

Achieved results: Digital Notice Boards for patients at dental clinics are common. Information about the project has been incorporated in existing slideshows for TV screens in the waiting rooms and treatment rooms at 154 dental clinics in Praktikertjänst. 4,400,000 patients and visitors to Praktikertjänst's dental clinics have been reached with information about the project.

State-of-play after 3 years: 8,800,000 contacts are estimated to be reached. The goal of 700,000 persons reached by digital notice boards has already been reached (see above). Hence, this goal has been modified (increased).

Surveys regarding awareness of the environmental/climate problem

Achieved results: Surveys were sent to 2,437 persons (1,066 respondents) so the goal has of 300 surveys have been reached. It has been a tool to raise awareness and knowledge. One survey was sent to dental staff and environmental inspectors at two different times, the first one during May in 2017 and the second one two years later, in May 2019. The survey was an activity for identifying the current knowledge and competence situation in Swedish dental facilities on how to mitigate mercury leakages from dental facilities. The purpose of sending out the survey on two different occasions was to enable us to see if there has been an increase in knowledge etc.

The respondents of the survey were asked to answer how they estimate their own knowledge regarding what effect mercury has on the environment. In general, both target groups (dental staff and environmental inspectors) estimate their knowledge on mercury's effect on the environment and their knowledge on safe handling of mercury waste as good. A survey/overview of knowledge about mercury management in European dental facilities was made as a questionnaire. It was sent to all the dental organizations in the EU, but only a few of the organizations responded. The dental nurses and inspectors at local authorities participating in the training seminars arranged by the project were asked some questions before and after the seminar by an on-line survey.

State-of-play after 3 years: The goal of 300 surveys has already been reached. Hence, this goal has been modified (increased).

Training and network (no of individuals trained)

Achieved results: The total number of individuals trained and networking is estimated to more than 5,000. More than 3,500 persons have been involved in training by using the web-based training tool or participating in training seminars. More than 200 individuals have been networking in dialogue meetings/workshops. Many stakeholders have been networking at fairs and conferences.

State-of-play after 3 years: The goal of 5,000 training and network (no of individuals trained) has already been reached. The web-based tool will be continued to be disseminated, especially to dental students in the EU (dentists and dental nurses, hence the goal has been modified to 6,500 individuals trained.

Full-time equivalents

Achieved results: No new personnel has been employed during the project. However, 8 people of SRAB have been active in the project.

State-of-play after 3 years: If EU should decide to implement new legislation re obligatory decontaminations, the figure of 30 new employments by mainly Sweden Recycling, as forecasted, is likely.

Running costs/year (€)
Achieved results: The yearly running cost for the project has been approx. 452,000 € (i.e. 1,358 000,000 € for the whole project) compared to 591,826 €/year as forecasted.

State-of-play after 3 years: No project cost will be relevant after the project end.

Capital cost (equipment, €)
Achieved results: Since no prototype equipment was developed in the project, this cost became 0 €.

State-of-play after 3 years: Since no prototype equipment was developed, this cost will be 0 € also after 3 years.

Expected savings (staff costs, €/year)
Achieved results: Based on the new decontamination method developed in the project, the savings are estimated at 400 € per decontamination (and 100 €/treatment chair), as forecasted.

State-of-play after 3 years: Based on the new decontamination method developed in the project, the savings are estimated at 400 € per decontamination (and 100 €/treatment chair) also 3 years after the project, as forecasted.

Payback time (year)
Achieved results: Based on approx. 230,000 dentists/facilities in Europe (https://www.statista.com/statistics/554977/dentists-in-europe) and a possible market share of 5% (if new EU legislation is introduced), 150 decontaminations per year will mean a revenue of 60,000 € for Sweden Recycling. This is equivalent to a payback time of 7.3 year (for invested project cost of approx. 439,000 € for Sweden Recycling). The forecasted payback time was 1 year.

State-of-play after 3 years: Since the investment is already taken, the figure is 0 after 3 years.

Continuated transfer of tehnology and know-how
Achieved results: Through the LIFE project, we estimate that approx. 1,000 people (mainly dentists and dental teams) as forecasted have been informed of new methods developed in the project.

State-of-play after 3 years: If EU should decide to implement new legislation re obligatory decontaminations, the goal of 6,000 people (mainly dentists) informed of new methods developed in the project seems likely to be reached.