Nanoremediation of water from small wastewater treatment plants and reuse of water and solid remains for local needs

RusaLCA

LAYMAN'S REPORT
LIFE12 ENV/SI/1000443

THE BISTRICA STREAM DURING A PERIOD OF DROUGHT

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Design: Poesis d.o.o.

Slovenian National Building and Civil Engineering Institute, September 2017

Project aims

More than 70% of the Earth's surface is covered by water, but only 3% of the total quantity of water is fresh. The following illustration can be made: if all the Earth's fresh water were to be contained in a container with a capacity of 1 litre, then the amount available to us would fill just a teaspoon. Climate change, which manifests itself also through water scarcity and ever more frequent and longer periods of drought, therefore requires changes in our way of thinking and in our behaviour, as individuals and society as a whole. Thus sustainable water management and greater efforts to reduce water demand by using renewable sources of water and effectively managing water are essential.

The solutions presented in this LIFE RusaLCA project represent an innovative, feasible, efficient, cost-effective, and timely adaptation to already present and expected future climate changes, of which drought and water scarcity are the most pronounced phenomena in Slovenia. Existing water management practices using small wastewater treatment plants (which, although the water is purified to some extent, do not return it to reuse) are unsatisfactory, as well as the use of drinking water for various other purposes (e.g. washing, watering, and sanitary water). The new approach will save drinking water, and make the management of existing resources easier.

A sustainable approach to the efficient use of water and the creation of a water-saving society was demonstrated within the scope of the project by means of a small wastewater treatment plant (SWTP), which is located in the municipality of Šentrupert, and was built in 2015 next to the Bistrica stream in the settlement of Poštaje. The wastewater, which is conventionally treated in this plant, is further purified, in a second stage, by an innovative remediation process using zero-valent iron nanoparticles, so that the processed water acquires the status of drinking water. However, this water is not actually intended for drinking, but for secondary purposes in households, and for common public needs. It is estimated that in this way the consumption of drinking water will decrease by about 30%. This will also reduce the cost of municipal services, and increase the economic efficiency of households and local communities.

The used zero-valent iron nanoparticles were very efficient in the cleaning of the water from the SWTP. During the purification process, several complex reactions take place, in which bacteria are destroyed and most other pollutants are degraded, or else the pollutants are adsorbed onto the formed iron oxides and hydroxides. The pollutants which are not degraded by nanoparticles are removed by means of a sand and activated charcoal filter and an ion exchanger.

The entire process does not in any way burden the environment with waste, since both the sludge from the purification process and the sediment from the remediation process are recycled, and then used in the civil engineering industry. This contributes to the conservation of natural resources due to the recycling of waste, which means that less waste is disposed of at landfill sites, and that a zero wastewater management system can be established.

One of the important goals of the project was to disseminate the acquired knowledge and good practice to both the professional and the lay public. The operational pilot wastewater management system with zero waste is a good example for other geographical areas with similar characteristics to follow.

Summary of the project

The LIFE RusaLCA project attempts to make a contribution to the mitigation of the problems caused by climate change, among which the lack of water and ever more frequent and longer periods of drought have been frequently experienced in the south-eastern part of Europe, as well as in many other areas worldwide. The project's main aim was to find a way in which the consumption of drinking water from natural sources could be reduced by 30 %, by means of an innovative technology for the improved purification and therefore possible reuse of municipal wastewater.

The proposed technology was first optimized at the laboratory level, by combining together conventional purification methods and the use of zero-valent iron nanoparticles. It was successfully brought into practice by the construction of a pilot wastewater remediation system, which is located in the municipality of Šentrupert in Dolenjska, in the southeastern part of Slovenia. This system enables the further purification of municipal wastewater, first treated in a small wastewater treatment plant, to such a degree that it is suitable for people's secondary water consumption needs (apart from drinking water), i.e. for the watering of gardens and vegetable gardens, for the washing down of roads and of cars, for the needs of fire-fighters, and for local industry.

Within the framework of the project the organic sludge which is created during biological treatment in the small wastewater treatment plant was used, with the addition of recycled paper ash, in the production of geotechnical composites. Additionally, the sediment from the nanomediation process was recycled for use in the production of concrete. A zero-waste management system for municipal wastewater (i.e. a protocol) was developed, which takes into account the requirements of the corresponding national and European legislation.

Analyses of data obtained in the water purification process regarding the reuse of water and the proposed zero-waste wastewater management system were performed by means of Life Cycle Analysis models. The results of these calculations confirmed the environmental benefits of these two approaches. By means of the additional purification and reuse of water, a reduction in eutrophication was achieved, as well as an improvement in the ecological status of surface waters and the preservation of natural sources of drinking water. Through the described recycling of waste, environ-

mental pollution due to landfilling was reduced, and a contribution to the conservation of natural raw materials was made.

The knowledge and experience obtained in the course of the LIFE RusaLCA project was successfully disseminated at the local, regional and international level. Four public presentations (one of which was at the international level) were organized by the project consortium, as well as similarly organized lectures for students from five university faculties.

The results of the project have been presented at several scientific conferences and in high-grade technical journals, as well as in the daily press and non-technical journals. They even became the inspiration for an art project that was conducted by students at the Department of Textiles, Graphic Arts and Design at the Faculty of Natural Sciences and Engineering of the University of Ljubljana, where, as in the project, attempts were made to convince the general public about the importance of the implementation of responsible and sustainable water management.

Reduction of water consumption

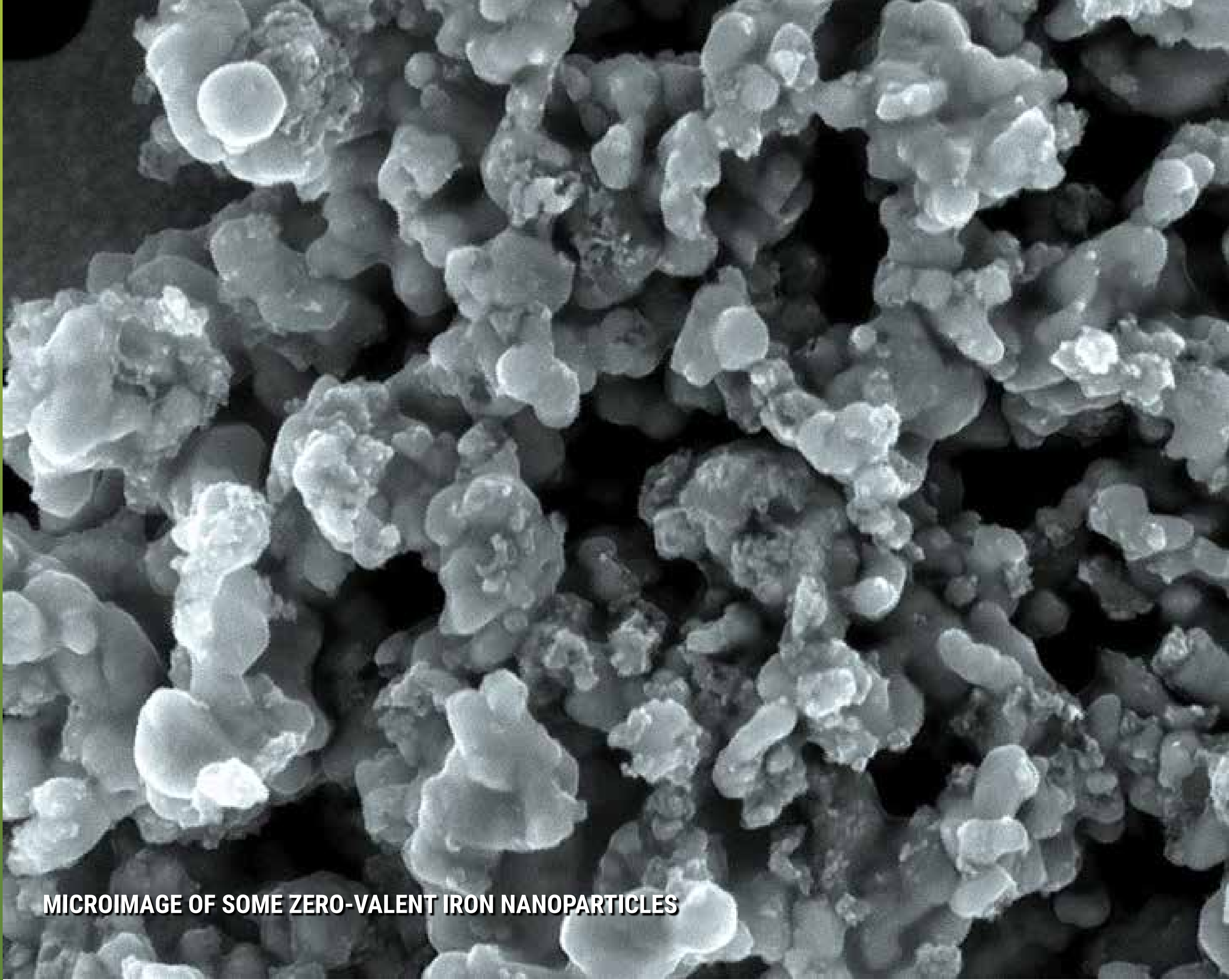
The main aim of the project, which was to reduce the consumption of drinking water by 30% in the studied village of Poštaje, was achieved through the development and application of an innovative remediation process using zero-valent iron nanoparticles, so that 480 m^3 of municipal wastewater was purified to a level which made it suitable for reuse. This water was then used in the village for purposes where drinking water quality was not needed, thus reducing the consumption of water obtained from natural sources.

Recycling of organic sludge and of sediment from the nanoremediation process

The sludge from the small wastewater treatment plant at Poštaje was treated and successfully used, with the addition of paper ash, as a recycled material for geotechnical composites which conform to environmental standards for use in the construction of embankments or as fill. The sediment of spent iron particles from the nanoremediation process was recycled for use in the production of concrete, which, due to its light-brown shade of colour, has additional architectural potential. In this way a zero-waste management system for municipal wastewater was established.

Dissemination of knowledge

Numerous new skills and valuable experience from the LIFE RusaLCA project were disseminated at four public presentations (including one at the international level) which were organized by the project consortium, as well as at similarly organized lectures for students at the national and international level. The results of the project have been presented at scientific conferences and in high-grade technical journals, as well as in the daily press and non-technical journals.



MICROIMAGE OF SOME ZERO-VALENT IRON NANOPARTICLES

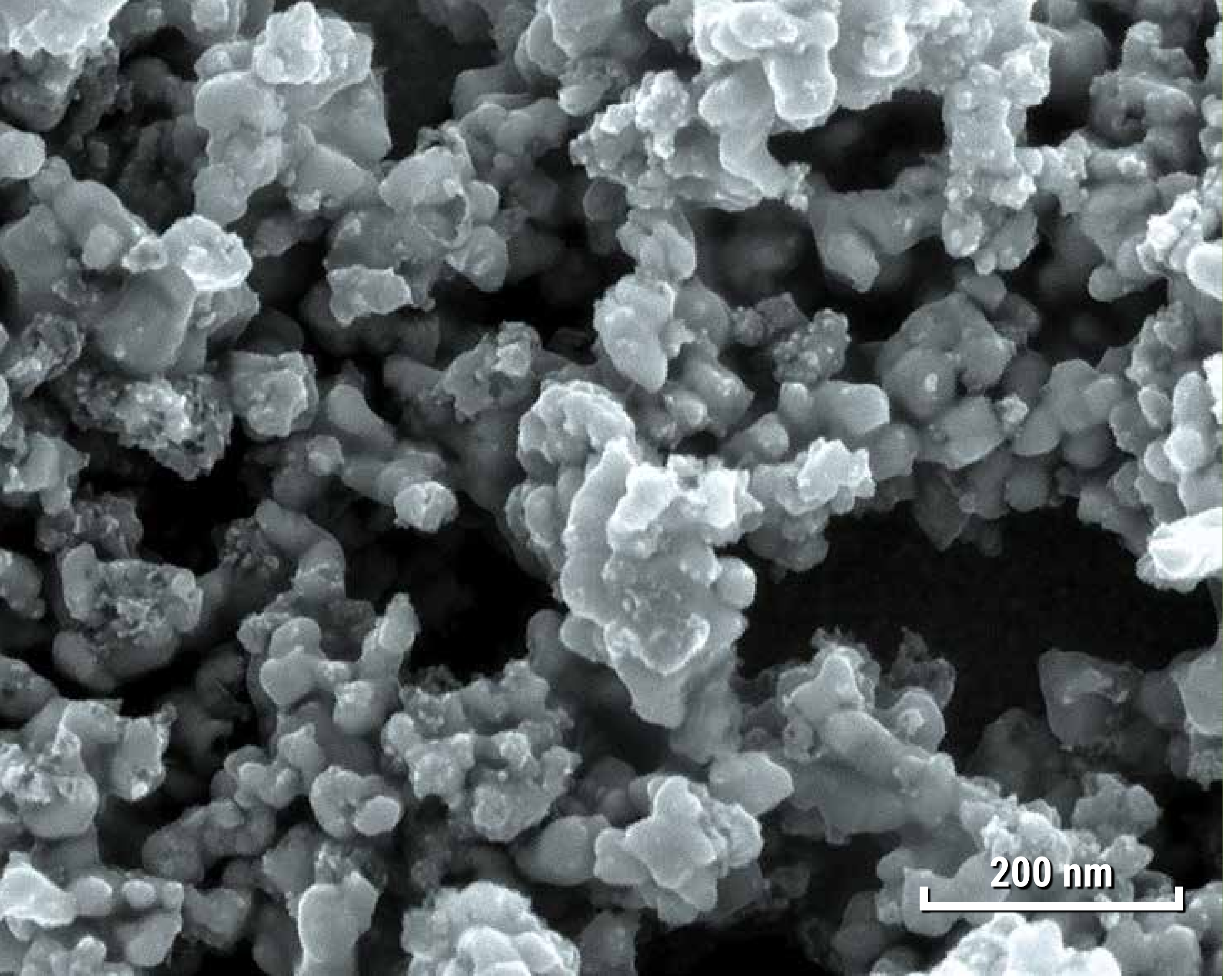
Initial study

The study provides valuable insight into the condition of water environments and wastewater management. Available data show that the negative consequences of climate change and of the non-sustainable management of water resources are already being felt in Slovenia. This is mainly reflected in the worsening of the ecological state of surface waters, the lowering of the level of underground aquifers, and water-supply problems due to more and more frequent and longer periods of drought. Due to Slovenia's dispersed settlements and diverse topography, the construction of wastewater treatment systems is limited. Thus, the use of small wastewater treatment plants, together with corresponding local sewage systems, is the only feasible solution.

As part of the study, the current legislation in the field of the construction and use of small wastewater treatment plants was carefully examined, since such plants can be upgraded by means of a pilot remediation system, such as that presented in the LIFE RusaLCA project. This system is based on the use of zero-valent iron nanoparticles, which can be used to purify water from the outlets of small wastewater treatment plants so that it can be reused by local inhabitants and small businesses (SME). For this reason the properties of such nanoparticles were studied in detail, in order to confirm their effectiveness in the removing of pollutants from water.

In the process of water treatment, the generation of waste, mostly in the form of organic sludge, cannot be avoided. The latter can, however, be removed by licensed companies for further processing. Since the aim of the project was to develop a zero-waste management system, various possibilities for the recycling of such sludge from the small wastewater treatment plant, as well as of the sediment from the nanoremediation process, for the needs of the civil engineering industry, were investigated.

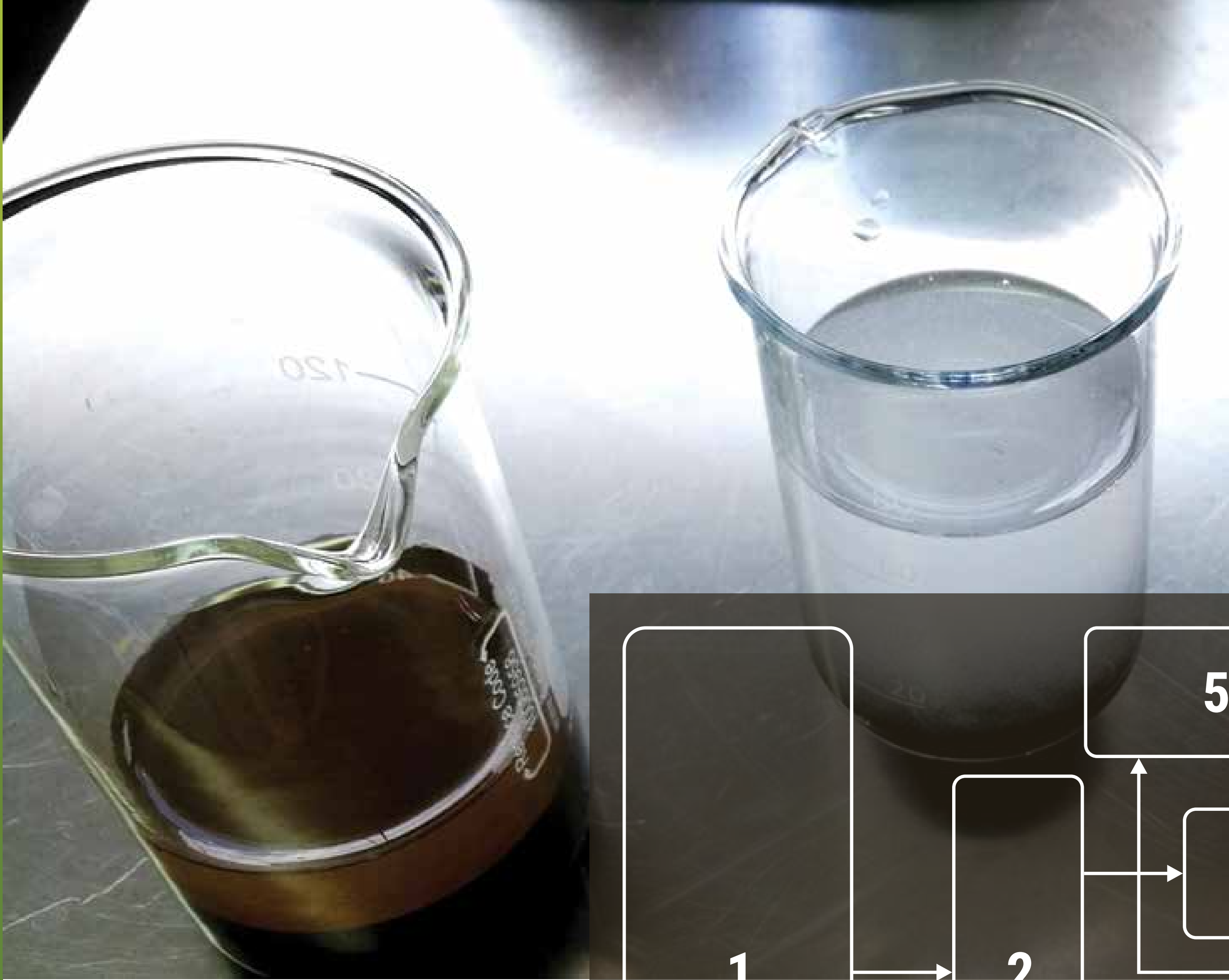
The study was concluded by life cycle assessments of the pilot remediation system and the proposed zero-waste management system. Preliminary results have shown positive effects on a number of environmental indicators, such as reduced a carbon footprint, reduced acidification, eutrophication and toxicity, and the conservation of natural resources due to the recycling of waste.



The process parameters and optimization of the nanoremediation

In small wastewater treatment plants, municipal wastewater is first cleaned by means of biological processes, which remove most of the toxic nitrogen compounds and nutrients. Such treated water is then suitable for discharge into the natural environment, but it cannot be reused since it still contains many hazardous microorganisms, organic pollutants, and potentially toxic elements. More efficient water purification solutions are provided by nanotechnology, which is a rapidly developing science and industry, and in particular by zero-valent iron nanoparticles. Such nanoparticles are very effective in the disinfection of water, and in the removal of potentially toxic elements and organic pollutants. However, for the successful transfer of knowledge from the laboratory to practical use, the process parameters need to be optimized.

In the LIFE RusaLCA project, more than 120 laboratory experiments and simulations were performed in order to optimize the pilot remediation system, based on the use of zero-valent iron nanoparticles, and thus bring it to a higher level of technology readiness. The most suitable nanoparticles were selected, based on their optimal concentration, the optimal length of time needed to mix the water with them, and the optimal duration of the settling period of the spent iron particles. Under such conditions, nanoparticles were able to remove 99% of hazardous bacteria, thus reducing the concentrations of potentially toxic elements below the limit values for drinking water, and degrading the majority of organic pollutants. In order to achieve the best quality of water, the remediation system was upgraded with an additional oxidation process, filtration using a sand and activated carbon filter, and an ion exchanger. In this way drinking water quality was achieved. The optimized process parameters, within the scope of a multi-stage purification process, were then used in the design and real-case use of the pilot remediation system for municipal wastewater.



Planning and construction of the pilot municipal wastewater remediation system

The pilot system for the remediation of municipal wastewater, which is coupled to a small wastewater treatment plant (SWTP) of the moving bed biofilm reactor type, for 100 population equivalents, was constructed in March 2015. It is located in the Municipality of Šentrupert, at the village of Poštaje, on the left bank of the Bistrica stream. The village consists of houses and their associated farm buildings, as well as some small businesses (SME), from which the wastewater is drained into the SWTP. When planning the pilot system, the corresponding annual water meter readings were made available by the manager of the water supply system, the Municipal Public Services of Trebnje.

In accordance with present legislation in the Republic of Slovenia, it was necessary to obtain a building permit for the construction of the SWTP and the pilot remediation system next to it. This permit was issued by the Trebnje Administrative Unit in April 2014. The project which was submitted in order to obtain a building permit contained the following plans: a lead folder which dealt with the spatial location of the building together with all the necessary consents, outline plans of the proposed building structures, and a plan of the electrical installations.

The pilot wastewater remediation system is a device which purifies the water from the SWTP outflow by means of the batch mode. Zero-valent iron nanoparticles are used, in combination with other conventional purification methods, for the preparation of water of drinking water quality. In this process, the partly purified water is first pumped from the intermediate tank to the nanoremediation tank, and then to the oxidation tank. From the oxidation stage, the water is then pumped through a sand and activated carbon filtration system and an ion exchanger, which are located in an above-ground building. The purified water is temporarily stored in a storage tank with a volume of 40 m^3. All these tanks are made of glass-fibre reinforced plastic, and

Pilot system for remediation of municipal wastewater within the scope of the LIFE RusaLCA project

1. Small wastewater treatment plant
2. Intermediate tank for partly purified water
3. Nanoremediation tanks
4. Dosing system for nanoparticles
5. Oxidation tank
6. Dosing system for oxidant
7. Sand and activated carbon filtration system, ion exchanger
8. Storage tank for purified water
9. Pump for purified water
10. Tap for purified water distribution
11. Underground tank for sediment from the nanoremediation process

are installed underground. The whole system of pumps and blenders is controlled electronically. Both the suspension of nanoparticles and the oxidant are dosed automatically during the purification process, from a refrigerator. The removal of the suspension of spent nanoparticles is also performed automatically, and the waste sediment is stored temporarily in an on-site underground tank made of concrete.

The filtration system, the electronic components, and the refrigerator with its stock of nanoparticles and oxidants are all located in the above-ground timber-framed and heat-insulated building. The whole pilot system is enclosed by a wire fence and decorative shrubs, which prevent the access of unauthorized persons. The ground surfaces are covered by grass, and there are sand-covered paths leading to the individual tanks. For the distribution of purified water, a basin and tap with a water consumption meter has been installed outside the fenced-off area. There is a parking space next to the tap.

Whenever the pilot remediation system is working, monitoring of the cleaning processes and replenishing of the stock of nanoparticles and oxidant is carried out once a week. In the event of the occurrence of any fault, the system stops automatically, and reports such a failure to the manager. All the important parameters, such as the duration of the processes, the quantity of pumped water, and the quantity of added nanoparticles or oxidant, can be adjusted as and when necessary.

Monitoring and optimization of the pilot remediation system

The cleaning of wastewater in small wastewater treatment plants is a biological process that is subject to the influence of many different environmental factors. In particular, weather conditions and the habits of all local inhabitants can significantly affect the quality of the water at the outflow from such plants. Regular monitoring of the parameters of the water at the outflow, which was performed within the scope of the project, showed that informing of people about “what can and what mustn’t go down the drain into the sewage system”, is very important for the proper operation of small wastewater treatment plants. This is also crucial for the implementation of additional purification of municipal wastewater using the LIFE RusaLCA project’s pilot remediation system, which is connected directly to the SWTP. During the system’s operation, only small corrections of the laboratory-determined parameters for the purification process were needed in order to achieve the desired quality of purified water. By monitoring these parameters after each stage of the purification, it was possible to perform some additional improvements to the pilot remediation system.

Research conducted by the Jožef Stefan Institute showed that the use of nanoparticles for water purification does not pose any hazard to humans or to the environment, since after use they are transformed into inert iron compounds in the form of particles with larger dimensions. The results of the analyses carried out by the National Laboratory of Health, Environment and Food, showed that the purified water met the strictest chemical and microbiological limit values for the watering of vegetable gardens. The purified water in fact achieves the quality of drinking water, but nevertheless it will be used to satisfy people’s secondary water consumption needs. The National Laboratory of Health, Environment and Food also performs periodical monitoring of the purified water so that the safety of water users is ensured. The operation of the pilot remediation system is supervised by qualified managers employed by the Public Municipal Services of Trebnje, who check the proper functioning of the cleaning processes on a daily basis.

Recycling and beneficial use of organic sludge and sediment

The municipal wastewater first arrives at the small wastewater treatment plant, where it is purified to such a degree that it can be released into the environment. During this treatment, organic sludge occurs as the first type of waste. The second step of the procedure is an innovative nanoremediation process, where the water is further treated with zero-valent iron nanoparticles. In this process, a second type of waste is produced, i.e. sediment consisting of spent iron particles. These two types of waste have dissimilar properties, and occur in different quantities, so that they have to be used in different composites.

The organic sludge obtained from the small wastewater treatment plant is first processed at the main wastewater treatment plant, which is located in Trebnje. It is then converted into a construction product. All the components are mixed together mechanically with paper sludge ash (produced at VIPAP VIDEM KRŠKO) into a composite which can be used, at sites for the disposal of non-hazardous waste, for the installation of impermeable sealing layers, as well as for the construction of handling and service areas, and of transportation routes.

Because of its properties, the best way to recycle the sediment from the nanoremediation tank is to use it in the production of concrete, which can be used locally. Since the sediment contains a considerable amount of water, less mixing water needs to be added to the concrete, whereas the iron nanoparticles are able to replace part of the fine-grained natural aggregate. Because of the presence of iron, the concrete has a light-brown colour. It can also meet more demanding conditions for use, such as in the preparation of structural concrete which may be exposed to freezing and thawing conditions.

Within the scope of the LIFE RusaLCA project it was shown that both the organic sludge and the sediment resulting from the treatment of municipal wastewater at small wastewater treatment plants can be beneficially recycled, so that it would be possible to introduce a system in which municipal wastewater could be treated without leaving any solid waste.

PILOT SYSTEM FOR THE REMEDIATION OF MUNICIPAL WASTEWATER

Effects of the project

Within the scope of the LIFE RusaLCA project, the environmental aspects of additional water purification at a small wastewater treatment plant (SWTP) were analysed by means of the Life Cycle Assessment method. The discussed remediation took place at the pilot SWTP. The purification of municipal waste water, to the extent that it can be reused for various secondary purposes, is associated with certain environmental benefits. Since the outflow into surface streams of only partially purified water is prevented, the quality of the surface waters improves, with a consequent simultaneous improvement in the conditions of the aquatic ecosystem.

The reuse of purified water also reduces the consumption of groundwater resources. By means of Life Cycle Assessments (LCA) it was confirmed that additional purification of municipal wastewater significantly reduces surface water eutrophication. By reducing the outflow from the small wastewater treatment plant to surface streams (the emissions were considered as a chemical need for oxygen and biochemical oxygen demand), the impact of the treatment plant on eutrophication was reduced by 20%. The main benefit of the additional purification was the protection of surface and groundwater reserves.

Another important part of the project was the recycling of organic sludge obtained after the biological treatment of the wastewater had taken place at the small wastewater treatment plant, and of sediment from the nano-remediation tank. The first type of waste, i.e. organic sludge, can be used as a raw material for the production of geotechnical composites, whereas the second type of waste, i.e. sediment, can be used as a raw material in the production of concrete. The environmental benefits of such uses are linked to the conservation of natural, i.e. mineral resources, whereas, at the same time, disposal and/or incineration of this “waste” become unnecessary. The latter two waste treatment methods are associated with considerable environmental burdens.

The organic sludge generated during the biological phase of the waste water treatment was used as a raw material for the production of geotechnical composites, which can be used to construct impermeable layers for the sealing of landfill sites for non-hazardous waste, as well as for the handling and service areas of such sites. By using such composites, it is possible to avoid the use of a natural mineral material, i.e. clay, which is commonly used to construct such impermeable layers. The proposed procedure of sludge management shows

only small environmental burdens. However, in comparison with the incineration of sludge, which is the most commonly used practice in Slovenia, greenhouse gas emissions are reduced by a factor of 170, the effect on eutrophication by a factor of 90, and the effect on acidification by a factor of 20.

The sediment from the nanoremediation tank was used as a raw material in concrete. In this way, the beneficial use of waste was achieved. As well as this, part of the mixing water was saved in the concrete plant during the production of concrete, which also represented an economic saving.

The treatment of the organic sludge generated during the biological process of wastewater treatment, and of sediment from the nanoremediation, is therefore optimized to the extent that it presents neither an environmental nor a financial burden. All other, more usual procedures for sludge management (incineration, use in a biogas plant, disposal) would be less favourable from the financial point of view. In the latter case the majority of the costs are related to the charges for the removing of this waste. It is estimated that sludge incineration would be about fifty times more expensive than the use of sludge for the production of a geotechnical composite.

The project included interviews with various stakeholders, i.e. with the representatives of the local community, water users, value chains, and employees, in order to determine the social impacts and aspects of the constructed pilot remediation plant and of the innovative technology for municipal water remediation. These analyses were performed according to the recommendations of the United Nations Environment Program, after a social analysis of the effect of the construction of the treatment plant had been organized. The results of the analyses confirmed the hypothesis that the social acceptance (or so-called social license) of new innovative technologies is essential for their optimal use in the field of municipal wastewater treatment for local communities.

PARTICIPANTS OF THE INTERNATIONAL CONFERENCE LIFE RUSALCA

Feasibility study for the transfer of the innovative technology

A feasibility study was also performed in order to examine the further purification of water from small wastewater treatment plants by means of the innovative technology developed within the scope of the LIFE RusaLCA project. This included the reuse of the obtained purified water, and the beneficial recycling of organic sludge and sediment resulting from the purification process. When compared to large sewage treatment plants, small wastewater treatment plants are the best solution for south-eastern Slovenia, which is statistically the latter's largest region. On the one hand it has a characteristically varied terrain, with a Dinaric-Karstic landscape and a lot of woodland areas, whereas on the other hand there is an inadequate communal infrastructure, and some parts of it are practically cut off from main traffic routes. For the transfer or replication of the proposed wastewater remediation system it is important to have available data about the geographical situation and predominant use of the soil, as well as about the population, and about the region's geological and hydrogeological structure, together with information about the current legislative framework and investment possibilities.

The results of the performed feasibility study showed that there is a great potential for the use of purified water for the irrigation of farmland, as well as of gardens and vegetable gardens. This is particularly important in light of the increased fluctuations of temperatures, and the longer and ever more frequent periods of drought, which have been observed in recent years. For instance, 2017 was the third warmest year in the history of weather records in Slovenia, with heat waves lasting up to 8 days, the largest temperature changes being characteristic for south-eastern Europe and Slovenia. In this region recycled organic sludge from such small wastewater treatment plants, as well as sediment, could be beneficially used since enough consumers of such secondary raw materials live here.

In the final part of the study, a comparison was made between currently available systems for municipal wastewater treatment and the LIFE RusALCA pilot system for the remediation of water, organic sludge, and sediment, particularly in terms of their corresponding environmental impacts. A comparison of these systems with regard to the sociological and economic impacts which they have on the local community was also performed.

Communication and dissemination

Communication activities included a wide range of goals and target groups and formed an important part of the project. They have a particularly important role with regard to contacts with the local community, who are direct users of water from the wastewater treatment plant, as well as other people who live in the area affected by the treatment plant. In the first phase of such communications, we explained the operation of the treatment plant to them, and tried to inform them about the importance of protecting natural resources. Local community support and understanding of the project's objectives proved to be one of the key elements of success in this field.

There were also numerous intensive communication activities between the partners of the project and the professional public about the organization of conferences which were held in Šentrupert and Ljubljana, with international participation, in order to exchange experience and acquire new knowledge. Within this context more than forty technical papers and non-technical contributions was published in technical publications and in the national and local media.

One of the main hubs of the project for the target public has been the website **www.rusalca.si**, which contains all information about the project, as well as practical guidelines for the local inhabitants. For information distribution purposes a series of leaflets, posters and other related matter was prepared in order to promote the visibility of the project within the community, as well as in Slovenia as a whole.

USE OF PURIFIED WATER FOR THE WATERING OF A VEGETABLE GARDEN

Consumption of purified water

The saving of drinking water from natural resources was a key objective of the RusaLCA project, which thus made a not to be underestimated contribution to our adaptation to climate changes, which are characterized by ever more frequent and longer periods of drought. For this purpose, in the LIFE RusaLCA project a total of 480 m^3 of municipal wastewater was purified by means of advanced purification procedures to such a degree that this water was suitable for people's secondary water consumption needs, e.g. the watering of gardens and vegetable gardens, the washing down of roads and the washing of cars, and, in one case, for the needs of local industry. The amount of purified and used water represents 30% of all the drinking water needs of the inhabitants of the village of Poštaje, for a period of half a year.

Within the scope of the project, a total of 25 plastic storage containers, each with a capacity of 1000 litres, were distributed to the inhabitants of the village of Poštaje for the temporary storage of purified water. Filling of the containers was performed by the Municipal Public Services of Trebnje. The villagers were able to use this water for the irrigation of their gardens and vegetable gardens, as well as grassed areas. It was also available at a tap to other citizens. The purified water was also made available to local industry. In the company TIMS LOVŠE, d.o.o., which is located in the immediate vicinity of the pilot remediation system, part of the municipal water supply of drinking water was successfully replaced by the purified water obtained from the LIFE RusaLCA project. For this purpose, in co-operation with the staff of the nearby concrete production plant, a secondary water supply pipeline was constructed, having a length of approximately 80 metres, measured from the underground tank for purified water to the place of consumption. A pump for the automatic pumping of purified water was installed inside this tank. The pumped water was used for the production of concrete, for the curing of prefabricated concrete products during their drying, and for the washing of the plant's machinery. Interestingly, the company is engaged in the production of small wastewater treatment plants, so it could be said that new such plants are created there with purified water from a similar treatment plant. In this way local industry was able to reduce the possibility of stoppages in production due to possible reductions in water supply, so that water resources are more efficiently used, and that the concrete production plant itself becomes independent of changing climatic conditions.

Use of sediment

Concrete made without sediment (in the middle), and concrete made with sediment (left: sediment content of 12.1 kg/m^3, right: sediment content of 0.5 kg/m^3).

Project partners

The project consortium consisted of a total of seven partners, whose talents and expertise complement each other. The project coordinator was the Slovenian National Building and Civil Engineering Institute (ZAG), which was involved in all the activities. The Jožef Stefan Institute led the experimental development of the remediation technology. The acquired knowledge was successfully transferred from the laboratory to practical use through a pilot municipal wastewater remediation system that was designed by Esplanada. The Municipality of Šentrupert supplied all the necessary technical and administrative documentation, as well as part of the funds for the construction, and continues to finance the further operation of the pilot remediation system. In parallel with the work on water remediation a zero-waste management system for municipal wastewater was developed by Structum, PKG, and ZAG. NZHOL, Slovenia's National Laboratory of Health, Environment and Food, monitored the quality of the analysed purified water, in order to confirm the effectiveness of the remediation process, thus ensuring the safety of water users.

www.zag.si

ZAG
ZAVOD ZA GRADBENIŠTVO SLOVENIJE

The Slovenian National Building and Civil Engineering Institute (ZAG) is a public research institute and Slovenia's leading authority in the field of construction. Its top-level team of experts provides the construction industry with comprehensive scientific and technical support. ZAG's three key activities are: scientific research work, quality control, and consulting, and other expert activities. In recent years ZAG has helped to shape the European landscape of construction, and continues to be actively involved in many Slovenian and international research projects.

www.ijs.si

IJS

The Jožef Stefan Institute is the leading Slovenian research organisation. It is responsible for a broad spectrum of basic and applied research in the fields of the natural sciences and technology, as well as the life sciences. The institute's staff perform research in the fields of physics, chemistry, nanotechnologies, new materials, biotechnologies, management and production, electronics and information sciences, environmental sciences, and nuclear technology. More than 200 of the institute's employees are involved in the educational process at different universities.

www.sentrupert.si

The Municipality of Šentrupert lies in the middle of the Dolenjska region (also known as Lower Carniola), in the Mirna Valley. The Šentrupert micro-region is located at the transition from the Mirna-Mokronog plain to the Posavje hills. It has an area of 42 km², and about 2,400 inhabitants live in closely-built settlements along the edge of the plain, and in the nearby sparsely-populated and partly-forested hilly areas nearby. The municipality is well-known for its unique museum of hay racks, and for the first low-energy kindergarten in Slovenia, built entirely of wood. It has been involved in many successful projects.

www.esplanada.si

ESPLANADA

Esplanada brings together successful, innovative and highly-motivated people, who are able to satisfy the needs of even the most demanding clients. The company is focused on the production of high-quality, interesting and modern architectural solutions, envisages becoming the leading creator of modern architecture in the Dolenjska region, and throughout Slovenia, as well as achieving the same high level of quality as that of Europe's leading architectural design offices.

www.structum.si

Structum
Inštitut za gradbenišvo d.o.o.

Structum is a research and development company, which operates in the field of building materials and civil engineering both in Slovenia and other countries. The company's main goal is to transfer theoretical knowledge into practical applications, particularly when new building projects are involved. The company is specialised in the preparation of new innovative types of asphalt mixtures, concrete mixtures, and soil stabilizing products, and in the case of the use of recycled materials made from industrial waste, it tries to achieve better performance and higher quality of the final product.

www.nlzoh.si

NACIONALNI LABORATORIJ ZA ZDRAVJE, OKOLJE IN HRANO

NLZOH, the National Laboratory of Health, Environment and Food, is Slovenia's most important public health laboratory. It is concerned with hygiene and health-orientated / ecological activities, with environmental protection issues, and with microbiological and other research work, and performs all kinds of chemical analyses of different samples. In cooperation with other institutions, NLZOH participates in national and international research, as well as in applicative and consulting projects.

PKG

PKG provides the comprehensive professional and administrative waste management services which are needed in the field of the processing and reuse of waste materials, mostly with respect to the execution of construction works, particularly those aimed at improving safety against floods, and to the rehabilitation of degraded areas and other landscaping works.

Project information

Co-financing by the European Commission
Program LIFE+ (LIFE12 ENV/SI/1000443)
Duration: 1.7.2013 - 31.12.2016
Costs of the project: 852.388,00 EUR
Co-financing: 50 % (426.192,00 EUR)

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