(PP3) PILOT ACTION REPORT

Version 1

Deliverable D.T3.3.6

01
2019

Contents

1. Pilot Action Title

IMPLEMENTATION OF REMEDIATION METHODS ON BROWNFIELD STARA CINKARNA

2. Place/area of PA implementation

The pilot brownfield site for the project purposes is degraded area in the Municipality of Celje, which reflects the different types of degradation that covers 9 ha, situated in the urban core, as it lies only 500 m from the old city centre borders (in the first industrial belt of the city).

The Old Cinkarna site was used from 1873 to 1990 by metallurgical and chemical industry Cinkarna Celje.

3. Duration of PA implementation

Nina: From March till November 2018

4. Costs related to PA

Methods	Unit	Estimated cost
Imobilization with calcareous paper ash	m^3	100 EUR
Cold recycling a) only a field with a foam bitumen bonded carrier layer in a thickness of 25 cm b) added asphalt mixture in a thickness of 6 cm c) plowing 30 cm of ground layer with grass (for greenery)	m^2	 20,75 19,85 19,45
Organic-mineral substrate Note: the price includes the preparation of the terrain, the preparation of the substrate, the execution of works with supervision and the cost of implementing the final landscape arrangement of the surface	m^2	341 EUR

5. Background and challenges faced

The pilot brownfield site for the project purposes is degraded area in the Municipality of Celje, which reflects the different types of degradation that covers 9 ha.

The Old Cinkarna site was used from 1873 to 1990 by metallurgical and chemical industry Cinkarna Celje.

At the beginning was there for a few decades production in roasting zinc ore and zinc smelting. The carbonate zinc ore was firstly dug around Celje later was replaced by

sulphate ore, which was imported from places that are more distant. Parallel to the roaster production new industrial facilities designed for supporting basic production were introduced (production of generator gas, production of lead blocks, lead sheets, sulphuric acid production ...).

Production was also causing serious environmental burdens. Emissions of harmful gases and polluted wastewater were discharged directly into air and water bodies without adequate treatment plants. Hazardous waste management was neither normative nor otherwise regulated, many environmental impacts were not yet even known.

Estimated environmental risk at the site of pilot area are:

- Contaminated soil with heavy metals (identified as the extreme contamination with some heavy metals) and mineral oils. They can represent during construction and excavation works wastes, which may contain hazardous substances;
- Buried industrial waste and tar pits;
- Buried reservoirs and underground drainage technology;
- Lack of information/research on soil contamination in depth and groundwater in the area.

6. PA objectives

Within the framework of the planned activities of the EU GreenerSites project in the pilot area of the Old Cinkarna, PA objective was to test three methods / procedures for the remediation of contaminated soil which were successfully carried out.

Another objective was to install the piezometers for monitoring the quality of underground water and to collect data about the direction and velocity of the current at different water levels. On the basis of measured chemical parameters, limit values for the parameters and the framework of the spatial distribution of pollutants were defined. Following the synthesis of all measurements, the degree of influence of the contaminated soil on the groundwater, which poures into the surface water, is defined.

Finally, the objective was to start gathering data for the visualisation and management of geodata about polluted and degradated soil. For that purpose, the Municipality of Celje launched the GIS tool which is at current state of internal use because it shall be unpgraded with atributes and additional interpretation of data. However, the GIS tool represents the initial database for the pilot site and broader FUA area.

7. Activities carried out

Deliverable D.T3.3.1 - Detailed analysis of all pollutants on the pilot area

To get information on all types of soil pollution besides heavy metals and expected tar pits with unknown locations the Municipality of Celje ordered a study - Processed soil contamination analyses in the MOC area was implemented. In the first (preparatory) phase, the following activities were carried out:

2.1. Preparation of data

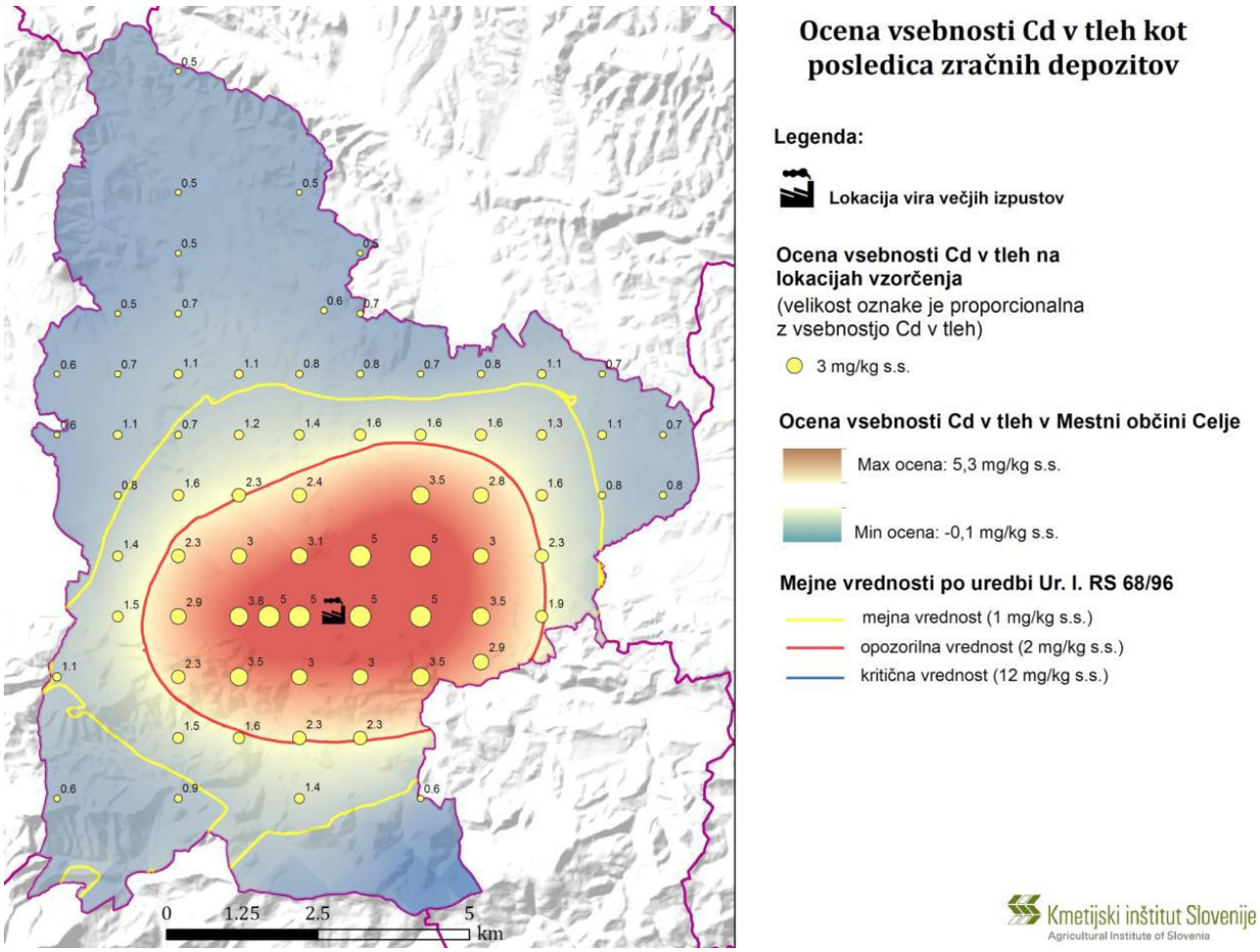
The results of the processed soil contamination analyses in the MOC area include data on heavy metal pollution (Cd, Pb, Zn) at the same sampling locations for soil pollution in Celje for the year 1989 and 2016. The data of the previous analysis (for the year 1989) had been collected and analyzed and the .csv table for use in statistical processing was prepared.

2.2 Selection of statistical program

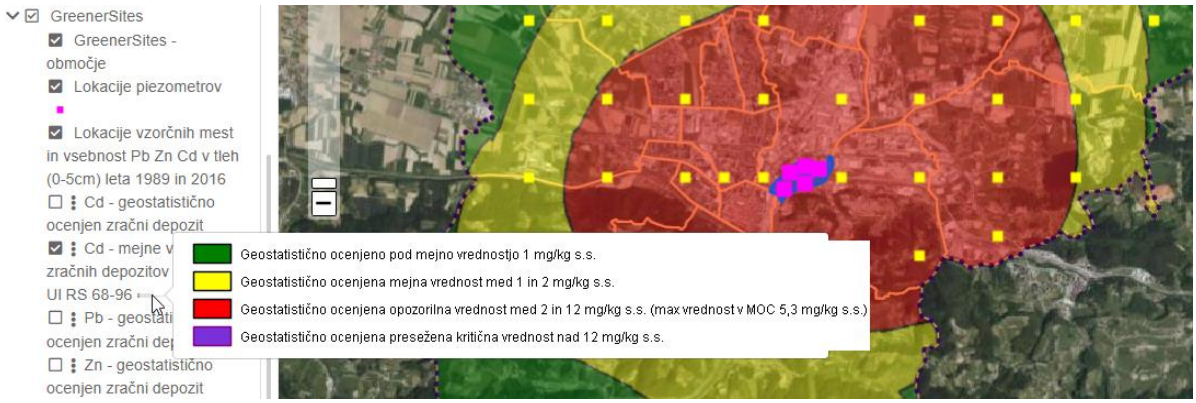
For the geostatistic data processing, the (geo) statistical program "R" was selected and spatial extrapolation using the kriging method with manufacture of variograms was used.

On the basis of the statistical and geostatistical analysis of the Cd, Pb, and Zn content measured in soil in year 2016, the study presents the method and maps of soil contamination with heavy metals (Cd, Pb and Zn) in the area of the Municipality of Celje. The following maps as well as GIS information layers were produced within the study: maps with a) estimated air pollution by Cd, Pb and Zn; and b) locations of point pollution sites that were caused by the deposition or addition of materials with increased heavy metal content (Cd, Pb and Zn). The soil contamination maps include indication of dispersal (aerial transport) and hot spot contamination with heavy metal content.

Picture 1: An example of a map.



Picture 2: An example of the test GIS information layer



Translation of the legend: the test GIS tool information layer visualizes the GreenerSites area (blue), locations of installed piezometers (purple), locations of point pollution sites where the concentration of Pb, Zn and Cd in the ground was measured in 1989 and 2006 (yellow) and areas of limit values of Pb, Zn and Cd air deposits according to the Slovenian law (green, yellow, red).

Deliverable D.T3.3.2 - Results of testing the effectiveness of methods for PA decontamination

Pilot tests of most cost and environmental effective methods for Celje pilot area were performed.

M1. Remediation with calcareous paper ash

The method is performed by mixing of contaminated soil with a suitable additive, whereby potentially toxic elements are, by means of chemical and physical mechanisms, transformed into low mobile, non-bioavailable and non-toxic chemical species.

Scientific studies show that calcareous paper ash from the paper industry is a very promising immobilization additive. It consists of the hydraulic active minerals, which form new mineral phases, when they are in contact with water. This leads to the formation of a bonded matrix suitable for immobilization.

Within a scope of this study, the soil sample from the Old Zinc-Works site was first sieved, grains larger than 16 mm were then crushed and the sample was homogenized. Paper ash produced by VIPAP VIDEM KRŠKO, d.d. was used as an additive. A geotechnical composite was prepared, which contaminated soil and paper ash, at a dry mass ratio of 3: 1. Modified Proctor procedure according to SIST EN 13286-2: 2010/AC, was performed, to obtain the optimum moisture content and the reference maximum dry density of the composite, which were 19.3% and 1.54 Mg/m3, respectively.

Tests showed that average unconfined compressive strength of the composite test samples, after 28 days of curing, was inert.

M2. Remediation with cold recycling

Contractors conducted an attempt to remediate the contaminated soil in the pilot area of the "stara Cinkarna" with the crushed stone 0/32 mm (buffer layer) in a thickness of 30 cm (concentrated state) and the implementation of cold recycling (WIRTGEN WR 250) with cement and foamed bitumen at a depth of 25 cm. This makes bitumen cement stabilization,

while the contaminated layer remains covered and intact. In this way, it is impossible to raise dust, heavy metals and dangerous substances into the atmosphere. The advanced watertight containment barrier represents an innovative and comprehensive approach to the implementation of the remediation process in industrial degraded areas where the cold recycling process does not interfere with critical contaminated soil and requires relatively low installation of the composite for the construction of a barrier (30-35 cm). Also, the proposed approach is environmentally most acceptable, since a product, which is the integrated composite can be fully recycled.

M3. Preparation of suitable mixture of organo - mineral substrate

In order to determine the appropriate mixture of ingredients for the active substrate, a pot experiment was carried out under controlled conditions in a glasshouse. Three hyperaccumulator plants were used as test plants, due to their affinity for heavy metals: ribwort plantain (Plantago lanceolata L.) and two vegetables, known to take up heavy metals by absorbing them from contaminated soils, lettuce (Lactuca sativa L.) and carrots (Daucus carota subs. Sativus). Ribwort Plantain is the test (fitoaccumulation) plant for soil contamination research in Slovenia, as for vegetables, very strict criteria is set for the level of heavy metals in food. All three plants were represented in pots in the same proportion. Five different mixtures of the active substrate were composed from: i) organic component – municipal compost; ii) mineral component - unpolluted, silty-clay soils, and iii) Zeolite powder.

Analysis showed that that the substrate mixtures suitable for soil remediation of the Old Cinkarna area are: 10:40:50 and 10: 50:40 (zeolite: mineral component: organic component), according to the accumulation of heavy metals in test plants. Although heavy metals were detected in the plants we used, the content was below the threshold value, what means that this compost is suitable for use in urban gardens.

Deliverable D.T3.3.3. - Innovative monitoring system

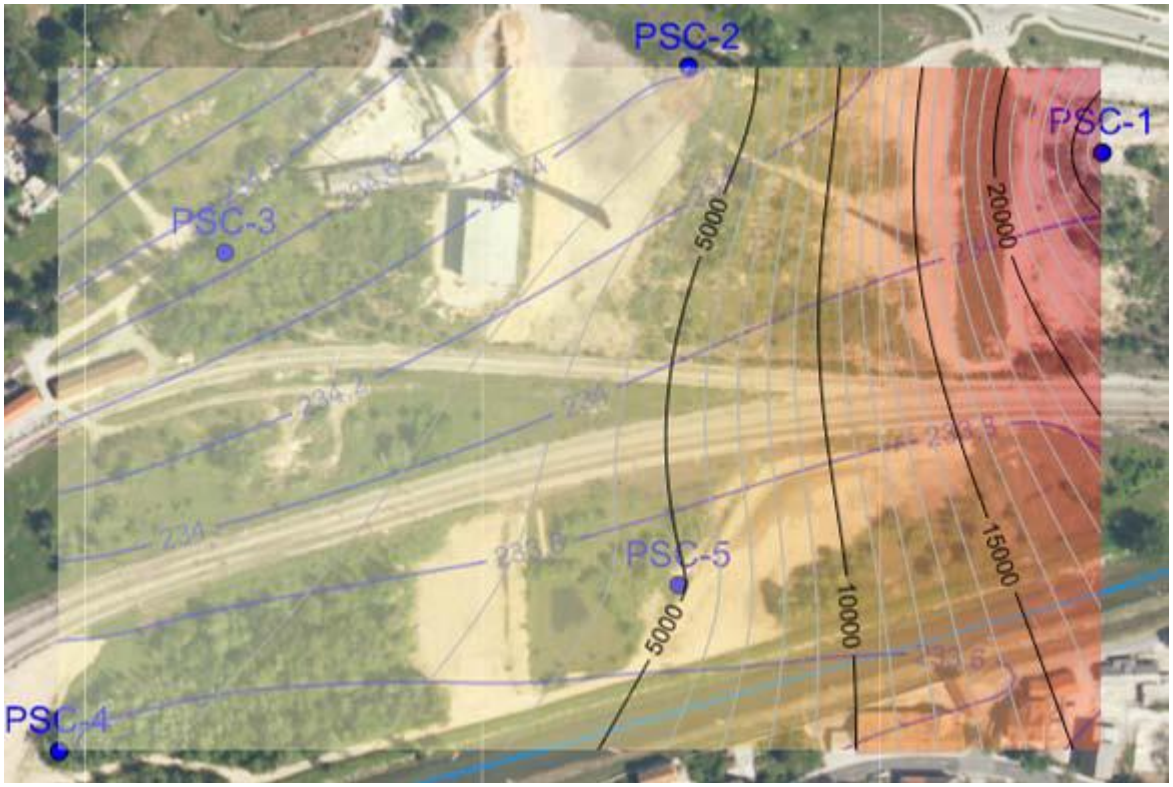
To get comprehensive control monitoring system of groundwater quality and features a study was ordered - The layout of piezometers and first chemicals analysis of the underground water.

In the area of the old Cinkarna, an observation network of piezometers was established in which studies of the sediment transmissivity and a zero-shot of the chemical state of the underground water were implemented. A continuous quantitative monitoring is also in progress.

The ultimate goal of the groundwater-monitoring project is the definition of the direction and speed of the groundwater flow and the impact assessment of the potential pollution of groundwater from the area under consideration to groundwater and surface watercourses.

Picture 3: The following picture indicates the location of the piezometers at the PA site

Picture 4: A map (from the test GIS tool) indicates the distribution of Zinc [µg/l] at the location of the PA Site as well as similar distribution of cadmium (their amount increases towards the east):



8. Technical specifications and solutions tested

Two of the three methods tested in the framework of the GreenerSites project are immobilization methods: M1 by using the additive - calcareous paper ash and producing an inert composite and M2 by using bitumen and producing waterproof load-bearing layers, meaning that both prevent future dusting and leaking of pollutants to the underground water. The third method enables the establishment of a fertile soil for the greening of this area - the establishment of green spaces.

M1 **Remediation with calcareous paper ash**

The results of the study had shown that the described method is effective because obtained composite is inert and is suitable for the construction of embankments or fills for the rehabilitation of this degraded area. It could be used for the preparation of inert cover of the polluted area thus preventing the migration of pollutants to underground water or the dusting of polluted soil.

M2 - Remediation with cold recycling

Cold recycling technology is an environmentally friendly and economical method to produce new quality load-bearing layers, thus eliminating the cost of excavation and consequently disposal of it and the costs of preparing and transporting new material. Finishing sealing layer is made of waterproof membrane that prevents dusting and leaking of pollutants to underground water. Additionally, the finishing sealing layer may be covered with 30 cm of previously analysed ground layer (10.8 m3), upgraded with grass sowing (red fescue, cat grass, sheep fescue). Characteristics: densely tufted, the sensitivity of plants to metals and metal retention in the roots (phytoremediation).

M3. Preparation of suitable mixture of organo - mineral substrate

By using organo - mineral substrate and greening the degraded and contaminated areas, it is also possible to reduce the risks associated with land contamination. In particular, it would limit wind velocity (wind erosion) and thus inhaling heavy metal particles, direct ingestion and skin contact. Remediation would also contribute to reducing heavy metal contamination of ground water as well as above ground water and thus the transfer of heavy metals to other parts of environment and indirectly to human again.

9. Impact/ results/ experience (how many target groups/ stakeholders were reached, pilot events)

In the framework of the project, the Municipality of Celje organised 4 stakeholder tables (3 reported in the RP 4), a local training, a local pilot event on different but inter-linked topics related to the PA implementation with the aim of supporting the partners and their stakeholders in the activities linked to their pilot actions, as well as and to raise their awareness and knowledge about specific issues related to environmental management of the pilot area and the entire FUA area.

The trainings addressed the majority of relevant stakeholders: local decision-makers and administrators (Municipality of Celje), technicians from the involved partner institutions (private and public companies, research institutes), students and researchers, and the stakeholders at the national level, in particular from the Ministry of the Environment and Spatial Planning.

We have translated the training material (DT 2.1.2) which was delivered to the participants of the events. The topics were selected on the basis of the training needs' analysis carried out in the previous months and tailored to the specifics of the local territory and local and national institutions. Special attention was given to he in-depths analysis of the national and local legislative framework for managing the environmental rehabilitation and remediation of brownfields.

1. Round table/local event in Celje on the 27th of November 2017
The main topic of this first local event was presentation of the main elements of the Strategic Action Plan (SAP). Participants were administrators and decision-makers of the Municipality of Celje, including the Heads of Departments and Sectors, as well as external experts in the field of soil management, spatial and urban planning. Active discussion was promoted.

2. Round table/local event in Celje on the 18th of December 2017
The main topic of the second local event was a discussion about the appropriate techniques for the PA and their feasibility in relation to our national legislation, incl. the implementation of thermal treatment, immobilisation techniques and other techniques for soil remediation (Slovenian National Building and Civil Engineering Institute - ZAG and Agricultural Institute of Slovenia - KIS).
Participants were administrators and decision-makers of the Municipality of Celje, including the Heads of Departments and Sectors, as well as external experts in the field of soil remediation. Active discussion was promoted.

3. First Stakeholder meeting in Velenje on the 15th of May 2018
The aim of the event was to present the first Pilot Action results and to raise the awareness of the local stakeholders in in the neighbouring Municipality Velenje; the first results of the remediation method with calcareous paper ash and with cold recycling, GIS tool and its application. The presentation was also held on how and to what extend can the pollutants (hazardous elements in the soil) be transferred through different measn from soil to humans.
Participants were: the external experts from ZAG, KIS and VOC (a construction company), students and professors of the Environmental Protection College from Velenje, administrators of the Municipality of Celje.

4. Second Stakeholder meeting in Šentjur on the 21st of May 2018
The aim of the event was to present the first Pilot Action results and to raise the awareness of the local stakeholders in the neighbouring Municipality Šentjur; the first results of the remediation method with calcareous paper ash and with cold recycling, GIS tool and its application. The presentation was also held on how and to what extend can the pollutants (hazardous elements in the soil) be transferred through different means from soil to humans.
Participants were: the external experts from ZAG, KIS and VOC (a construction company), students and professors of the School Center Šentjur, College for Agriculture and Spatial planning in Šentjur, administrators of the Municipality of Celje.

5. Third Stakeholder meeting in Celje on the 28th of May 2018 and additional one on the 5th of June 2018
The aim of the events was to present the brownfield Site of Old Cinkarna and the results of the processed soil contamination analyses in the MOC area. The focus of the discussion which was moderated by lecturer of the Agricultural Institute of Slovenia was on the impact of soil contamination on human health and safe gardening.
The participants were: representatives of local communities, representatives of the Faculty of Civil and Geodetic Engineering, University of Ljubljana, the lecturer of the Agricultural Institute of Slovenia and MOC administrators.

6. Local Training in Celje on the 15th of June 2018
The aim of the event was to present the brownfield Site of Old Cinkarna and the results of the processed soil contamination analyses in the MOC area. Special attention was given to:
- the presentation of the Pilot Action results,
- possible aspects of spatial planning of the Pilot Site of the Old Cinkarna,
- presentation of the national legal framework, in particular of the consolidated Environmental Protection Act with an emphasis on the envisaged legal regulations on the rehabilitation of old environmental burdens,
- presentation of possible approaches towards the implementation of the process of remediation of the degraded area

Among the participants were: representatives of organisations who tested all three methods of remediation (ZAG, KIS, VOC), spatial and urban planning specialists of the Municipality of Celje, representatives of the Ministry of the Environment and Spatial Planning, the Faculty of Civil Engineering and Geodesy of the University of Ljubljana, administrators and decision-makers of the Municipality of Celje.

7. Local Pilot Events in Celje on the 23rd of October 2018 (DT 3.13.2)
At the event we presented the brownfield Site of Old Cinkarna and the final results of the processed soil contamination analyses in the MOC area, which were presented and visualized with the GIS information maps, as well as the final results of the PA (including the results with regards to the preparation of suitable mixture of organo - mineral substrate).

On the basis of complete and comprehensive PA results, the discussion was focused on the guidelines for the preparation of the national SAP. A case study of the remediation of the old environmental burden – illegal landfill Bukovžlak (plot no 115 in the cadastral municipality k.o. Teharje) was presented.

Among the participants were: external project evaluator, spatial and urban planning specialists and administrators of the Municipality of Celje, representatives of research organisations (external expert organisation KIS), spatial and environmental planning organisations, external expert involved in the preparation of the SAP - Zavod Zavita and the representative of the Ministry of the Environment and Spatial Planning.

Tested methods proved to be effective and useful in the pilot area, which the local community intends to reurbanise in the future. All the events turned out to be an opportunity for knowledge exchange and networking.

In reurbanisation (the construction of new buildings) the earth excavations are expected to contain high concentrations of heavy metal elements. By using the pilot method in which calcareous paper ash is used, hazardous waste/soil could be converted into a building composite, meaning the further dusting and leaking of pollutants to underground water would be prevented. With this project we also learned that equipment and a registered contractor are available for this method.

By using another method with bituminous mass (cold recycling), infrastructure facilities, roads, parking lots can be used in this pilot area without prejudice to intervene to contaminated soil.

Using the third method, it is possible to prepare a mixture of suitable mixture of organo - mineral substrate that could be used for greening of the proposed areas.

10. Contribution to project objectives

Pilot actions contribute to the project's main objective - to improve the environmental management of unused or underused industrial areas (brownfields) through the definition of strategies, tools and actions based on a sustainable integrated approach to make involved Functional Urban Areas (FUA) cleaner, healthier and more liveable places - by:

- establishing a database for hotspots and brownfields for future spatial management of FUA
- by successfully testing three methods to demonstrate possible solutions and new uses for degraded areas (brownfields). Those technical solutions have positive effect both, on the environment because they require recycling and reuse of the existing materials (soil) by immobilizing them and on the financial costs of remediation as they do not trigger additional investments and public funds.

11. Transnational added value - how PA contributed to other activities implemented by the project & added value for partners

PA contributed and has an added value to other partners by:

1.offering the opportunity for the information, knowledge and good practices' exchange.

2. By successfully testing different methods of remediation we showed the project partners at the local, national and the European level what could be a solution for the future of degraded areas and brownfields.

3. With the GIS tool, which has been developed in the framework of the project, we gained access to valuable data and an opportunity for more effective management of brownfields.

12. Compliance with the sustainability principles

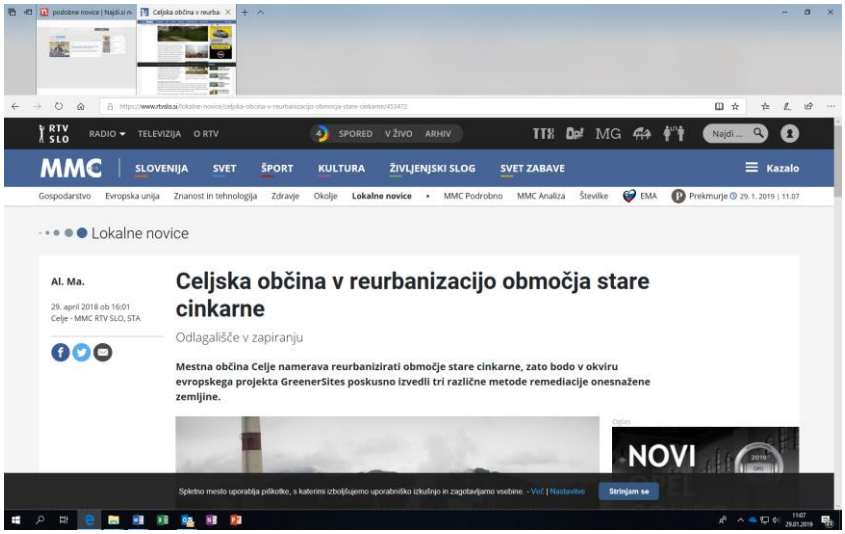
In PA we used green technologies to curb the negative impacts of human involvement. Successful implementation of this technologies also enables the reusage of degraded areas – expansion of urban environment in sustainable way (not using agricultural areas). The usage of secondary raw material (calcite ash, compost) is also encouraged with our tested methods, thus enabling a new, sustainable usage of waste.

This piloted area (Brownfield), which is being re-urbanized, re-utilizes the degraded area for new activities (construction of central operations), thus enabling the expanded cities in a sustainable way, because the abandoned area is revitalized again. With this, the city of Celje is cleaner ... (the pressure of construction in agricultural areas is reduced). With these pilot methods that have been tested and have proven effective in revitalizing the pilot area as well as wider on the FUA and other areas with a similar type of pollution, we encourage the reuse of secondary raw materials (calcite ash, compost).

13. Media coverage

In the time period between 19th of March 2018 and 22nd of January 2019, there were 32 press releases published in 19 different media, 5 reports published at the Municipality of Celje website and 3 press releases. There are all attached as annex in a single document. Some of the examples are:

13.1 National Television, RTV Slovenija



Available at: https://www.rtvslo.si/lokalne-novice/celjska-obcina-v-reurbanizacijo-obmocja-stare-cinkarne/453472 (29.4.)

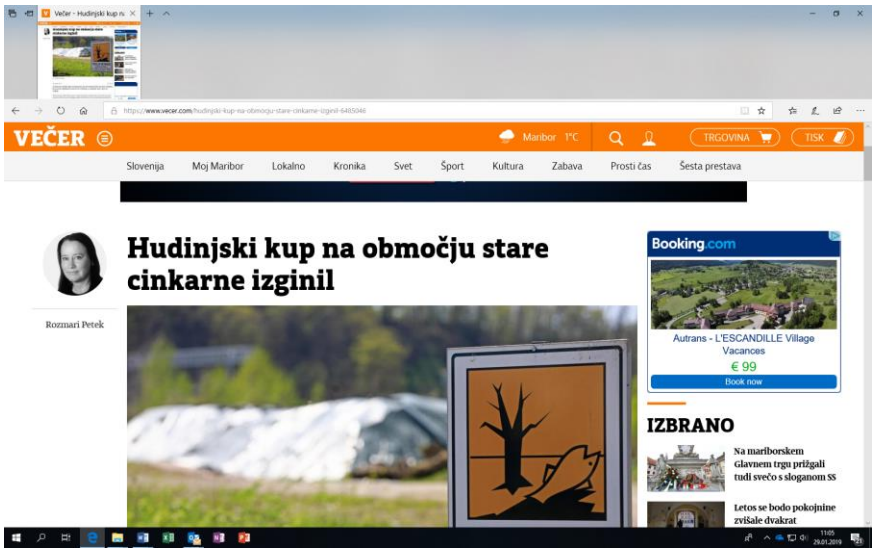
13.2 National television 24.ur

Available at: https://novice.svet24.si/clanek/novice/slovenija/5c17af2517c46/med-deli-so-naleteli-na-ekolosko-bombo (17.12.2018)

13.3 National Newspaper Dnevnik

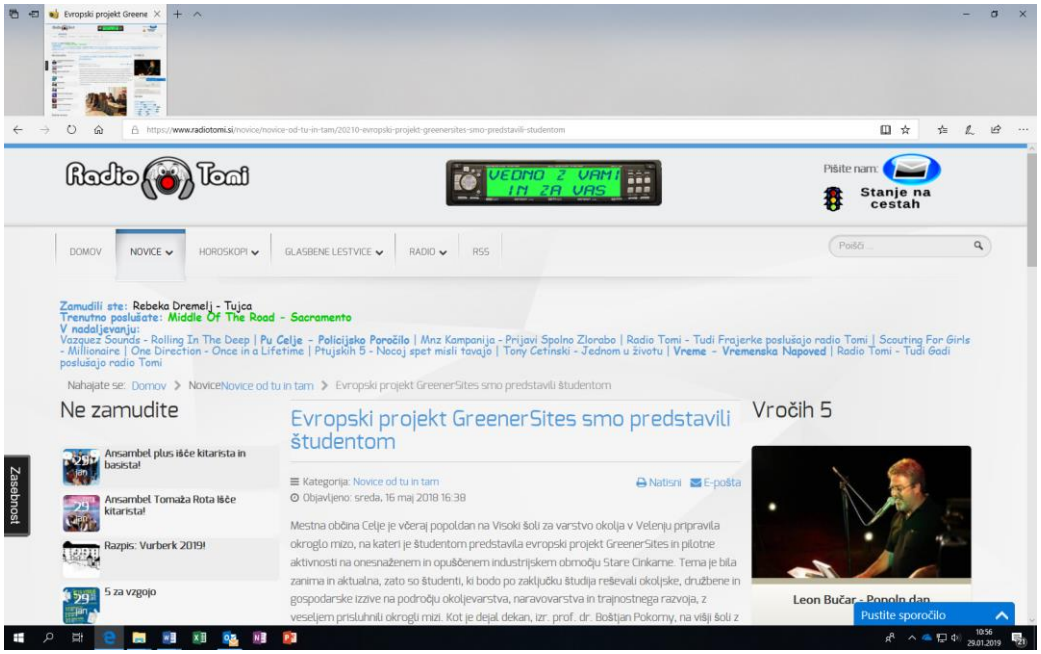
Available at: https://www.dnevnik.si/1042821098 (8.5.2018)

13.4 National Newspaper Večer

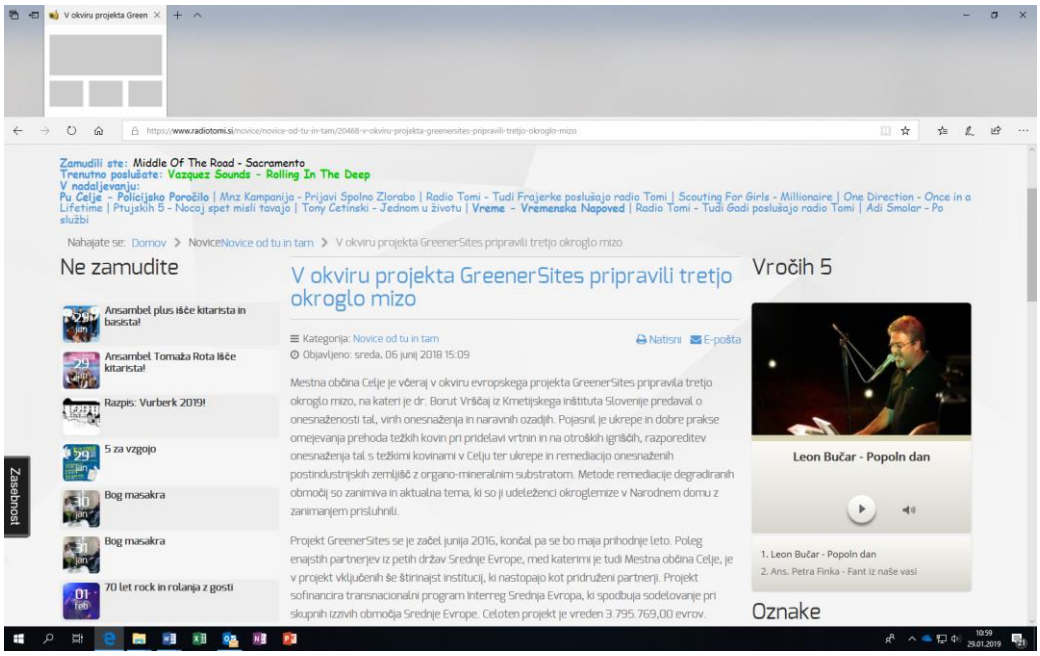


Available at: https://www.vecer.com/hudinjski-kup-na-obmocju-stare-cinkarne-izginil-6485046 (1.6.2018)

13.5 Local Radio Tomi



https://www.radiotomi.si/novice/novice-od-tu-in-tam/20210-evropski-projekt-greenersites-smo-predstavili-studentom (16.5.2018)

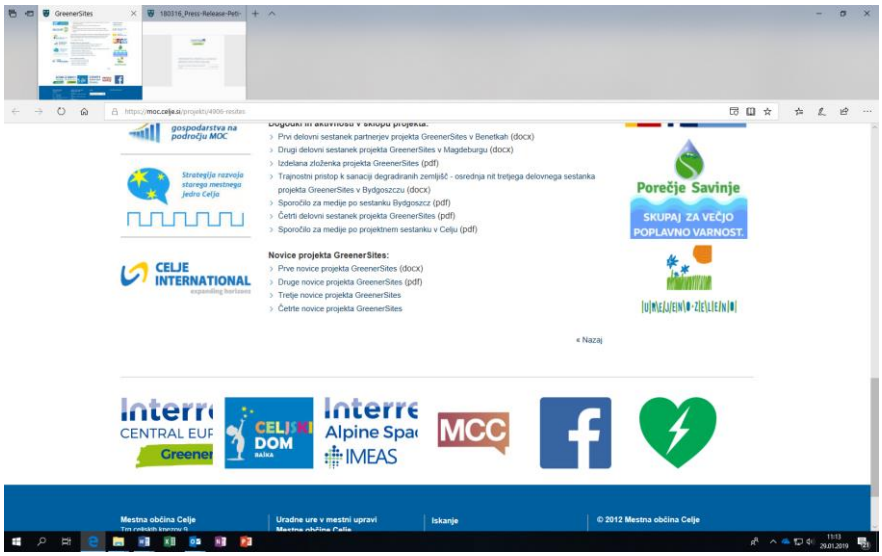


https://www.radiotomi.si/novice/novice-od-tu-in-tam/20468-v-okviru-projekta-greenersites-pripravili-tretjo-okroglo-mizo (6.6.2018)

13.3 Local Celje TV (21.6.)

A broadcast about the training of the relevant stakeholders in remediation.

13.4 Municipality of Celje website



https://moc.celje.si/projekti/4906-resites