COOP-CT-2004-508698

PURILEACH

Modular purification system for heavily polluted leachate

Co-operative Research Project
Thematic Priority 6: Sustainable Development, Global Change and Ecosystems

D8.3

Publishable final activity report

Period covered**:**	**from 1st February 2005 to 31st January 2006**
Date of preparation:	**4th April 2005**
Start date of project:	**1st February 2005**
Duration:	**24 months**
Project coordinator name:	**Mr. Claudio Fernández Acevedo**

Project coordinator organization name: **L'Urederra Fundación para el Desarrollo Tecnológico y Social**

Table of content

1. Project execution

Modular Purification System for heavily polluted leachate

PURILEACH

Contract number: COOP-CT-2004-508698

Start date: 01/02/2005

Duration: 24 months

Total Project Costs: 763.768,00 €

EC contribution: 412.117,00 €

European countries use landfill as a disposal method for 60% of their municipal and hazardous waste. One of the main problems associated with landfills is leakage of potentially toxic liquids into soil and groundwater. Biological and chemical wastewater treatment units separately do not achieve high removal efficiency - microbial population is not able to survive in such contaminated environment. There is a need to develop new effective and inexpensive method, based on both microbial and non-microbial leverage and find the way for safe and efficient landfills' water treatment in accordance with EC Landfill Directive.

The leachate is generated in the result of the aerobic and anaerobic decomposition of the landfill waste. Treatment of leachate is a complex task due to its nature. A typical leachate is highly contaminated with ammonia, organic contaminants, halogenated hydrocarbons and heavy metals, also with high concentrations of inorganic salts. This wastewater profile is changing from landfill to landfill as well as with time within the same landfill. The key factors that must be considered and influence treatment facilities design include leachate character and loads, costs and effluent discharge regulations. Research is designed to evaluate optimal leachate treatment technology based on a modular solution and to develop an integral operational system for wastewater analysis and feedback for working regimes optimisation.

The PURILEACH project intends to develop flexible modular approach with “smart” feedback for selection of treatment regimes relevant for processing of the varying in composition wastewater. The on-site adaptive leachate treatment system consists of the specific technological modules with integrated operational system for regime optimisation according wastewater composition and quantity. The envisaged “on-line” system design is based on decision-table and expert systems techniques for knowledge processing.

Strategic project objectives:

- Introduction an adaptable modular leachate treatment system into the European market within 3-3.5 years including:
  - 10% of the European landfill leachate treatment market within 5 years.
- Reduction in leachate treatment costs by ca 50% in material costs where PURILEACH technology is employed (on-line control and dynamic optimisation of technological regimes).
- Reduction in treatment facility engineering and installation costs by ca 50% in labour costs for specialised adjustment to site where PURILEACH technology is employed.
- Increase SMEs manufacturers' competitiveness by reducing the cost of treatment plants manufacture by PURILEACH technology allowed non-specialized production.

Main project objectives:

Objective	Milestone/Deliverable	Month for delivery
To develop the adaptive modular and adaptive technology for leachate treatment with integrated operational system for regime optimization.	Leachate composition and treatment processes parameters defined.	4
	Technical modules specifications complete.	12
	Operation control system developed.	12
	Completion of prototype of modular leachate treatment system.	16
To assemble complete leachate treatment system and install it onsite; Prepare conditions for PURILEACH introduction to market.	Economics evaluation performed.	16
	Treatment system installed on-site.	18
	System performance monitored and evaluated.	24
	Plan for use and dissemination of knowledge in place.	24
	Future exploitation plans established.	24
	Web site and other dissemination materials prepared	24

Project consortium:

Organisation Name	Role in PURILEACH
Coordinator: **Fundación L'Urederra** (ES) http://www.lurederra.es/ **Area of Business Activity** The main RTD fields are waste management (reduction, recovery, recycling and reuse) and machinery development, manufacturing and material technologies.	RTD partner: Project Coordinator, WP-leader in WP1 and WP9 (Project management). The main actions carried out by LUREDERRA during the second reporting period were research activities under WP6, WP7 and technical, administrative and financial project management: • Research activities: - Statistical data of contaminants composition; - Samples collection and analysis; - Analysis of data; - Comparison of data of leachate characterisation; - Analysis of data of COD removal; - Analysis of results to gain knowledge for definition of optimal leachate treatment. These actions implied to get the following progresses towards objectives and achievements: - Collection of statistical data of contaminants composition and percentage; - Pollutants analysis and quantity statistics turned to a range for each parameter studied; - Recommended input value for each parameter; - Recommended output value for each parameter; - Prior proposed treatment; - Modular design specification, input and output parameters have been compared with preliminary characterisation; - Laboratory evaluation of the new modular system treatment designed; - After receiving the relevant information from BIOCENTRAS, LUREDERRA proceeded to evaluate two possibilities of treatment in comparison with the developed technology. The major conclusion of the evaluation that LUREDERRA has made of the system is that it is really important and successful the purification achieved with the system developed according to the total costs of the system, overall considering the low maintenance costs; - Preparation of recommendations for further improvements; - Dissemination activities; - Preparation of exploitation plan an assessment of IPR. • Technical management: - The main activity was coordinating the WP4 through the responsible RTD partner BIOCENTRAS, the information flow (mainly exchange of e-mails) between co-ordinator and the WP co-workers was performed at least on weekly basis or more frequently if any issue needed to be solved; - The development deliverable D4.1 – Modular system prototype with integrated operational system – was behind schedule in two months (due to late delivery of Westfalia decanter), also influencing other two deliverables (D4.2 and D4.3) although, this issue was solved and project R&D tasks are back to the schedule; - The coordination of testing of the developed system for achievement of

Organisation Name	Role in PURILEACH
	wide range of adaptability results. • Administrative management: - The activities were mainly carried out for preparation of the 12 month, 18 month 24 month and final reports, i.e. gathering financial statements from partners, consulting on reporting issues. The day to day communication among partners was based on e-mails and phone calls; - The organisation of meetings: Kick-Off, 6 month, 12 month, 18 month meeting (in Vilnius, Lithuania): Partners visited the site where the system was installed for testing. The tasks were rescheduled for achievement of project results on time. Decisions on further exploitation were made. 24 month meeting (in Brussels, Belgium) the presentation of successfully achieved final project results and project closure; - The preparation of Exploitation Agreement; - The dissemination and exploitation Plan is being constantly updated; - The quality of work carried under the project is assured by intensive communication and information exchange among partners; - The main risk of the project was the time lag of two months of the prototype development due to the long delivery of some parts of Westfalia Separator. This issue was discussed among partners – as the installation of the prototype does not require envisaged time – so there will be enough time for testing and the project will return to its schedule. • Financial management: - The monitoring of cost performance (for variances from plan detections) is constantly performed; - The distribution of Community's Contributions was performed under the scheme agreed in Consortium Agreement; - The consultations on financial issues (especially SME partners) were discussed personally with interested partners.
Hidraulica, Depuracion y Ecologia, S.L. (ES) http://www.hideco.es/ **Area of Business Activity** Waste water treatment, solutions for industrial waste treatment	SME partner: Responsible for the WP7. The main actions carried out by HIDECO during the project consists on collaborative actions with LUREDERRA: • Analysis of data: (leachate generation statistics); • Corroboration of the results obtained by LUREDERRA and SMSA about leachate generation statistics; • Analysis of results to gain knowledge for definition of optimal leachate treatment; • With the provided data of statistic of pollutants, HIDECO collaborated with LUREDERRA on the activities carried out by LUREDERRA in terms of determination and identification of treatment route; • Corroboration that the system developed implies an accurate solution for the problem considered in the present project; • Preparation of economical estimations of PURILEACH treatment system (for D4.2). The economical evaluation was finalised after the system testing results were received.

Organisation Name	Role in PURILEACH
Bomers Engineering (NL) http://www.bomers-engineering.nl/ **Area of Business Activity** Programmable control system design and implementation for industrial, commercial, and manufacturing facilities.	SME partner: Up to 18 month BOMERS intensively assisted LOKMIS in development of operating system scheme of leachate purification unit according to the basic flow diagram of modular purification of leachate, developed by company BIOCENTRAS. BOMERS also provided consultancy to AGAVA on on-line data management for software development. From the October 2006 the communication with BOMERS was tenuous and after some time, consortium got a letter of bankruptcy of Bomers Engineering.
Servicios de Montejurra S.A. (ES) http://www.montejurra.com/ **Area of Business Activity** Waste treatment (landfilling, recycling), water purification and distribution.	SME partner: WP-leader in WP5. The main contribution of SMSA to PURILEACH project and WP 4 and WP 5. The main actions carried out by SMSA technicians were related with analysis of samples taken in the landfill owned by the company in Cárcar. The methods that the company used for this analysis are based on recommended methodic for design of sampling programmes. The progress towards objectives targeted is the real collection of statistical data of contaminants composition and percentage. Afterwards these data have been considered as very valuable data due to the fact that all of his parameters are representative of every landfill (they can be included in the ranges recommended by the EPA), furthermore this characterisation has been done by LUREDERRA (technicians visited the landfill, took the samples and made the analysis). As well as this, Cárcar landfill could be considered as a model one because it is part of the Urban Waste Treatment plant of SMSA which consists of separate collection, a composting plant and a landfill, and in this plant biodegradable fraction, plastic, metals and paper are separated using landfilling as a final alternative (the main objective of Council Directive 99/31/EC). SMSA provided input to deliverable D4.3 – User manual – as having long experience and understanding of the end-user needs and expectations. The technology already established for leachate treatment in SMSA landfill had provided good prospects for comparable economical analysis of proposed technology (input for D4.2 Report on economical evaluation).
OZON kornyezetvedelmi Szolgáltatóo Kft (HU) **Area of Business Activity** Waste treatment, landfilling, recycling.	SME partner: Efforts were made in WP1 - OZON participated in the statistics analysis of the leachate of landfill – collected data from different landfills in Hungary and provided it for analysis The analysis was done for defining the optimal process parameters necessary for treatment; The main activities of OZON in phase B the assembly, installation and supervision of the full leachate treatment system were done according to WP4, WP5, WP6 and WP7 work packages. OZON determined the most effective features and pointed out the potential deficiencies and actively participates in the evaluation of the results of testing on-site and make suggestions for the possible developments (in WP6). Prepared to the commercial exploitation of PURILEACH system in Hungary.

Organisation Name	Role in PURILEACH
Lokmis UAB (LT) http://www.lokmis.lt/ **Area of Business Activity** Development of electrical, pressure and temperature measuring equipment; design and technical solutions for integrated microelectronic and electronic systems.	SME partner: The main activities of LOKMIS were carried out under WP3. According to the basic flow diagram of modular purification of leachate, developed by company BIOCENTRAS, operating system scheme of leachate purification unit was developed and integrated in to the modular leachate treatment system by LOKMIS. Original software was also developed, for proper control of the f leachate purification unit. The software of leachate purification unit is responsible for controlling of pumps, valves, p-H meters and temperature meters. This enables to optimise the process of leachate purification by setting the optimal values of the p-H and the temperature in the reactors.
Agava UAB (LT) www.agava.lt/ **Area of Business Activity** Development of automatic control systems for industrial processes.	SME partner: responsible for the WP3. During laboratory trials the initial technological scheme of purification of leachate has been changed and simplified. For increase of process rate decanter for dewatering sludge was included. The control unit will carry out a lot of functions of process control such as counting, frequency measurement and so on. Therefore envisaged AGAVA's role in project was much simplified although AGAVA's preliminary developed software (in WP3) in some approach by LOKMIS for more optimised and economic performance of treatment system.
UAB-Prekybos namai "Krivis" (LT) **Area of Business Activity** Development of wastewater treatment systems for the individual needs of customers. Services cover whole cycle from system design and manufacturing to installation on site.	SME partner: responsible for the WP4. KRIVIS developed required parts for compatible modules (tanks, stirrers and etc.) under the specifications developed by BIOCENTRAS for particular modules: • Reagent preparation; • Coagulation-flocculation; • Advanced oxidation (Fenton Oxidation); • Filtration module.
Aqua Enviro (UK) http://www.aqua-enviro.net/ **Area of Business Activity** Training providers for environmental professionals involved in: Water & Wastewater Treatment; Sludge Handling; Industrial Wastes; Environmental Legislation.	SME partner: responsible for the WP6. AETT prepared estimation of future market potential and mid-term economics and also case study and plan for future exploitation, contributing to the development of Exploitation plan and assessment of IPR. AETT undertook several mail shots to advise their industry sector of the technology and gauged reaction. AETT publicised the project and attended the meetings within their network and discussed the opportunities for marketing the technology within waste water treatment sector.

Organisation Name	Role in PURILEACH
Biocentras UAB (LT) http://www.biocentras.lt **Area of Business Activity** Treatment of soil, water and wastewater heavily contaminant by various organic and non-organic contaminants, grease, oil pollutants; design, construction and operation treatment and storage facilities.	RTD partner: responsible for the WP2, WP4 and WP5. On the basis of results generated in WP1 and laboratory experiments BIOCENTRAS developed new simplified and more detailed technological process of purification of leachate. The process is illustrated on flow sheet of purification of leachate. The main groups of technological stages consist of: • Preparation of reagents: it is necessary to prepare 4 liquid solutions of reagents and 3 dry reagents. • Chemical purification: It is necessary to treat leachate by process of coagulation-flocculation, decant formed sludge. Next step is Fenton oxidation process after which it is necessary to decant formed sludge too. • Physicochemical purification: At first, partially purified leachate is filtrated through sorbent (ZeoVit) to remove ammonium nitrogen. Next step is filtration through activated carbon. • Biological purification: Final step of purification of leachate is run in biological purification unit where active sludge is used at aerated conditions. Sludge after coagulation-flocculation and Fenton oxidation is collected by decanter and removed back to landfill. Sludge after biological purification is separated, part of it is reused and left part is utilized.Prototype modules for each leachate treatment stages are developed according required technical specifications. For development of prototype for leachate purification a decanter and a trailer were purchased. The smallest variant of Westfalia decanter allows significantly speed up purification process because decanting proceeds much more faster than natural sedimentation. To make compatible all purification processes the prototype size has increased and was necessary to assemble all modules on a big platform. For that reason the tent trailer was purchased of size of 2,75 x 7,5 m and capacity of 16 t. The modules necessary for leachate purification at prototype level were designed, constructed and assembled to the modular system prototype (deliverable D4.1) together with UAB-Prekybos namai “Krivis”. After development of all modules the assemblage of system purification system had been completed. The late delivery of Westfalia decanter has caused some delay of assembling process. After finalisation of implementation of operational system (by LOKMIS) the evaluation of system and testing were performed. The results of these activities are summarised in the deliverables D5.1, D5.2. The video of PURILEACH system was also developed (D7.1).

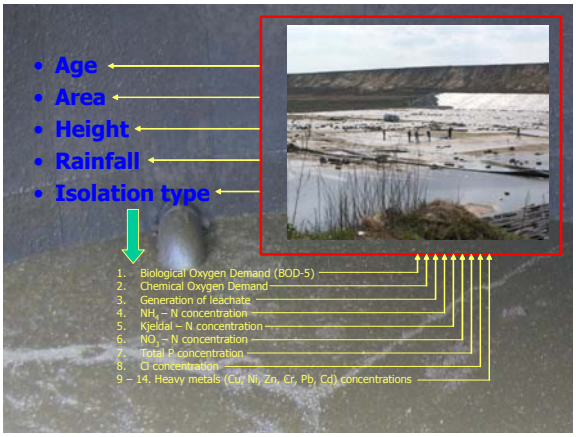
Silesian University of Technology, (PL) http://www.polsl.pl/ **Area of Business Activity** Identification of pollutants and their expansion, economic aspects of air protection, environmental protection systems.	RTD partner is very active in WP1 and WP6,WP7. Key activities carried out by SUT: • Monitoring of pollutants in municipal landfill leachate in EC; • Monitoring of quantity municipal landfill leachate in EC; • Statistical research of leachate: - statistical analysis; - artificial neural network model; - fuzzy knowledge-based system; • Quality and quantity leachates from landfills are changeable, therefore statistical model is not so good for determination of quality and quantity leachates from landfills, mathematical model with fuzzy knowledge-based system is better. Mathematical model using neuron net is the best for determination of quality an quantity leachates depending on volume of wastes, high of weather fall, surface of storage and quality of wastes. A procedure of object's identification for a complex biochemical system of solid waste landfill was presented. A multilayer feed-forward artificial neural network was used as an "black-box" model. The elaborated model enables one to simulate the object's responses (generation of leachates and their chemical composition) in various technological conditions what is necessary for any design calculations. The net's abilities for rendering complex, sometimes strongly nonlinear relations coupled with not totally identified and theoretically predicted synergistic/antagonistic effects proved itself useful in the area of calculations concerning objects of this class' complexity. Also the idea of a stochastic process with fuzzy states has been shown. The probability-based methods and fuzzy modelling are used for creating such description of a dynamic system in which both measurements and experts' linguistic information are employing. The constructed fuzzy knowledge representation gives possibilities of using computer-based systems for the prediction and making decision. Similar fuzzy models can be constructed for every variable of the process • The evaluation of the field trails, economical evaluation and evaluation of field trails in accordance with standards of developed PURIELACH system were carried out (Summarised in the deliverable D6.1); • Several publications and monograph is prepared on the basis of knowledge generated during PURILEACH project implementation (D7.3).

Main project achievements:

I. Determination of spectrum of leachate composition and quantity by collection and analysis:

- Statistical data of contaminants composition:
  - Contact with different European Environment Agencies
  - Data searching: Specific databases, articles, specialized searches.
  - Direct contact with landfills.

- Statistical and modelled data on leachate generation depending on:
  - Landfill age, area, height, rainfall and isolation type.
  - Relation between area of the landfill, leachate generation and leachate purification volume.



- Samples:
  - Characterisation of the landfill of Cárcar, Navarre, located in the Shire of Estella.
- Data:
  - Concrete data of landfills in Spain, France, Ireland, United Kingdom and Germany.
  - Leachate characterisation.
  - Parameters were grouped according to the pollution they caused (physico-chemical, organic loading, heavy metals, nitrogen parameters, rest of parameters)
- Gained knowledge for definition of optimal leachate treatment:
  - Recommended range.
  - Input system value.
  - Legislation analysis based on limit values depending where the purified leachate is going to be poured into.
  - Output system value.

The Council Directive 76/464/ECC of 4 May 1976 on pollution caused by certain dangerous substances discharged into the aquatic environment of the Community tells that Member States shall take the appropriate steps to eliminate pollution of the waters referred to in Article 1 by the dangerous substances in the families and groups of substances in List I of the Annex and to reduce

pollution of the said waters by the dangerous substances in the families and groups of substances in List II of the Annex, in accordance with this Directive, the provisions of which represent only a first step towards this goal. It is important to distinguish whether the purified leachate is going to be poured into the riverbed or the main sewer, because these limit values are marked in different legislations.

II. Development of operational system for composition analysis and regimes control:

According to the processes employed in modular purification of leachate, operating system structure of leachate purification unit was developed.

- On the basis of laboratory experiments new requirements for control unit of leachate purification unit were implemented;
- The control module of leachate purification unit is responsible for controlling of pumps, valves, water meters, output meters, p-H meters and temperature meters were developed, enabling optimisation of the process of leachate purification by setting the optimal values of the p-H and the temperature in the reactors.

III. Developed prototype of the complete leachate treatment system consisting of five modules:

- Reagent preparation;
- Coagulation-flocculation;
- Decantation;
- Advanced oxidation (Fenton Oxidation);
- Filtration.

Efficiency of operating system and adaptability of treatment system performance was tested. The system was tested with different in composition leachate from free landfills, in three control points three steps of treatment: coagulation-flocculation (65.1 % of COD removed), advanced oxidation by Fenton reagent (65-83 % of residual COD removed) and filtration (20-50 % of residual COD removed). The tests results are presented in the Table 1. All residual values of COD treated leachates were 109 – 121 mg/l and did not exceed the norms of purification of 125 mg/l.

Table 1. COD data of landfill leachate after three steps of purification

Leachate from	Initial COD, mg,l	Residual COD, mg/l	Removal of COD, %
COD data of landfill leachate after 1st step of purification			
I landfill	2490 ± 35	870 ± 43	65.1
II landfill	1957 ± 32	1043 ± 17	46.6
III landfill	970 ± 24	431 ± 15	55.6
COD data of landfill leachates after 2nd step of purification			
I landfill	870 ± 43	216 ± 34	75.2
II landfill	1043 ± 17	175 ± 27	83.2
III landfill	431 ± 15	152 ± 17	64.7
COD data of landfill leachates after 3rd step of purification			
I landfill	216 ± 34	109 ± 26	49.5
II landfill	175 ± 27	114 ± 29	34.9
III landfill	152 ± 17	121 ± 22	20.4

Calculations of price of purification of leachate by developed prototype show that it significantly depends on volume of tanks in equipment. If calculated price for prototype was 32.12 euros per m3 of leachate, 5 times increase of tanks volume can reduce price to 14.39 euros.

In a set of photos below PURILEACH prototype for treatment of landfill leachate is presented:

The PURILEACH model tanks

PURILEACH leachate pumping system

PURILEACH reagents tanks and reactors

Installation inside the movable trailer – a general overview

Installation inside the movable trailer – a general overview

Installation inside the movable trailer – an external overview

2. Dissemination and use

2.1. Dissemination of project results

Every invention has the inevitable problem of being unknown by potentially interested parties. A policy of wide dissemination of project results has been pursued and has been well received by the end users affected by this project. Dissemination planned activities consist of:

- Participation in leading trade shows and the publication of the successful results in trade journals. This was anticipated as the most important for dissemination of the results.
- Publications in relevant magazines.
- Dissemination through the project website (http://purileach.europarama.lt);
- Video of the modular treatment system prototype is been carried out and published as an MPEG-file on the website.
- Dissemination of information to the networks and established distribution channels of the individual partners. Every partner involved in PURILEACH project is already driven towards promoting the project in its institution. In that prospective, means of dissemination vary: annual review meetings and internal presentations.

2.2. Exploitation of knowledge

Generated under implementation of project exploitable knowledge is presented in the table below:

Exploitable Knowledge (description)	Exploitable product(s)	Sector(s) of Application	Timetable for commercial use	Patents or other IPR protection	Owner & Other Partner(s) involved
Novel leachate treatment technology: modular solution with integral operational system for wastewater analysis and feedback for working regimes optimisation.	Compatible modules for particular treatment processes to optimise leachate treatment route.	Environmental technologies	2008-2009	Patent on employment of strained sedimentation during the treatment processes	Consortium
	Integrated operational system for analysis and control.		2008-2009	No patents	LOKMIS, AGAVA
	Sensors for measuring loading rate and inflow-outflow composition parameters, module junctions and valves.		2008-2009	No patents	LOKMIS
	Hardware for measuring loading rate and inflow-outflow composition parameters		2008-2009	No patents	BIOCENTRAS, LOKMIS
	Control system with on-line overview of the state of waste water.		2008-2009	No patents	LOKMIS, BOMERS
	Compatible module for particular treatment processes	Environmental technologies	2008-2009	No patents	BIOCENTRAS, LUREDERRA,
	Compatible module for particular treatment processes	Environmental technologies	2008-2009	No patents	BIOCENTRAS

As the project is implemented successfully, and the novel modular highly polluted leachate treatment system is developed having an excellent commercial potential. Three main business models for exploitation of the main project achievement – modular leachate treatment system – are proposed by consortium partners:

- To provide leachate treatment services with mobile modular leachate treatment system;
- To build partnership with big landfills for they will provide services (to sell the license of manufactured modular system to them and provide services of technological up-scaling);
- To sell to large landfills manufactured stationary leachate treatment system.

To ensure fluent exploitation of the developed system the exploitation agreement (D8.1) is prepared, where is stated that SME Partners in cooperation among them and with RTD Performers had developed Modular purification system for heavily polluted leachate, consisting of leachate treatment system, comprised of the following modules: reagent preparation, coagulation-flocculation, decantation, advanced oxidation (Fenton Oxidation) and filtration as well as software for control of leachate treatment process (hereinafter referred to as Knowledge) and had agreed to further formalize their relationship for the development and commercialization of the Modular purification system for heavily polluted leachate.

L'Urederra Fundación para el Desarrollo Tecnológico y Social
Mr. Claudio Fernandez
San Anton 3, 31272 Zudaire (Navarre), Spain
Tel: +34-948-539334/38
Fax: +34-948-539539
e-mail: Claudio.fernandez@lurederra.es
www.lurederra.es

http://purileach.europarama.lt/