Deliverable D1.3

Final Report on project progress

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Deliverable D1.3

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[1] PU = PUBLIC
PP = Restricted to other programme participants (including the Commission Services)
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Publishable Executive Summary

Deliverable 1.3 "Final report on project progress" gives an overview of the status of the project covering all the tasks foreseen the period from M25 to the end of the project M42.

PureNano project completed successfully all the tasks described in the GA. In more details, MNPs production line has been optimized and validated and all the needed MNPs have been produced in the required quantities. Thorough MNPs characterization has been performed and partners implemented activities regarding the functionalization of MNPs with biopolymers provided new types of MNPs with higher acidic stability. The purification plants for both Gaser and CNano pilot lines finalized the installation of the plants in their premises. Activities to assess the recycling routes of the used MNPs as well as studies on sustainability of the MNPs production and wastewater purification processes have been completed. Market assessment as well as ecological, financial and social evaluation of the proposed technology are taking place. Finally, safety, training and standardization activities have been also completed to better inform targeted market and society on technological advantages of the developed PureNano solution.

This document summarizes all the Tasks completed in the last 18 Months of the project and gives a detailed view of the milestones achieved, the pitfalls encountered and the progress of the project.

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Abbreviations and acronyms

BET	Brunauer–Emmett–Teller analysis
CAPEX	Capital expenditures
D&C	Dissemination & Communication
EN	European Norm (European Standards)
FTIR	Fourier-transform infrared spectroscopy
ICP	Inductively Coupled Plasma
IPR	Intellectual Property Rights
ISO	International Organization for Standardization
KER	Key Exploitable Result
LCA	Life Cycle Analysis
LCC	Life Cycle Costing
LCI	Life Cycle Inventory
LCIA	Life Cycle Impact Assessment
MNPs	Magnetic Nanoparticles
MS	Mass Spectrometry
PBCM	Process Based Cost Model
PDADMAC	Polydiallyldimethylammonium
PEDR	Plan for the Exploitation and Dissemination of Results
PESTLE	Political, Economic, Sociological, Technological, Legal and Environmental Analysis
PL	Pilot Line
SEM/EDS	Scanning Electron Microscopy with Energy Dispersive Spectroscopy
SM	Social Media
SOP	Standard Operating Procedure
SWOT	Strengths, Weaknesses, Opportunities, and Threats analysis
TEM	Transmission electron microscopy
TGA	Thermal Gravimetric Analysis

1. WP1 - Management & Coordination

1.1 Overview of activities in WP1

An amendment has been submitted and approved, due to the COVID-19 outbreak and its impact on the research activities, requesting:

A. **In order to implement successfully the delayed activities presented above, the consortium request and extension of the end date for the action for six months at 30/11/2022 (M42)**.
B. **Changes in the description of other direct costs for PoliMi and Kampakas to enhance dissemination and communication activities for the projects results.**
C. **A new risk has been included about force majeure situations.**

1.1.1 Task 1.1: Administrative and financial project management

Polimi as project coordinator was responsible for the execution of this Task. Following the activities as planned for the first reporting period, the administrative and financial management followed these subtasks; (a) Financial monitoring; (b) Preparation and submission of periodic reports; (c) Provision of information and support to project partners regarding reporting and financial rules in H2020; and (d) Progress reporting to EC.

Regarding management tools, PoliMi had set up and continuously updated the mailing list of the project, which contained the contact details of all the involved partners. Microsoft Teams and Skype software were being used to host the teleconferences between partners and One Drive as well as Google Docs were used for file sharing between project partners. Regarding financial management, budget corresponding to the first interim payment transferred to PureNano partners. All partners manage internally their financial and reporting structure setup, and they also, monitored continuously their expenses and personnel effort according to the allocated budget.

PoliMi led the administrative activities and coordinated technical activities through regular Teams teleconferences organized according to partners' and project needs. During the second period, three consortium meetings were organized, two online meetings and one hybrid meeting:

- ✓ 29M telematic Consortium meeting, 7 October 2021
- ✓ 37M telematic Consortium meeting, 17 June 2022
- ✓ 41M Hybrid Consortium meeting, Milan & Microsoft Teams, 3-4 October 2022

During these meetings, partners presented the progress of the activities, identified issues and defined tasks to be completed. The 41M meeting combined WP sessions, live demonstrations and visit to partner premises.

1.1.2 Task 1.2: Technical project management

The technical project management consisted of the following tasks:

- Co-ordination of tasks and risk assessment of technical activities
- Review of technical work
- Review and submission of deliverables
- Technical progress monitoring and reporting to the project officer

The last twenty-two deliverables have been submitted during the second period and are awaiting approval from the EC, completing the submission procedure of the project first 18 months of the project.

The Technical project manager (Prof. Anwar Ahniyaz, RISE) in close coordination with PoliMi and Captive Systems is following the technical work plan. The timely delivery of technical reports and technical deliverables is also being followed up and monitored.

1.2 Achievements and results of WP1

1.2.1 Task 1.1: Administrative and financial project management

Administrative and financial project management, led by PoliMi, is in the final stage, and by the time this Deliverable is written (M42), there are some last tasks to be finalized by the end of the project:

- successful revision of the project,
- identify and resolve any remaining issues arise from the review process, (remaining tasks, Deliverables, Periodic report),
- Final budget to be transfer to PureNano partners

1.2.2 Task 1.2: Technical project management

The technical project management allowed PureNano consortium to:

- submit all deliverables specified in the Grant Agreement in M25-M42
- achieve all milestones scheduled in M25-M42
- successfully implement activities and identify delays

Table 1. *WP1 Deliverables submitted*

Deliverable Number	Deliverable Description	Date
D1.3	Final report on project progress	30/11/2022

2. WP2 - Generation of Specifications & Requirements

2.1 Overview of activities in WP2

WP2 activities were focused on define and provide specification about the technical aspects of PureNano project.

The activities carried out in WP2 in the second part of the project were:

A. Update of the material to be used in the synthesis of MNPs
B. Update of end user's requirements
C. Update of purification plants design

2.1.1 Task 2.4: Update of Specification deliverables

The activities of this task related to the identification of any deviations in terms of technical progress of Pure Nano project. Throughout the duration of the project, technical partners shared in detail all the implemented and planed actions through mails, calls, and datasheets. This information was helpful to achieve the optimization of the different aspects of the project and gave the opportunity to apply some changes as it was given the opportunity to some important issues to be identified, discussed, and the needed changes to be implemented. These data also helped in the development of the project and the optimization of the experimental activities in the final purification system.

2.2 Achievements and results of WP2

2.2.1 Task 2.4: Update of Specification deliverables

Specification deliverables were update successfully with the following data:

- Update of specification on material to be used in new formulated MNPs, with wider selection of functionalized group.
- Update of design choices about purification plants in CNano and Gaser facilities.
- Update of end user's requirements about solution purification and plating characteristics

Table 2. *WP2 Deliverables submitted*

Deliverable Number	Deliverable Description	Date
D2.4	Updated report on Pure Nano specifications	01/12/2020

3. WP4 - Functionalization of MNPs

3.1 Overview of activities in WP4

3.1.1 Task 4.1: Development of Cationic Coating for MNPs

The objective of this task was the development of cationic polymeric coating on the magnetic particle aggregates to produce magnetic beads to be able to remove anionic species from the spent electrolytic bath. The outcome of this task was the standard operating procedure (SOP) for lab-scale synthesis developed by RISE and shared with partners for implementation at a pilot scale.

After consultation with PoliMi and Captive Systems, the cationic bio-polymer chitosan was chosen for its metal ion chelating properties at low pH. Furthermore, selection of a bio-degradable biopolymer lowers the possible environmental impact of the magnetic beads, by avoiding synthetic polymers. The chitin derived polysaccharide chitosan exhibits interesting properties, largely due to that the saccharide rings are substituted with primary amine groups. Under acidic conditions, protonation of the amine groups render the amines positively charged, which makes chitosan an interesting alternative for ion exchange purposes, e.g., for pH responsive catch-and-release of negatively charged ion species in from a solution. The magnetic chitosan beads were initially found to dissolve under acidic conditions of the electrolytic bath, and work was also focused on crosslinking the chitosan to improve its stability in acidic environments.

The chemical crosslinking strategy gave surprisingly good results, both in terms of stability under acidic environments and in terms of capture capacity for anionic and cationic components, under simulated and real spent baths.

Then the samples were then scaled up by Captive systems based on an SOP sent by RISE, which was used for testing simulated and real spent baths by Captive systems.

The first set of experiments was done by producing a synthetic water containing nickel ions at two different pH levels, 2.5 and 3. The residual amount of nickel after the treatment and the release of iron were measured through ICP- MS technique.

The MNPs showed an excellent stability at pH 2.5 and 3 even in the presence of nickel ions. Moreover, they showed a good adsorption capacity in removing nickel ions at such acidic pH.

The second set of experiments was done by two samples of electroplating spent bath coming from CNano, NI-P bath and NI-P/Sic bath. The experiments were conducted using the same procedure of the previous tests; the spent baths were treated at their original pH that was lower than 2 and a pH equal 2.5 in accordance with CNano. The residual amount of nickel after the treatment and the release of iron were measured through ICP- MS technique.

As expected, the MNPs were not stable in the experiments conducted at pH lower than 2. At pH 2.5 all the MNPs showed a good stability. Not only there was not release of iron, but they were able also to absorb the initial iron that was present in the solution. The MNPs showed a good adsorption capacity of nickel ions, in each case over than 1 g of nickel removed per gram of MNPs.

3.1.2 Task 4.2: Development of anionic Coating on MNPs

As for Task 4.1, the objective of this task was to develop anionic polymeric coating on the magnetic particle aggregates to remove anionic species from the spent electrolytic bath. Similar in this case, the outcome was a standard operating procedure (SOP) for lab-scale synthesis developed by RISE and shared with partners to implementation at a pilot scale.

After consultation with PoliMi and Captive Systems, anionic modified Starch was chosen. Furthermore, selection of a bio-degradable biopolymer lowers the possible environmental impact of the magnetic beads, by avoiding synthetic polymers.

First few batches of starch coated magnetic beads were also prepared and characterized. Stability test demonstrated a good stability at pH = 2 for 24hrs with a negligible dissolution of iron oxide. Further details are described in previous reports

After doing lab scale synthesis and acid stability tests, the samples were sent to Captive systems for detailed acid stability tests by ICP method. Then the samples were scaled up by Captive systems based on an SOP sent by RISE.

Due to the surprisingly good performance of cataionic coated MNPs, the preparation and evaluation of both anionic and non-ionic coating was reduced in priority, and we mainly focused on cationic coating, that worked for removal of both metal ions and anionic residues.

3.1.3 Task 4.3: Development of non-ionic Coating on MNPs

For the last functionalization of the MNPs a non-ionic polymeric coating was developed, capable of capturing non-ionic compounds from the spent plating baths. In line with Tasks 4.1 & 4.2 RISE worked on the development of a SOP that used for the upscaling of the non-ionic MNPs production by partner CaptiveS.

In close coordination with PoliMi and Captive Systems, RISE developed non-ionic biopolymer coated magnetic beads, based on Lignin. The lignin-based magnetic beads are prepared by flocculation of lignin modified iron oxide with cationic polymers (presently using Polydiallyldimethylammonium chloride, PDADMAC).

The samples were prepared at a lab-scale and tested for acid stability. Further details are described in previous reports. Due to the surprisingly good performance of cationic coated MNPs, the preparation and evaluation of both anionic and non-ionic coating was reduced in priority, and we mainly focused on cationic coating, that worked for removal of both metal ions and anionic residues.

3.1.4 Task 4.4: In depth characterization of functionalized MNPs

The objective of this task was to provide the needed characterizations of functionalised MNPs, considering the crucial properties that would best describe the MNPs.

3.2 Achievements and results of WP4

3.2.1 Task 4.1: Development of Cationic Coating for MNPs

After testing several strategies for cationic coatings on MNPs based on chitosan, the chemical crosslinking was very successful. Using this strategy, we obtained high degree of acid stability which was verified at lab-scale with simulated acid environments at pH 2 and metal ion uptake with simulated electrolytic baths were also surprisingly successful, consistently showing an uptake of more than 1000 mg/g of MNPs. These particles were also tested and found to show a very high uptake of hypophosphite from the spent electrolytic bath. Finally, the recipe for lab-scale coating from RISE was scaled up to a pilot scale by Captive Systems. With these particles produced at a pilot-scale, we also tested with real electrolytic baths, and we observed an undiminished metal ion and hypophosphite removal. Detailed analysis showed that there was negligible leaching of Fe ions into the electrolyte system.

3.2.2 Task 4.2: Development of anionic Coating on MNPs

Initially, a coating based on anionic-modified starch was explored. The coating provided very good acid stability, with no evidence of Fe ions leaching out after 24h at pH2. We also evaluated the capacity of removal of metal ions. Nevertheless, due to the surprising performance of cationic coating, in terms capturing both metal ions and anionic hypophosphites, we reduced the activities on this track.

3.2.3 Task 4.3: Development of non-ionic Coating on MNPs

Initially, a coating based on modified lignin was explored. The coating provided very good acid stability, with no evidence of Fe ions leaching out after 24h at pH2. Nevertheless, due to the surprising performance of cationic coating, in terms capturing both metal ions and anionic hypophosphites, we reduced the activities on this track.

3.2.4 Task 4.4: In depth characterization of functionalized MNPs

The objective of Task 4.4 was to ensure that the developed NMPs will be properly characterized, concerning the properties that are of great importance for the quality of these materials. Following this direction, and after the collection and evaluation of the capacities of all involved partners, it was decided that the development of MNPs would be benefited by measuring in particular their morphological characteristics. Properties and characteristics measured for functionalized MNPs were the same as for non-functionalized, namely FTIR, Raman, EPS, TGA, SEM/EDS, TEM, Size distribution and BET, while the measurements were performed by the partners who performed them also in WP3. All the results of the in-depth characterization of functionalized MNPs were included in the WP4 deliverables.

Table 3. *WP4 Deliverables submitted*

Deliverable Number	Deliverable Description	Date
D4.1	Report on anionic coatings for capturing the cationic moieties	31/05/2022
D4.2	Report on cationic coatings for capturing the anionic specious	31/05/2022
D4.3	Report on non-ionic coatings for capturing the non-polar and hydrophobic specious	31/05/2022

4. WP5 - Integration of purification system and safe disposal of MNPs

WP5 focused on the development of the purification system for the electroplating and electroless processes in the Purenano project at Cnano and Gaser facilities.

Within the activities of this WP5, a mathematical model including the plating processes and all the necessary unit operations for the purification process developed. A set of documents related to the integration of the purification system have been generated. The documentation also updated according to the final installation in the pilot lines.

Part of WP5 concerned the safe disposal of MNPs after their use in removing different types of pollutants. A three-way approach was investigated for this purpose: 1. Metals recovery and MNPs reuse; 2. Water treatment; 3. Integration in concrete formulation.

4.1 Overview of activities in WP5

4.1.1 Task 5.1: Process model formulation and process optimization

The activities carried out during the last period of the project mainly consist of updating the previous work related to the process modelling activities and the development of the process engineer.

In previous reports, the detailed results were based on bibliographic information, but with the available experimental results in WP6, the electroplating and electroless models have been updated, and more realistic results have been obtained. Thus, experimental information provided by Cnano, Gasser, and Captive has been included as input data in the simulation to improve the results obtained. Moreover, an optimization process has been carried out to maximize the process profitability

On the other hand, the engineering documents have also been updated with the last information available, detailing the final configuration of the two pilot lines linked to the PureNano project, thus reflecting the pilots equipment and process methodology.

In this context, both the models and the engineering documents can be employed to study potential uses of the pilot and the MNPs in potential clients or stakeholders.

4.1.2 Task 5.4: Sub assembly manufacturing and installation

During the period of M25 – M42 of the project the purification systems have been manufactured and installed in the premises of Gaser and Cnano. More specifically, Gaser has installed the purification system regarding the regeneration of the spent electroless bath. The effective volume of the system is 4 cubic meters. Additionally, concerning the portable purification system, Kampakas company has proceeded in the manufacturing of the various components and in collaboration with Cnano, a system of 120L capacity was installed initially in the premises of Peristeri and afterward in the new premises of the company in Metamorfosi. Both systems have been tested via some initial runs and thoroughly checked for leakages or other misfunctions. Finally, some necessary modifications have been made in order to optimize the overall purification process, especially in the portable system.

4.1.3 Task 5.5: Safe disposal of used MNPs

With reference to the Magnetic Nanoparticles that were used for the conduction of the experiments for the realization of Task 5.5.c, samples produced in two different WPs were used: **WP3 non-coated MNPs** and **WP4 coated MPNs**. The received MNP samples originated from spend baths, from the removal of different species (Ni^{2+}, Zn^{2+}, Cu^{2+}, lubricant, orthophosphates). Therefore, two distinct experimental series were performed; one for WP3 non- coated MNPs and one on WP4 coated MNPs.

In the first period up to June 2021 the incorporation of WP3 MNPs was examined into cement/mortar and cement formulations. During the period between June 2021 up to November 2022, NTUA continued the experiments regarding the integration of MNPs into concrete formulations.

The primary objective of the performed experiments was to identify any possible effect that the addition of MNPs could have in: i) the rheological properties and ii) the compressive strength of the samples. An equally important second objective for Task 5.5.c was the evaluation of the environmental performance of the produced materials.

For the incorporation of any non-traditional additive into concrete mix- design, it is considered more efficient to be first checked and evaluated into paste and mortar formulations, therefore this was also the approach that was followed for the MNP concrete. Based on the first paste/ mortar results, it was then possible to identify the optimal synthesis-important parameters as well as the required modifications of the mixing process and proceed to upscaling by integrating the findings into the concrete mix- design. This approach was followed for both WP3 and WP4 MNPs.

In the period between June 2021 and November 2022, the following activities were performed, according to the experimental design:

1. Environmental tests of pastes, mortars and concrete samples prepared using WP3 (non-coated) MNPs
2. Evaluation of the rheological and mechanical properties of pastes and mortars prepared using WP4 (coated) MNPs
3. Synthesis of concrete samples using WP4 (coated) MNPs, based on the optimum parameters and optimum synthesis process, as indicated by the evaluation of pastes and mortars.

4.2 Achievements and results of WP5

4.2.1 Task 5.1: Process model formulation and process optimization

The process model formulation leads to some interesting achievements and results. The developed simulations provide information about the electrodeposition of the desired metal in the treated pieces, the quantity of contaminants that the NPs can adsorb in the adsorption tank, and the NPs which can be captured by the magnetic trap or the conventional filter. Thus, the mass balances of the complete processes have been solved.

Moreover, the output parameters achieved by running these simulations have been used as inputs in the optimization process, obtaining the optimum values of the process optimization with economic criteria (Net Present Value maximization).

On the other hand, the final engineering documents have been developed with the help of previous engineering steps and results obtained in the modelling activities. Different points of view of partners helped in the final configuration of the purification lines, and progress was achieved to get the final design in the detailed step.

The design results present specifications for all the involved equipment in each purification process and the system configurations. Some pieces of equipment have been manufactured under exhaustive control, and in other cases, a commercial solution has been adopted, adapting to the Purenano project case studies. The assembling of all parts is the result of the design phase, which has been executed in the last months in Cnano and Gaser facilities according to the generated specifications.

4.2.2 Task 5.4: Sub assembly manufacturing and installation

Both systems have been successfully designed, manufactured and installed in the premises of the metal finishing end users. The systems have been tested and the final modification have been made prior to the first trials. The portability of the portable system has been also demonstrated.

4.2.3 Task 5.5: Safe disposal of used MNPs

After the evaluation of all experiments the main finding was **that it is possible to successfully integrate Magnetic Nanoparticles originating from spent baths, into concrete formulations.** Furthermore, **the results of the environmental tests indicate that the synthesized concrete materials are stable into aquatic environment, thus the incorporation of MNPs into concrete can be considered as a meaningful option for their safe disposal.**

The use of MNPs into concrete formulations was found to be compatible with the use of commercial superplasticisers, which can be used to modify the rheological properties of the resulted concrete towards the targeted workability according to the set application.

The performance of the MNP-containing mortars in the compressive strength test, depends strongly on the MNP type:

a) The addition of non- coated MNPs into the mortar system leads to an increase of the compressive strength up to 17%. Furthermore, compressive strength seems to be affected by the % content of MNPs.

b) The use of coated MNPs in mortars appears to have a neutral to negative effect on the compressive strength. The effect of % w/w MNP content is less evident, and it can be considered that the increase of % MNP content marginally affects compressive strength either positively or negatively.

Based on the results of the standard leaching test EN 12457.04 performed on MNPs paste, mortar and concrete samples, it was concluded that:

- The concentration of most of the elements analysed in the leachates of MNPs paste and mortar samples was in general lower than the quantification limit of the analytical method applied and in compliance with the strict criteria for the acceptance of wastes in landfill for inert wastes. The concentration of Cr satisfies the criteria for non-hazardous wastes. The leachability of Mo from samples with increased MNP content (≥2%) was slightly higher than the limit for inert wastes.
- The MNPs samples generally exhibited similar leaching behavior with the reference samples (paste and mortar without addition of MNPs). However, the MNPs sample have slightly higher Mo leachability as compared with the reference samples.
- Regarding MNPs concrete samples, the leachability of all the parameters examined, except Cr, satisfies the limits for the landfill of inert waste. The concentration of Cr is in compliance with the limits for the landfill of non-hazardous wastes.

Table 4. *WP5 Deliverables submitted*

Deliverable Number	Deliverable Description	Date
D5.4	Revised optimized process conditions after demonstration activities	30/09/2022
D5.6	Report on metals recovery and MNPs reuse	30/09/2022
D5.7	Report on water treatment utilizing used MNPs	31/05/2022
D5.8	Report on integration of MNPs in concrete formulations	30/11/2021

Table 5. *WP5 achieved Milestones*

Milestone Number	Milestone Description	Date
MS6	First engineering design for electroless line approved by GASER	11/02/2021
MS7	a. Delivery of a 1kg batch of anionic functionalized MNPs to Cnano b. Integration of the separation subassembly in the Cnano pilot line	01/04/2022
MS9	First successful recovery of Ni and Cu from used MNPs	30/06/2022

5. WP6 - Demonstration activities

5.1 Overview of activities in WP6

5.1.1 Task 6.1: Production of functionalized MNPs aggregates

The MNPs were produced according to SOPs delivered by RISE, that was in charge for the development of new coatings for the MNPs. CaptiveS started by reproducing the SOPs at lab scale in order to gain confidence with the new procedures and then moved to obtain the new functionalization MNPs by using the production pilot plant.

5.1.2 Task 6.2 Purification of Electroless baths

The goal of this task was to demonstrate the use of MNPs in purification of electroless nickel solution from pollutants, and the performance of the purified solution in industrial environments.

This task also provided information about the characterization of plating, process parameters and performance of nickel electroless before and after the purification process.

5.1.3 Task 6.3: Purification of Electrodeposited baths

The main target of the task was to proceed in the treatment of two different types of spent Ni based electroplating baths: pure Ni-P and composite Ni-P/SiC electrolytes. In the case of Ni-P electrolyte a spent bath of a total volume of 40lt has been treated, while in the case of Ni-P/SiC composite, three spent baths have been treated: 12, 40 and 90L.Various electrochemical studies have been conducted in fresh, spent and regenerated baths in order to better understand the mechanisms of the bath's degradation and the efficiency of the purification process. Furthermore coatings have been produced tested from the spent and regenerated baths and their structural, morphological and mechanical properties have been studied and compared with the properties of coatings produced from fresh baths. Finally, trials have been made on Cu and Zn spent electrolytes that are very acidic (i.e. ph ~1).

5.2 Achievements and results of WP6

5.2.1 Task 6.1: Production of functionalized MNPs aggregates

In order to check if the MNPs produced at pilot scale are consistent with the one produced at lab scale, so to verify if the scaling-up process worked, all the material were analyzed. Comparing the both the results regarding the physiochemical characteristic and the one related to the performances of the new functionalized MNPs, it can be stated the production scaling-up processes were accomplished.

5.2.2 Task 6.2 Purification of Electroless baths

During the implementation of task 6.2 the following goals were achieved:

- Purification of electroless solution in Gaser purification line using MNPs
- Definition of purification process parameters during operations

- Definition of PureNano purification method efficiency, applied to Electroless Nickel
- Evaluation of plating performance and quality after purification in industrial environment.

During this task, the functionality of PureNano technology in electroless nickel industry was demonstrated.

5.2.3 Task 6.3: Purification of Electrodeposited baths

The regeneration process has been evaluated based on the efficiency of removal of unwanted chemical species as well as on the properties of the produced coatings from the regenerated baths. For the case of Ni-P spent bath the Ni removal was 26% with a set target of 40%, while in the case of the Ni-P/SiC composite spent electrolytes the Ni removal varied between 20.6% and 37.3% with a set target of 40%. The coatings produced from the regenerated bath has shown significant improved properties compared to the coatings produced from spent baths in all cases. Furthermore, the thorough electrochemical study conducted in the baths has revealed that the purification process has a beneficial effect on the electrochemical behaviour of the electrolyte during the electroplating process.

Finally, trials conducted in Cu and Zn spent baths by Tecnochimica didn't have the same level of success. Main obstacle was the far more acidic baths (i.e. $pH < 1$) that lead to dissolution of the magnetic nanoparticles.

Overall, the trials concerning the Ni based spent electrolytes are characterized as successful since the behaviour of the baths have been improved compared to the spent baths, and the coatings produced present acceptable morphology, structure and mechanical properties. This is based on the remarkable fact that partners RISE, PoliMi and CaptiveS have managed to effectively protect the MNPs in a pH environment of 2-2.5. However, additional studies are required in order to further lower the operational pH of these particles, so as to treat very acidic electrolytes.

Table 6. *WP6 Deliverables submitted*

Deliverable Number	Deliverable Description	Date
D6.1	Report on the production of MNPs	31/05/2022
D6.2	Report on the purification process of electroless baths	31/08/2022
D6.3	Report on the purification process of electrolytic baths	31/10/2022
D6.4	Public report on demonstration activities of PureNano Project	30/11/2022

Table 7. *WP6 achieved Milestones*

Milestone Number	Milestone Description	Date
MS8	First successful purification of Ni-P electrolytic bath	31/05/2022

6. WP7 - Demonstration activities

6.1 Overview of activities in WP7

This work package was related to the environmental monitoring of the technology developed within the project. The overall objective was to i) analyse the End-of-life management chain in the electroplating sector and the best waste management practices, ii) assess the new technology from the environmental and economic point of view, iii) assess the health and safety risks of the technology, iv) ensure that the technology follows the current regulation v) highlight the circularity of the process and investigate a feasible economic model that includes the recycling and reuse concepts.

6.1.1 Task 7.1: Recyclability & Circular economy

The scope of this task was to provide an overview of the sustainability of the PureNano project, performing a step-by-step analysis, The analysis included: i) a general overview of the Circular Economy concept and of the sustainability of the finishing industry ii) the analysis of the End-of-Life management chain in the finishing industry iii) the description of the waste minimization approach and its application to the main Pilot Lines (PLs) implemented within the project, iv) the application of the most suitable Circular Business Model (CBM) to the main PLs.

6.1.2 Task 7.2: Safe by design

This task aims to contribute to the safety of PureNano technology, from a safe-by-design perspective.

Within the development of this task the application of the SbD approach to the 3 PLs Creative Nano, Gaser and Captive was performed, taking into account the conceptual pillars and core elements of Safe-by Design as the SbD challenges, the SbD strategies, the Stage Gate Cooper Innovation process, and the Step-by-step process for the implementation of SbD Roadmap.

One way to approach the gap between innovative materials and the present regulatory frameworks is by implementing Safe-by-Design (SbD). Therefore, SbD necessarily addresses both functionality and safety aspects to achieve or exceed the functional performance of current NMs the application they enable, while minimizing inherent hazard potential and avoiding exposure to human and environment at all stages of the life cycle. Depending on the property to be exploited for a distinct application, it might not be possible to maximize both functionality and safety at the same time, therefore only an optimized balance through SbD measures might be possible.

The SbD concept intends to balance safety, functionality and cost in an integrated way in order to improve innovation efficiency for the development process of better nanotechnology products, from the basic technology research into recycling.

The aim of this task only concerns the SbD “Risk analysis and management” component and doesn’t take into account the functionality or costs.

6.1.3 Task 7.3: Safety Lines & Nanosafety issues

In this task, a visit was made to the Gaser and Captive S PL facilities to collect information, in order to finalize the risk assessment of the PLs.

A tiered approach was applied to assess the exposure to **NMs** for which no legal Occupational Exposure Values (OEL) exists.

Tier 1 is focused on the gathering of information and apply Control banding tools, if necessary, prior to laboratory or field assessment, to assess possible release and exposure to NMs most effectively.

Initial assessment Gathering information concers:

- Nanomaterials – Identification, physical form
- Processes
- Activities
- Equipment
- Local visit and
- application of **Control Banding** tools.

All of these inputs were used to perform and complete the aforementioned risk assessment, the start of which was already shown in D7.2 and as input to the StoffenManager CB tool that was used.

The results of this task give the necessary information to perform Task 7.2.

6.1.4 Task 7.4: Standardization activities

The goal of this task was to facilitate the acceptance and utilization by the market of the developed processes and materials. Towards this direction a standardization landscape performed, including the relative to PureNano existing standards, as well as the related standardization committees and organizations involved. Additionally, the current state of HSE standards development for nanotechnologies have been presented and analyzed.

6.1.5 Task 7.5: Training Activities

A crucial step that follows the invention, towards the successful implementation of a project is raising awareness. Towards this direction, and in order to achieve a communication with a wider public and raise awareness, to disseminate effectively PureNano project, a concrete strategy were designed and followed.

6.2 Achievements and results of WP7

6.2.1 Task 7.1: Recyclability & Circular economy

Within this task, the following actions have been performed:

Analysis of the end-of-life management chain

The analysis started with the identification of the main wastes produced in the electroplating sector, the identification of the allowed concentration limits in the effluents, and the best practices used for reducing these contaminants. This first analysis showed that although the wastewater is mainly treated by using membrane processes, other wastes such as sludges and spent baths are usually disposed of after a neutralization process.

Implementation of the Waste Minimization (WM) approach and PureNano purification technology in the CNano and Gaser user cases.

To reduce waste production, the WM approach was analysed and adapted to the two user cases. Waste minimization (WM) is defined as the continuous application of a systematic approach to reducing the generation of waste at the source. It includes source reduction and on-site recycling. Waste minimization methods can be applied in each part of the value chain. In the plating industry they are related to the quality of raw materials, reduction of drag out and waste, process modification and management of process solutions. A questionnaire was sent to the interested partners to check whether the approach is used already or will be implemented in the future. Both partners gave positive feedback, and we could conclude that the application of the WM techniques reduces the cost of waste collection and these together with the PureNano purification technology, will reduce the environmental impact of the whole plating process.

Implementation of the most suitable Circular Business Model (CBM) in the economic strategy of the two industrial partners (CNano and Gaser)

The development of a circular business model required the integration of the circular business goals of recycling, reusing, and remanufacturing in the existing business model of the companies and the identification of the economic, social and technological changes necessary to achieve the transition from a linear economy to a circular economy.

In PureNano, based on the circularity concept, after the contaminants present in the plating bath are captured, MNPs are reused or regenerated. One of the main aspects of PureNano was the possibility to regenerate the MNPs through an electrolytic process or use them for i) removing heavy metals from wastewater or ii) in concrete formulation applied in the construction industry. Based on the nature of the spent baths one or more of the MNPs valorisation routes can be prosecuted.

The step related to the identification of the circular business goals based on the valorization of the MNPS was fundamental to identifying the most suitable CBM for the main end users of the project.

Among the CBMs present in literature, AXIA Innovation selected the classification adopted by Accenture and reported by OECD[2], where 5 types of CBMs were considered and applied to the PureNano Pilot Lines (PLs): (i) circular supply models, (ii) resource recovery models, (iii) product life extension models, (iv) sharing models, and (v) product service system models.

The Product-Service System model and the Resource Recovery Model turned out to be the most suitable CBMs for both PLs. The first model offers the companies exclusive ownership of the pilots, providing at the same time other exploitation routes. Resource Recovery was applied to the reuse/regeneration of the MNPs. This business model gives value to the materials contained in the waste streams and can be realized in the form of industrial symbiosis.

The implementation of the selected CBMs highlighted the advantages from the environmental and economic points of view and provided new inputs for further investigation. The detailed analysis is reported in the Public Deliverable 7.4 “Report on the circularity of PureNano technologies”.

6.2.2 Task 7.2: Safe by design

This task has two main results:

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[2] OECD (2019), Business Models for the Circular Economy: Opportunities and Challenges for Policy, OECD Publishing, Paris, https://doi.org/10.1787/g2g9dd62-en

1 - The application of the Safe by Design concept to the Purenano Project Pilot Lines: Creative Nano, Captive, and Gaser, was done considering the Risk assessment already made in the Deliverable 7.2. “Recommendation document on safety issues of pilot lines” and completed with the application of the nanosafety control banding tools, taking into account the current applicable legislation, the existing standards and the available risk management tools. This work is the content of D7.5 Report on Health & Safety of the new processes and technologies.

2 - Following this work an internal training session - Safe-By-design - was held which included a review of current literature highlighting which variables and parameters serve to classify the PureNano technology as tentatively safe, including hazard identification, the Stage Gate Cooper Innovation process, etc.

6.2.3 Task 7.3: Safety Lines & Nanosafety issues

This task has two main results:

1 – The application of the SbD approach to the 3 PLs Creative Nano, Gaser and Captive, with the conclusions:

a) Concerning the associated risk of the produced **MNPs** in powder, Captive decided to supply them dispersed in a solution, which is a risk measure categorised as “substitution” under the hierarchy of control. This implies a reduction in the risk level when compared to a **MNPs** handled in a powder form.

b) Liquid **NMs** suspensions typically offer less of an inhalation risk during routine operations, but the likelihood of exposure can increase significantly if they are aerosolized through sonication or in unexpected situations such as a spill.

c) For both Captive and Creative Nano PLs, their lab and pilot line scales reduce the risk of spillage or aerosolization of **MNPs**, giving them a low safety risk.

d) The Gaser PL, the use of larger amounts of **MNPs** in the purification system in open tanks could present a safety risk. In this PL the application of the Stoffenmanager control banding tool recommends that these containers should be closed, and general ventilation should be applied.

2 - Following this work an external training session - **Nanomaterials safety: The PureNano technology** - was held based on the current knowledge of nanomaterial’s risk assessment and management as proposed by several international bodies (ISO, OECD) combined with approaches that were used by the PureNano technology

6.2.4 Task 7.4: Standardization activities

Two versions of policy document (First & Final) were developed to provide an insight at key issues related to PureNano project; nanotechnology and wastewater treatment. The final document provides information regarding the standard documents referring to four major categories, fundamental for the project and its results.

6.2.5 Task 7.5: Training Activities

During the first period of the project six training activities were planned and presented in Deliverable 7.3 “Detailed training plan and material”. The planned training events were successfully implemented during the whole duration of PureNano project. Two training events were dedicated to the training of project partners, so as called, internal training activities; While four events were external training activities, aiming to present to relative stakeholders PureNano results and expected gains of the provided technology deployment in target markets. All the training activities are thoroughly presented in Deliverable 7.7 “Report on training activities”.

Table 8. *WP7 Deliverables submitted*

Deliverable Number	Deliverable Description	Date
D7.4	Report on the Circularity of PureNano technologies	30/11/2022
D7.5	Report on Health & Safety of the new processes and technologies	30/11/2022
D7.6	Report on the contribution to standards	31/07/2022
D7.7	Report on training activities	30/09/2022
D7.9	Final version of policy document	30/11/2022

Table 9. *WP7 achieved Milestones*

Milestone Number	Milestone Description	Date
MS10	Implementation of training workshop	31/07/2022

7. WP8 – LCA/ LCC

7.1 Overview of activities in WP8

This work package (WP) aimed to exploit and disseminate information to increase the awareness of the different stakeholders about the potential benefits of the PureNano developments. Thus, within the activities of this WP, both environmental, and economic impacts of the innovative PureNano purification method were assessed. The following sub-sections describe the main steps performed during the project to evaluate the sustainability of each process route, as well as the main results obtain in each activity.

7.1.1 Task 8.1: Life Cycle Analysis

In this Task 8.1. Life Cycle Analysis (LCA), the environmental impacts of the purification processes developed under the scope of the PureNano project were assessed. Moreover, the production and functionalization of the magnetic nanoparticles (MNPs) used in both spent baths were also studied. This innovative characteristic allows spent baths to have an extended life, since most of the pollutants are removed from them.

The LCA is a widely used methodology and it was performed according to the ISO standards (ISO 14 040 and ISO 14 044) throughout four steps: (i) Goal and Scope definition; (ii) Life Cycle Inventory (LCI); (iii) Life Cycle Impact Assessment (LCIA), and (iv) Results. Two different pilot lines (PLs) were studied (Cnano, and Gaser). Each of them developed a different purification technique for different spent baths (i.e., Cnano PL – spent bath from electroplating plating baths -, and Gaser PL – spent bath from electroless baths). Moreover, business-as-usual (BAU) scenarios were also studied to compare the PureNano purification routes with the conventional solutions that already exist for the spent baths. Overall, four different scenarios were studied for each PL:

- S0 – PureNano purification system, which considers the use of MNPs without their valorization (recycling).
- S0-R – PureNano purification system, which considers the use of MNPs with their valorization (recycling).
- S1 – Incineration (BAU).
- S2 – Underground deposit (BAU).

7.1.2 Task 8.2: Life Cycle Cost

The Task 8.2. Life Cycle Cost aimed to calculate the life cycle costs of the processes (spent baths purification) and products (MNPs) developed during the PureNano project. To assess the life cycle costs of each alternative, the process-based cost model (PBCM) framework was used for the same scenarios presented in Task 8.1 (S0, S0-R, S1, and S2).

This task was developed jointly with Task 8.1 since they share the same system boundaries, as well as most of the life cycle inventory (LCI).

7.1.3 Task 8.3: Eco-efficiency assessment

The eco-efficiency associated with the four scenarios depicted previously (S0, S0-R, S1, and S2) was calculated during Task 8.3. Eco-efficiency assessment. To do so, it was followed the guidelines presented in the ISO 14 045 along five main steps: (1) Goal and scope definition, (2) Environmental assessment; (3) Product-system-value assessment; (4) Quantification of eco-efficiency, and (5) Interpretation of the results.

The eco-efficiency indicator is known to be a ratio between the product value of a product and/or process and its environmental burdens. From the environmental point of view, the carbon footprint (or global warming potential – GWP) was chosen due to being a very studied, used, and well-known indicator.

7.2 Achievements and results of WP8

During the project, ISQ participated in several dissemination activities with the objective of disseminating the innovative processes developed, and their potential benefits. Specifically, a poster presentation entitled "*Life Cycle Assessment of purification and regeneration plating bath technologies with Magnetic Nanoparticles*" (Figure 1) was performed, virtually, on the 9th International Conference on Sustainable Waste Management (CORFU2022) that occurred from 15 to 18 of June 2022.

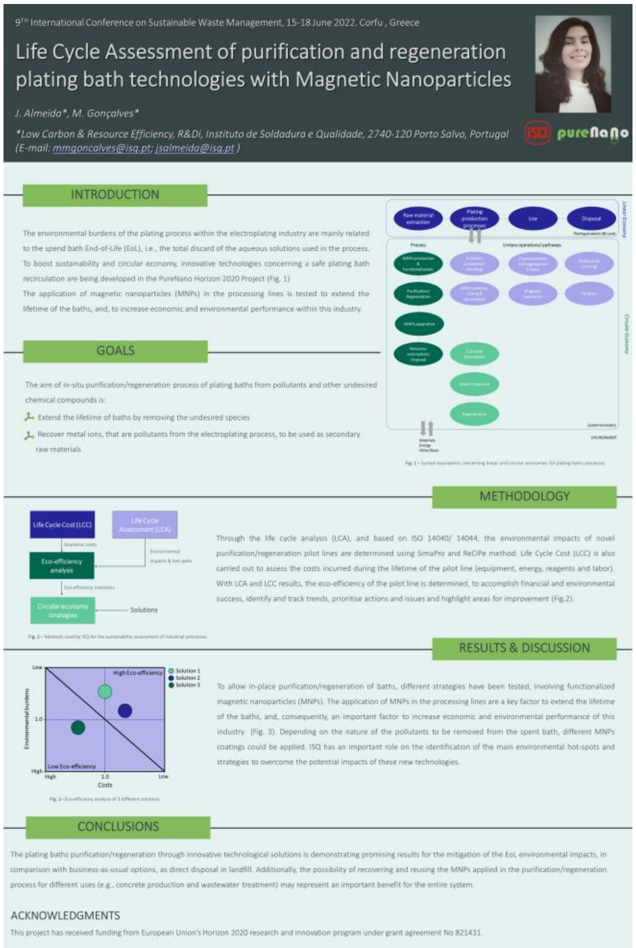


***Figure 1**. Poster presentation in CORFU2022*

Moreover, an oral presentation named "*Life Cycle Assessment of nanotechnology: carbon footprint and energy analysis*" (Figure 2) was conducted (virtually) on the 9th International Conference on Energy and Environment Research (ICEER2022) which occurred from 12 to 16 of September 2022.

Figure 2. *Oral presentation in ICEER2022*

7.2.1 Task 8.1: Life Cycle Analysis

The main achievements of this task were fully disclosed in the confidential report - D8.2. Final Report on Life Cycle Assessments (LCA, LCC). In this deliverable, the environmental impacts of the PureNano purification routes were quantified and compared with conventional alternatives already existing for the spent baths.

Overall, the analysis of the environmental impacts of MNPs production showed that the coating and functionalization of the MNPs are the main hotspots for all the impact categories under study. The same trend was observed for the production costs. Specifically, the materials used during the MNPs coating and functionalization are the main cost drivers, contributing to up to 90% of the total costs. After, two independent purification processes – carried out in Gaser and Cnano facilities – were analyzed. The environmental studies showed that the purification process itself is the main hot spot in the two pilot lines, mainly due to the use of the MNPs. When compared with the traditional processes, the results showed that the use of purified plating baths through the PureNano technology can lead to lower environmental impacts than other conventional alternatives. Specifically, when considering plating baths with burdensome additives

7.2.2 Task 8.2: Life Cycle Cost

The life cycle costs of each scenario studied within the scope of the Task 8.2 (S0, S0-R, S1, and S2) were depicted in the D8.2. Final Report on Life Cycle Assessments (LCA, LCC). In this report, the economic performance of each alternative was calculated and compared with conventional procedures for the spent baths.

In general, materials reveled to be the main cost driver differs in all processes analyzed. For the Gaser PL, the MNPs were the main hotspot. Regarding the CNano's process, the SDS additive used in the plating baths was the material that contributes the most for the processing costs, followed by

MNPs. Comparing these results with the conventional alternatives, since the production and recycling of MNPs showed to be expensive processes, the purification route evaluated at Gaser had higher costs than the conventional alternatives. Nonetheless, the PureNano alternatives could help cost to be reduced, namely when considering plating baths with expensive additives (i.e., in CNano's PL).

7.2.3 Task 8.3: Eco-efficiency assessment

The main outcomes of this task were fully presented in the confidential report - D8.3. *Final Report on Eco efficiency*. In this deliverable, the eco-efficiency of the PureNano purification routes were quantified and compared with conventional alternatives.

Generally, it was concluded that the PureNano valorization process can be more eco-efficient than other conventional alternatives due to resource recovery and reuse of valuable bath materials, as concluded for the CNano process. Additionally, some improvement measures were also suggested. For example, during the production and functionalization of the MNPs, the use of renewable sources of energy such as photovoltaic panels may be used to decrease the environmental burdens of MNPs, leading to the reduction of the spent baths purification impacts.

Table 10. *WP8 Deliverables submitted*

Deliverable Number	Deliverable Description	Date
D8.2	Final Report on Life Cycle Assessments (LCA, LCC)	30/11/2022
D8.3	Final report on Eco efficiency assessment	30/11/2022

8. WP9 – Dissemination & Exploitation

8.1 Overview of activities in WP9

WP9 was related to the exploitation, dissemination and communication activities. The overall scope of this WP was the development and implementation of a strategy in both areas, which was updated during the project and helped the partners to reach a wide audience and at the same time provided the instruments to approach the market.

8.1.1 Task 9.1: Exploitation activities

The main objective of task 9.1 was to develop an exploitation and commercialization strategy that included the i) identification of the Key Exploitable Results, ii) the analysis of the external environment, iii) and the individual exploitation strategy for the industrial partners and the research institutes. Some of these activities were implemented in the D9.3 MidPlan for the Exploitation and Dissemination of Results – PEDR and further developed in the Final plan for the Exploitation and Dissemination of Results – PEDR.

8.1.2 Task 9.2: Dissemination & Communication activities

Within this task, the dissemination and communication plan was developed and updated during the project. The strategy adopted by AXIA ensures project visibility and disposes of key performance indicators and monitoring tools that help measure the impact of the actions taken. Dissemination material (newsletter, press release, video, roll-up, posters etc.) was prepared and distributed through social media, the project website and dissemination events allowing coordinated dissemination of the results and news.

8.1.3 Task 9.3: Knowledge management and IPR protection

The content of this task includes the development of a strategy for knowledge management and IPR protection and the implementation of a Data Management plan.

The main activities carried out so far include:

- Knowledge management. This activity includes the identification, compilation, representation, and distribution process of knowledge generated
- IP Protection. A protection strategy was developed in collaboration with each partner. A patent search will support this activity.
- The collection, management, and sharing of the research data, as well as for the day-to-day quality assessment.

8.1.4 Task 9.4: Innovation management

This task includes all the activities foreseen for the implementation of the exploitation and communication and dissemination plan. Innovation management works in parallel to the dissemination and exploitation activities of project results intending to raise the awareness of stakeholders and the public.

This task included:

- The activities and materials prepared to support the exploitation and dissemination plan;
- The organization of workshops and training activities to raise awareness about the project and train the partners on how to attract the stakeholders.
- Identification and update of the Key exploitable results for the development of the business plan.

8.2 Achievements and results of WP9

8.2.1 Task 9.1: Exploitation activities

From the previous report submitted in June 2021, the following activities have been performed:

Key exploitable results

The KERs subdivision in groups was updated, but the general content and ownership were defined in the first reporting period and maintained the same.

Analysis of the external environment

The external environment analysis includes: i) PESTLE analysis, ii) Market analysis and iii) competitor analysis.

In the last year of the project, a PESTLE for the magnetic nanoparticles (MNPs) and electroplating market was developed, addressing the external forces that could affect the business of the partners working in these two areas. The PESTLE analysis provided an overview of the crucial external influences on the organizations. Regarding the MNPs analysis, all the external factors resulted to impact positively the development of this new business mainly from the economic and political points of view. Particular attention should be given to the technological aspect such as the upscaling which will require higher CAPEX and to legal factors such as the IPR enforcement.

The same applied to the electroplating market where the PESTLE analysis highlighted that a change in the waste treatment methodologies is well accepted by the market due to environmental restrictions and political actions.

The Market analysis was also extended providing further details about the market condition, the needs, the size and the diversity of the customer base. The analysis included further details about the electroplating market segmentation (based on the type of material, application, end-user sector and the geographical distribution of the key players) and market opportunities. In general, the sustainable solutions suggested by PureNano, are expected to invigorate market growth of the plating industry, shifting the business of plating shops and manufacturers towards viable regenerative processes.

The last step of the external analysis was the competitor analysis that, together with the Patent search, constitutes a strategic tool that helps identify the direct and indirect competitors of the partners' business. The competitor analysis was based on a market search and partners' suggestions and competitors in the field of MNPs production and electroplating field were identified. This analysis was completed with porter's five forces analysis which allowed us to understand the PureNano technology position within the industry and how to compare this with the potential competitors. Porter’s five forces analysis has shown t hat although the high rivalry among existing competitors, the innovative and sustainable nature of the PureNano project will help the partners to approach and penetrate the market, attracting the attention of customers who are sensitive to the sustainability topic.

Individual exploitation plan

The individual exploitation plans were further developed by adding i) SWOT analysis, ii) marketing strategy iii) and Financial analysis.

Each point of the individual business plan was developed thanks to the support of the partners who provided details of their business activities through questionnaires and personal interviews.

Relevant outcomes were obtained thanks to the implementation of the PureNano technology and the Waste Minimization approach in the Pilot Lines (PLs). In particular, Gaser estimated that PureNano technology together with the Waste Minimization approach (WM) can eliminate more than 150 t/yr of nickel waste currently disposed of. Considering the actual price of raw material, this will correspond to a saving of 15-20% on the overall costs correlated to the nickel-plating bath.

All the details related to the exploitation activities are reported in the D9.4 Final plan for the Exploitation and Dissemination of Results – PEDR.

8.2.2 Task 9.2: Dissemination & Communication activities

Website statistics

Based on statistical data, from August 2019 until the end of the project, PureNano website had 2242 unique visitors from 84 countries around the globe. Main visitors (Figure 3) were from European countries (ca 59%), followed by Asia (nearly 19%) and America (20%).

***Figure 3**. Visitors to the PureNano website*

Social media activity

The number of all social media followers increased considerably over the start of the project. The social media target was accomplished, reaching over 1000 followers in total, with more than 1000 followers on LinkedIn, 200 on Facebook, and 50 on Twitter.

Communication and dissemination kit

AXIA was responsible to monitor and prepare all the communication and dissemination activities of the project. Accordingly, the following actions were undertaken:

- Design of the PureNano Corporate Identity
- Development of the projects´ dissemination & communication kit which includes templates for agendas & presentations and for word documents, a folder, a leaflet, a roll-up, and a barcode
- Press release, Newsletter and video
- Infographic for PureNano dissemination
- Promotion materials and social media posts

The dissemination material was always uploaded to the website. Figure 4 and Figure 5 show the documents uploaded since June 2021.

***Figure 4**. Dissemination material*

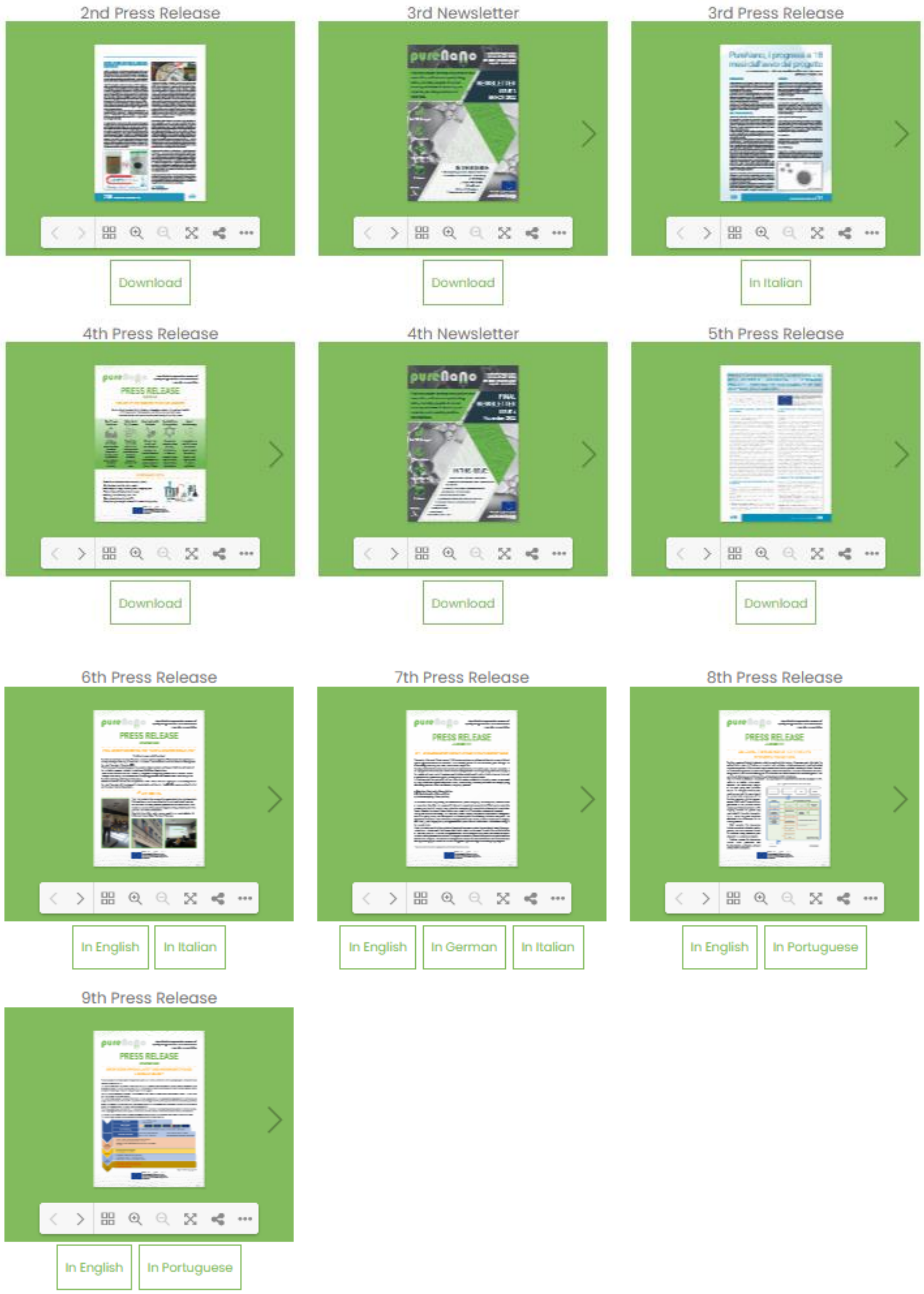


***Figure 5**. Dissemination material (press releases and newsletter)*

Newsletter

In the last year of the project, two newsletters (at M34 and M42) were published that covered the results, events and contribution to sustainability as reported in Figure 6 and Figure 7.

Figure 6. *3rd Newsletter Issue at M34*

Figure 7. *4th Newsletter Issue published at M42*

Press releases

A total number of 6 press releases were published since June 2021. The whole list of Press releases is presented in Table 11, and the ones published in the last years are shown in the following figures. The last PRs published were also translated into other languages (English, Italian, German and Portuguese) based on the language of the communication journal/website that published them.

Table 11. *Press Releases*

Press Releases			
Press Release Nr.	Content	Responsible partner	Date/Type
1	3M Meeting Press Release	AXIA	September 2019
2	PureNano Presented at Italian AIFM Magazine	ASFIMET	January 2020
3	PureNano 18M Progress Presented at Italian AIFM Magazine	ASFIMET	January 2021
4	PureNano Progress and Trends of the industry	AXIA	March 2022
5	Purenano 35M Progress presented at Italian AIFM Magazine	ASFIMET	April 2022
6	PureNano Final Consortium Meeting and Workshop activities (*)	AXIA	November 2022
7	The circularity concept applied to the PureNano project	AXIA	November 2022
8	ISQ on LCA/LCC results	AXIA	November 2022
9	ISQ on Nanosafety Results (*)	AXIA	November 2022

Figure 8*. Fourth (4th) Press Release - PureNano Progress and Trends of the finishing industry*

Figure 9*. Fifth (5*th*) Press Release - PureNano 35M Progress (AIFM Magazine)*

A purification/regeneration process of spent plating bath base on functionalized magnetic nanoparticles

PRESS RELEASE

NOVEMBER 2022

FINAL CONSORTIUM MEETING AND TRAINING ACTIVITIES IN MILAN, ITALY

PureNano is reaching its final stage!

PureNano is reaching its final stage! PureNano consortium gathered together at Politecnico di Milano premises in a two-day meeting in Milan, Italy, on the 3rd and 4th of October, under the context of the final consortium meeting before the end of the project in November 2022.
The final phase of the project focuses on the validation and demonstration activities and the further optimization of the purification processes installed in the facilities of GASER and Creative Nano.
The PureNano treatment lines were successfully integrated into the plating systems of the two industrial partners.
The spent baths coming from electroless and electroplating processes were treated to check the efficiency of the PureNano technology, obtaining promising results.
Besides the technical activities, the work performed in WP7, WP8 & WP9 is still ongoing and will be accomplished by the end of the project with the release of the standardization activities plan, the LCA/LCC analysis report and the final plan for dissemination and exploitation.

1ST DAY MEETING

The 1st day included a first overview of the project status by the project coordinator Prof. Luca Magagnin and presentations from the partners involved in technical activities. Each WP leader presented updates on the latest achievements, which included an overview of the successful integration of the purification system in the pilot lines, and MNPs functionalization.
Once this first part of the meeting was completed, the partners joined a tour visit to Technochimica and Gaser Premises in Milan area.

The PureNano project has received funding from the European Union's Horizon 2020 research and innovation programme under the Grant Agreement No. 821431

A purification/regeneration process of spent plating bath base on functionalized magnetic nanoparticles

COMUNICATO STAMPA

NOVEMBRE 2022

RIUNIONE FINALE DEL CONSORZIO E ATTIVITÀ DI FORMAZIONE A MILANO

PureNano sta raggiungendo la sua fase finale!

Il consorzio PureNano si è riunito presso la sede del Politecnico di Milano in un incontro di due giorni il 3 e 4 ottobre, nell'ambito della riunione finale del consorzio. Il progetto PureNano mira allo sviluppo di un sistema di purificazione in situ, in cui le nanoparticelle magnetiche funzionalizzate (MNPs) sono utilizzate per catturare i contaminanti da un bagno di placcatura esausto, prolungandone la durata. La fase finale del progetto si concentra sulle attività di validazione della tecnologia e sull'ulteriore ottimizzazione dei processi di purificazione installati nelle strutture di GASER (azienda italiana) e CNano (azienda greca). Le linee di trattamento PureNano sono state integrate con successo nei sistemi di placcatura dei due partner industriali. I bagni esausti provenienti dai processi di elettrodeposizione e nichelatura chimica sono stati trattati per verificare l'efficienza della tecnologia PureNano, ottenendo risultati promettenti. Oltre alle attività tecniche, il lavoro svolto nei WP7, WP8 e WP9 è ancora in corso e sarà portato a termine entro la fine del progetto con il rilascio del piano di attività di standardizzazione, del rapporto di analisi LCA/LCC e del piano finale di divulgazione e valorizzazione della tecnologia.

RIASSUNTO DEL PRIMO GIORNO DI RIUNIONE

Durante Il primo giorno il coordinatore del progetto Prof. Luca Magagnin ha dato una prima panoramica sullo stato del progetto e i responsabili delle attività tecniche hanno aggiornato gli altri membri del consorzio circa gli ultimi sviluppi. I partner coinvolti hanno mostrato il successo dell'integrazione del sistema di purificazione nelle linee pilota e della funzionalizzazione delle MNP.
Una volta conclusa questa prima parte dell'incontro, i partner hanno parlecipato a una visita guidata presso gli stabilimenti di Tecnochimica e Gaser nell'area di Milano.

The PureNano project has received funding from the European Union's Horizon 2020 research and innovation programme under the Grant Agreement No. 821431

***Figure 10**. Sixth (6th) Press Release - Final Consortium Meeting, Workshop and training activities in Milan (English and Italian versions)*

pureNano

A purification/regeneration process of spent plating bath base on functionalized magnetic nanoparticles

PRESS RELEASE

NOVEMBER 2022

WP7 – CIRCULAR ECONOMY CONCEPT APPLIED TO THE PURENANO PROJECT

The meaning of the words "Circular economy" (CE) has been explained using different definitions for a variety of different types of applications and industrial scenarios. Circular Economy provides solutions that address global challenges like climate change, biodiversity loss, waste, financial issues, and pollution[1].
Nowadays the transition towards a circular economy is fundamental since, in the last few years, the world has assisted in the rapid growth of natural resources and the increase in waste generation. The finishing industry contributes every day to the production of a vast amount of hazardous waste that is transported to specific treatment plants, where mainly chemical or electrochemical processes are applied, producing a large amount of sludge and wastes.
In PureNano project, the spent plating bath, one of the main wastes produced during the plating process, is regenerated by using functionalised Magnetic Nanoparticles (MNPs). The PureNano purification system aims to treat the spent plating bath coming from three different and commonly used plating processes:

a) Electroless Nickel plating (Gaser pilot line)
b) Zn /Cu electroplating (CNano pilot line)
c) Nickel electroplating (CNano pilot line)

On the basis of the circularity concept, after the contaminants present in the plating bath are captured, MNPs are reused or regenerated. One of the main aspects of PureNano is the possibility to regenerate the MNPs through an electrolytic process or use them for **i)** removing heavy metals from wastewater or **ii)** in concrete formulation applied in construction industry. Based on the nature of the spent baths one or more of the MNPs valorisation routes can be prosecuted.
Starting from the PureNano concept, AXIA Innovation (German Company) analysed the current end-of-life management chain in the plating industry and was responsible for the development of a methodology that had as main goals: **i)** the application of the so-called Waste Minimization (WM) approach to the pilot lines (PLs) installed in Gaser (Italian Company) and CNano, (Greek Company) and **ii)** the implementation of specific circular business model in the economic strategy of the two pilots plants.
Waste minimization consists of the application of a systematic approach to reduce the generation of waste at the source, reduce the raw materials used in the process and optimize the recycling and re-use of the waste. When applied to the PLs of Gaser and CNano, the WM includes the implementation of a set of techniques for the process modification, the drag-out reduction, and the process solution treatment, which appear to increase the process efficiency and have important economic benefits for the companies. The reduction of waste production reduces the waste treatment costs and maintenance costs showing that acting a priori instead of at the end of the pipe has a great advantage for the electroplating companies.

[1] *https://ellenmacarthurfoundation.org/topics/circular-economy-introduction/overview*

The PureNano project has received funding from the European Union's Horizon 2020 research and innovation programme under the Grant Agreement No. 821431

pureNano

A purification/regeneration process of spent plating bath base on functionalized magnetic nanoparticles

COMUNICATO STAMPA

NOVEMBRE 2022

IL CONCETTO DI ECONOMIA CIRCOLARE APPLICATO AL PROGETTO PURENANO

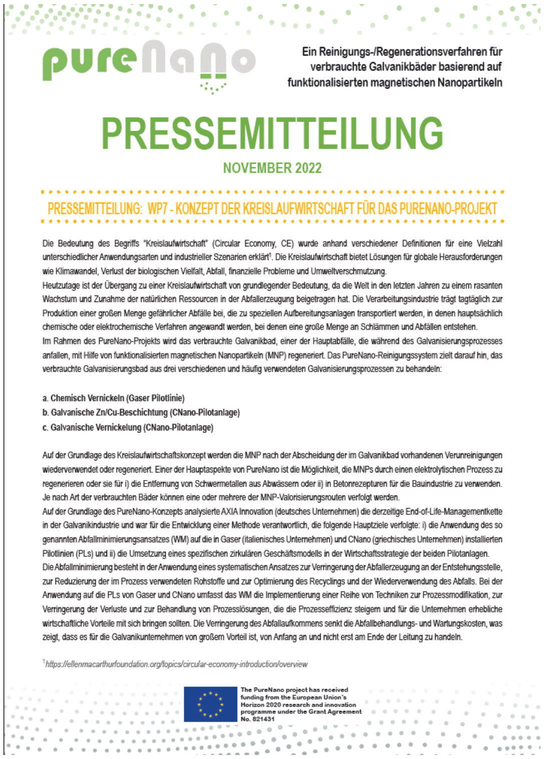
L'Economia Circolare racchiude una serie di azioni che mirano ad affrontare sfide globali come il cambiamento climatico, la perdita di biodiversità, la gestione dei rifiuti, e l'inquinamento[1].
Oggi la transizione verso un'economia circolare è fondamentale poiché, negli ultimi anni, il mondo ha assistito alla rapida crescita dello sfruttamento delle risorse naturali e all'aumento della produzione di rifiuti. L'industria galvanica contribuisce ogni giorno alla produzione di una grande quantità di rifiuti pericolosi che vengono trasportati in specifici impianti di trattamento prima di essere smaltiti.
Il bagno di placcatura esausto costituisce uno dei principali rifiuti prodotti durante il processo di placcatura. Il processo PureNano ha ideato un sistema di purificazione che rigenera il bagno utilizzando agglomerati di nanoparticelle magnetiche funzionalizzate (MNPs). Il sistema di purificazione PureNano mira a trattare il bagno di placcatura esausto proveniente da tre processi diversi e comunemente utilizzati:

a) Nichelatura chimica
b) Elettrodeposizione di Zinco e Rame
c) Elettrodeposizione di Nichel

Sulla base del concetto di circolarità, dopo aver catturato i contaminanti presenti nel bagno di placcatura, le MNPs vengono riutilizzate o rigenerate. Uno degli aspetti principali di PureNano è infatti la possibilità di rigenerare le MNPs attraverso un processo elettrolitico o di utilizzarle per i) la rimozione di metalli pesanti dalle acque reflue o ii) nella formulazione di calcestruzzo. In base alla natura dei bagni esausti, è possibile seguire una di queste strade per valorizzare le MNPs.
Partendo dal concetto PureNano, AXIA Innovation (azienda tedesca) ha analizzato le tecniche usate comunemente per la gestione dei rifiuti prodotti dall'industria della placcatura ed è stata responsabile dello sviluppo di una metodologia che aveva come obiettivi principali: i) l'applicazione del cosiddetto approccio di minimizzazione dei rifiuti (WM) alle linee pilota (PL) installate presso Gaser (azienda italiana) e Cnano, (azienda greca) e ii) l'implementazione di uno specifico modello economico (circular business model) nella strategia economica dei due impianti pilota. La procedura di minimizzazione dei rifiuti consiste nell'applicazione di un approccio sistematico per ridurre la generazione dei rifiuti alla fonte (e non dopo la loro produzione), ridurre le materie prime utilizzate nel processo e ottimizzare il riciclo e il riutilizzo dei rifiuti. Questa procedura è stata applicata ai due impianti pilota dove sono state implementate una serie di tecniche per la modifica del processo, la riduzione del drag-out ed il trattamento dei fluidi di processo, che sembrano aumentare l'efficienza del processo e avere importanti benefici economici per le aziende. La riduzione della produzione di rifiuti riduce i costi di trattamento e i costi di manutenzione, dimostrando che agire a priori ha un grande vantaggio per le aziende galvaniche.

[1] *https://ellenmacarthurfoundation.org/topics/circular-economy-introduction/overview*

The PureNano project has received funding from the European Union's Horizon 2020 research and innovation programme under the Grant Agreement No. 821431



pureNano

Ein Reinigungs-/Regenerationsverfahren für verbrauchte Galvanikbäder basierend auf funktionalisierten magnetischen Nanopartikeln

PRESSEMITTEILUNG

NOVEMBER 2022

PRESSEMITTEILUNG: WP7 - KONZEPT DER KREISLAUFWIRTSCHAFT FÜR DAS PURENANO-PROJEKT

Die Bedeutung des Begriffs "Kreislaufwirtschaft" (Circular Economy, CE) wurde anhand verschiedener Definitionen für eine Vielzahl unterschiedlicher Anwendungsarten und industrieller Szenarien erklärt[1]. Die Kreislaufwirtschaft bietet Lösungen für globale Herausforderungen wie Klimawandel, Verlust der biologischen Vielfalt, Abfall, finanzielle Probleme und Umweltverschmutzung.
Heutzutage ist der Übergang zu einer Kreislaufwirtschaft von grundlegender Bedeutung, da die Welt in den letzten Jahren zu einem rasanten Wachstum und Zunahme der natürlichen Ressourcen in der Abfallerzeugung beigetragen hat. Die Verarbeitungsindustrie trägt tagtäglich zur Produktion einer großen Menge gefährlicher Abfälle bei, die zu speziellen Aufbereitungsanlagen transportiert werden, in denen hauptsächlich chemische oder elektrochemische Verfahren angewandt werden, bei denen eine große Menge an Schlämmen und Abfällen entstehen.
Im Rahmen des PureNano-Projekts wird das verbrauchte Galvanikbad, einer der Hauptabfälle, die während des Galvanisierungsprozesses anfallen, mit Hilfe von funktionalisierten magnetischen Nanopartikeln (MNP) regeneriert. Das PureNano-Reinigungssystem zielt darauf hin, das verbrauchte Galvanisierungsbad aus drei verschiedenen und häufig verwendeten Galvanisierungsprozessen zu behandeln:

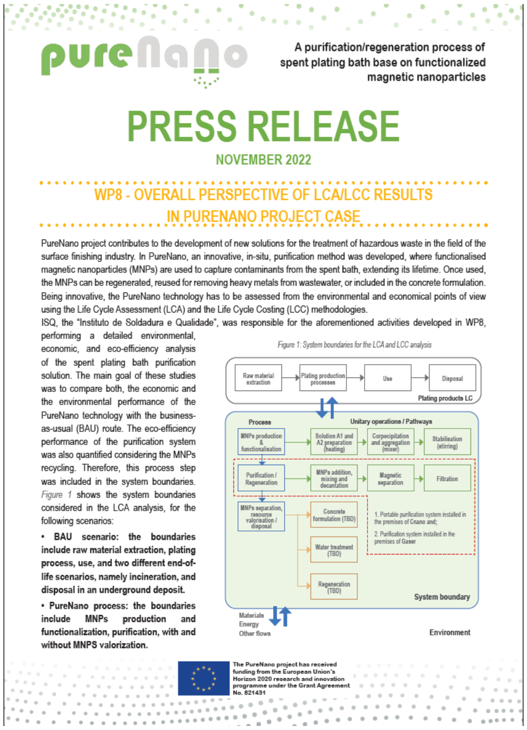
a. Chemisch Vernickeln (Gaser Pilotlinie)
b. Galvanische Zn/Cu-Beschichtung (CNano-Pilotanlage)
c. Galvanische Vernickelung (CNano-Pilotanlage)

Auf der Grundlage des Kreislaufwirtschaftskonzept werden die MNP nach der Abscheidung der im Galvanikbad vorhandenen Verunreinigungen wiederverwendet oder regeneriert. Einer der Hauptaspekte von PureNano ist die Möglichkeit, die MNPs durch einen elektrolytischen Prozess zu regenerieren oder sie für i) die Entfernung von Schwermetallen aus Abwässern oder ii) in Betonrezepturen für die Bauindustrie zu verwenden. Je nach Art der verbrauchten Bäder können eine oder mehrere der MNP-Valorisierungsrouten verfolgt werden.
Auf der Grundlage des PureNano-Konzepts analysierte AXIA Innovation (deutsches Unternehmen) die derzeitige End-of-Life-Managementkette in der Galvanikindustrie und war für die Entwicklung einer Methode verantwortlich, die folgende Hauptziele verfolgte: i) die Anwendung des so genannten Abfallminimierungsansatzes (WM) auf die in Gaser (italienisches Unternehmen) und CNano (griechisches Unternehmen) installierten Pilotlinien (PLs) und ii) die Umsetzung eines spezifischen zirkulären Geschäftsmodells in der Wirtschaftsstrategie der beiden Pilotanlagen.
Die Abfallminimierung besteht in der Anwendung eines systematischen Ansatzes zur Verringerung der Abfallerzeugung an der Entstehungsstelle, zur Reduzierung der im Prozess verwendeten Rohstoffe und zur Optimierung des Recyclings und der Wiederverwendung des Abfalls. Bei der Anwendung auf die PLs von Gaser und CNano umfasst das WM die Implementierung einer Reihe von Techniken zur Prozessmodifikation, zur Verringerung der Verluste und zur Behandlung von Prozesslösungen, die die Prozesseffizienz steigern und für die Unternehmen erhebliche wirtschaftliche Vorteile mit sich bringen sollten. Die Verringerung des Abfallaufkommens senkt die Abfallbehandlungs- und Wartungskosten, was zeigt, dass es für die Galvanikunternehmen von großem Vorteil ist, von Anfang an und nicht erst am Ende der Leitung zu handeln.

[1] *https://ellenmacarthurfoundation.org/topics/circular-economy-introduction/overview*

The PureNano project has received funding from the European Union's Horizon 2020 research and innovation programme under the Grant Agreement No. 821431

***Figure 11**. Seventh (7th) Press release on PureNano Circular Economy (English, Italian and German Version)*



pureNano

A purification/regeneration process of spent plating bath base on functionalized magnetic nanoparticles

PRESS RELEASE

NOVEMBER 2022

WP8 - OVERALL PERSPECTIVE OF LCA/LCC RESULTS IN PURENANO PROJECT CASE

PureNano project contributes to the development of new solutions for the treatment of hazardous waste in the field of the surface finishing industry. In PureNano, an innovative, in-situ, purification method was developed, where functionalised magnetic nanoparticles (MNPs) are used to capture contaminants from the spent bath, extending its lifetime. Once used, the MNPs can be regenerated, reused for removing heavy metals from wastewater, or included in the concrete formulation. Being innovative, the PureNano technology has to be assessed from the environmental and economical points of view using the Life Cycle Assessment (LCA) and the Life Cycle Costing (LCC) methodologies.

ISQ, the "Instituto de Soldadura e Qualidade", was responsible for the aforementioned activities developed in WP8, performing a detailed environmental, economic, and eco-efficiency analysis of the spent plating bath purification solution. The main goal of these studies was to compare both, the economic and the environmental performance of the PureNano technology with the business-as-usual (BAU) route. The eco-efficiency performance of the purification system was also quantified considering the MNPs recycling. Therefore, this process step was included in the system boundaries. *Figure 1* shows the system boundaries considered in the LCA analysis, for the following scenarios:

- **BAU scenario: the boundaries include raw material extraction, plating process, use, and two different end-of-life scenarios, namely incineration, and disposal in an underground deposit.**
- **PureNano process: the boundaries include MNPs production and functionalization, purification, with and without MNPS valorization.**

Figure 1: System boundaries for the LCA and LCC analysis

The PureNano project has received funding from the European Union's Horizon 2020 research and innovation programme under the Grant Agreement No. 821431

pureNano

A purification/regeneration process of spent plating bath base on functionalized magnetic nanoparticles

COMUNICADO DE IMPRENSA

NOVEMBRO 2022

PERSPETIVA GERAL DOS RESULTADOS DE LCA/LCC REFERENTES AO PROJETO PURENANO

O PureNano contribuiu para o desenvolvimento de novas soluções de tratamento de resíduos perigosos no setor de acabamento de superfície. Foi desenvolvida uma metodologia inovadora, in-situ, onde nanopartículas magnéticas funcionalizadas, doravante MNPs, são usadas para a captação de contaminantes provenientes do banho gasto, estendendo assim o seu tempo de vida. Após utilizadas, as nanopartículas podem ser regeneradas e reutilizadas para a remoção de metais pesados presentes em águas residuais ou adicionadas na formulação de betão.

Por ser uma solução inovadora, a sustentabilidade da tecnologia desenvolvida no PureNano deve ser avaliada. Desta forma, foram utilizadas as metodologias de Avaliação de Ciclo de Vida (LCA) e de Avaliação de Custo (LCC) para avaliar o sistema de uma perspetiva ambiental e econômica, respetivamente.

No âmbito do WP8, o ISQ (Instituto de Soldadura e Qualidade) foi a entidade responsável pelas avaliações supramencionadas desenvolvidas. Desta forma, realizou-se uma avaliação detalhada da performance ambiental, econômica e da ecoeficiência da tecnologia desenvolvida. Adicionalmente, os resultados obtidos foram comparados com o cenário "Business-as-usual" (BAU). A performance de ecoeficiência do sistema de purificação foi realizada, também tendo em conta a regeneração das MNPs. Desta forma, a etapa de regeneração foi tida em conta nas fronteiras do sistema. Na Figura 1, encontram-se os limites considerados para o sistema alvo de LCA e LCC dos cenários seguintes:

-**Cenário BAU: Os limites do sistema incluem a extração de matérias-primas, processo de galvanização, utilização e dois fins de vida possíveis: (1) incineração e (2) deposição em aterro;**

-**Processo PureNano: Os limites do sistema incluem a produção e funcionalização das MNPs e purificação dos banhos, com e sem valorização das MNPs.**

Figure 1: System boundaries for the LCA and LCC analysis

The PureNano project has received funding from the European Union's Horizon 2020 research and innovation programme under the Grant Agreement No. 821431

***Figure 12**. 8th Press release - ISQ on LCA/LCC Results*

pureNano

A purification/regeneration process of spent plating bath base on functionalized magnetic nanoparticles

PRESS RELEASE

NOVEMBER 2022

SAFE BY DESIGN APPROACH, SAFETY LINES AND NANOSAFETY ISSUES IN PURENANO PROJECT

PureNano project aims at the development of a purification system, able to remove contaminants from the spent plating bath, using functionalised magnetic nanoparticles (MNPs).

Two important tasks of the project were the application of the safe-by-design approach and the development of a strategy to improve the safety of the pilot lines. PureNano deals with the use of nanoparticles and therefore particular attention should be ensured concerning the utilization of MNPs and the pilots' management.

ISQ, the "Instituto d Soldatura e Qualidade", was responsible for these tasks and provided specific recommendations regarding the safety of the pilot lines (PLs) and the purification system.

The Safe-by-Design approach was implemented thanks to the close collaboration with the project partners responsible for the technical activities (Captive, Gaser and CNano), from the MNPs production to their use in the pilot lines. The partners provided information related to the i) substances used in the processes ii) operation conditions, iii) work tasks and location and iv) exposure controls (enclosures and ventilation) which were used to perform the hazard analysis and the risk and sustainability assessment.

Preliminary Hazard Analysis has shown that the risks encountered are those related to electroplating, electroless plating and chemical industries. When comparing the PLs to conventional plating and chemical labs, the main difference in terms of risks is related to the use of nanomaterials.

An inventory of the REACH requirements was compiled to advise on compliance with the REACH obligations, including nanomaterials issues.

The Safe-by-Design approach was also applied to CNano, Captive System and Gaser pilot lines.

Figure 1 Safe by Design approach

The PureNano project has received funding from the European Union's Horizon 2020 research and innovation programme under the Grant Agreement No. 821431

pureNano

A purification/regeneration process of spent plating bath base on functionalized magnetic nanoparticles

COMUNICADO DE IMPRENSA

NOVEMBRO 2022

A ABORDAGEM POR SAFE BY DESIGN, SEGURANÇA DAS LINHAS PILOTO E NANOSEGURANÇA NO PROJETO PURENANO

O projeto PureNano visa o desenvolvimento de um sistema de purificação, capaz de remover contaminantes do banho de galvanização, usando nanopartículas magnéticas funcionalizadas (MNPs).

A utilização DE nanopartículas no projeto Purenano determinou que fosse efetuada uma análise e gestão do risco para a saúde humana às Linhas Piloto. Essa análise foi desenvolvida no âmbito de duas tarefas importantes do projeto, onde foi aplicada a abordagem Safe-by-Design e o desenvolvimento de uma estratégia para melhorar a segurança das linhas piloto.

O ISQ, o "Instituto de Soldadura e Qualidade", foi responsável por estas tarefas e forneceu recomendações específicas sobre a segurança das linhas piloto (LPs) e do sistema de purificação.

A Análise Preliminar de Perigos mostrou que os riscos encontrados são aqueles relacionados com a galvanoplastia e indústrias químicas. Ao comparar os processos com a galvanoplastia convencional e de laboratórios químicos, a principal diferença em termos de riscos está relacionada com uso de nanomateriais.

Um levantamento dos requisitos do REACH foi compilado para aconselhar sobre o cumprimento das obrigações do REACH, incluindo questões de nanomateriais. A abordagem Safe-by-Design também foi aplicada nas linhas piloto das empresas Cnano, Captive System e Gaser.

Figure 1 Safe by Design approach

The PureNano project has received funding from the European Union's Horizon 2020 research and innovation programme under the Grant Agreement No. 821431

***Figure 13**. Ninth (9th) Press release - ISQ on Nanosafety Results*

All the PRs and Newsletters are available for download on the PureNano website.

PureNano Infographic

In June 2021 an infographic was designed to disseminate the project content among the main stakeholders. The infographic allows an effective and immediate visualization of the PureNano main messages as shown in Figure 14.

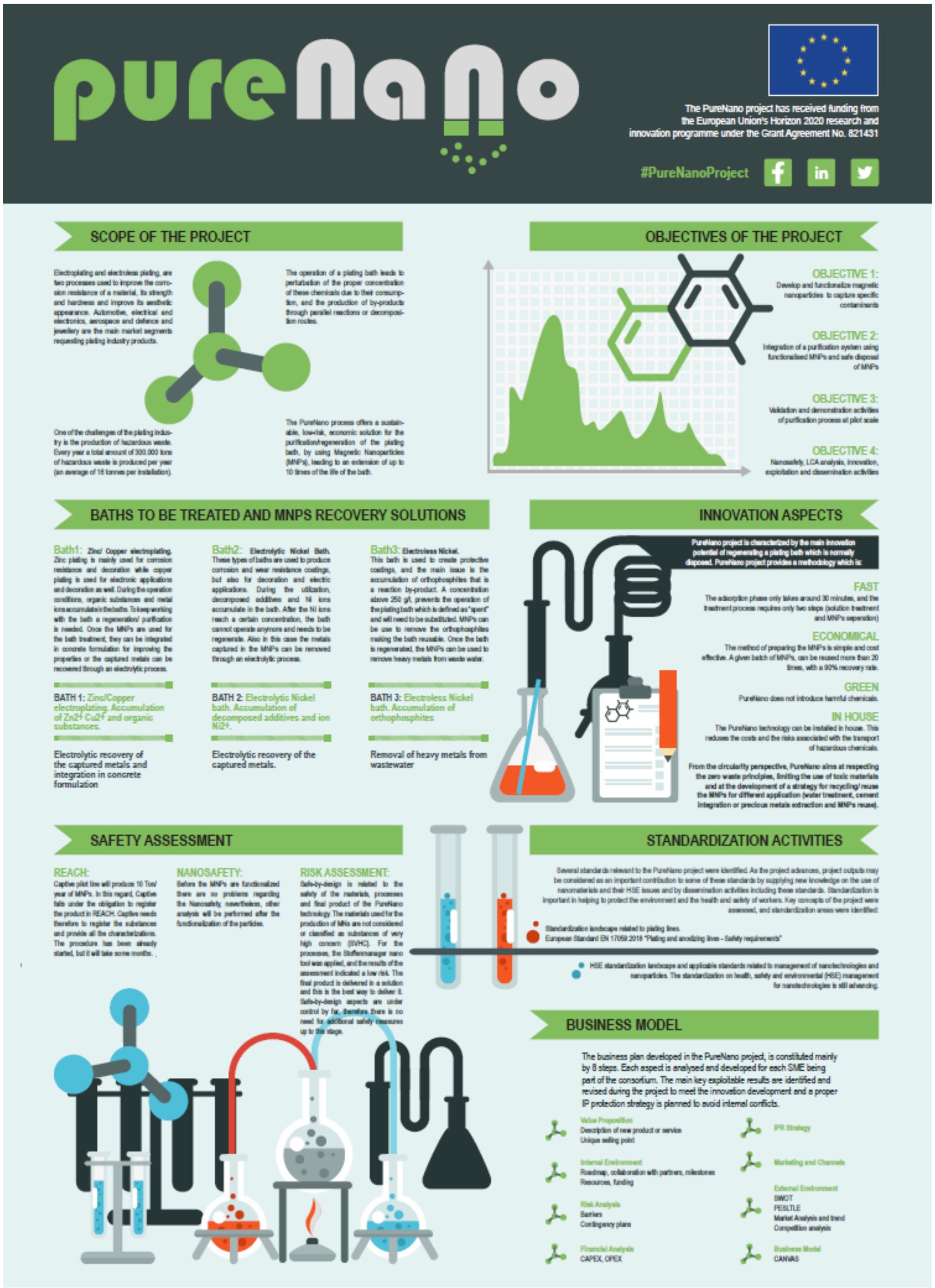
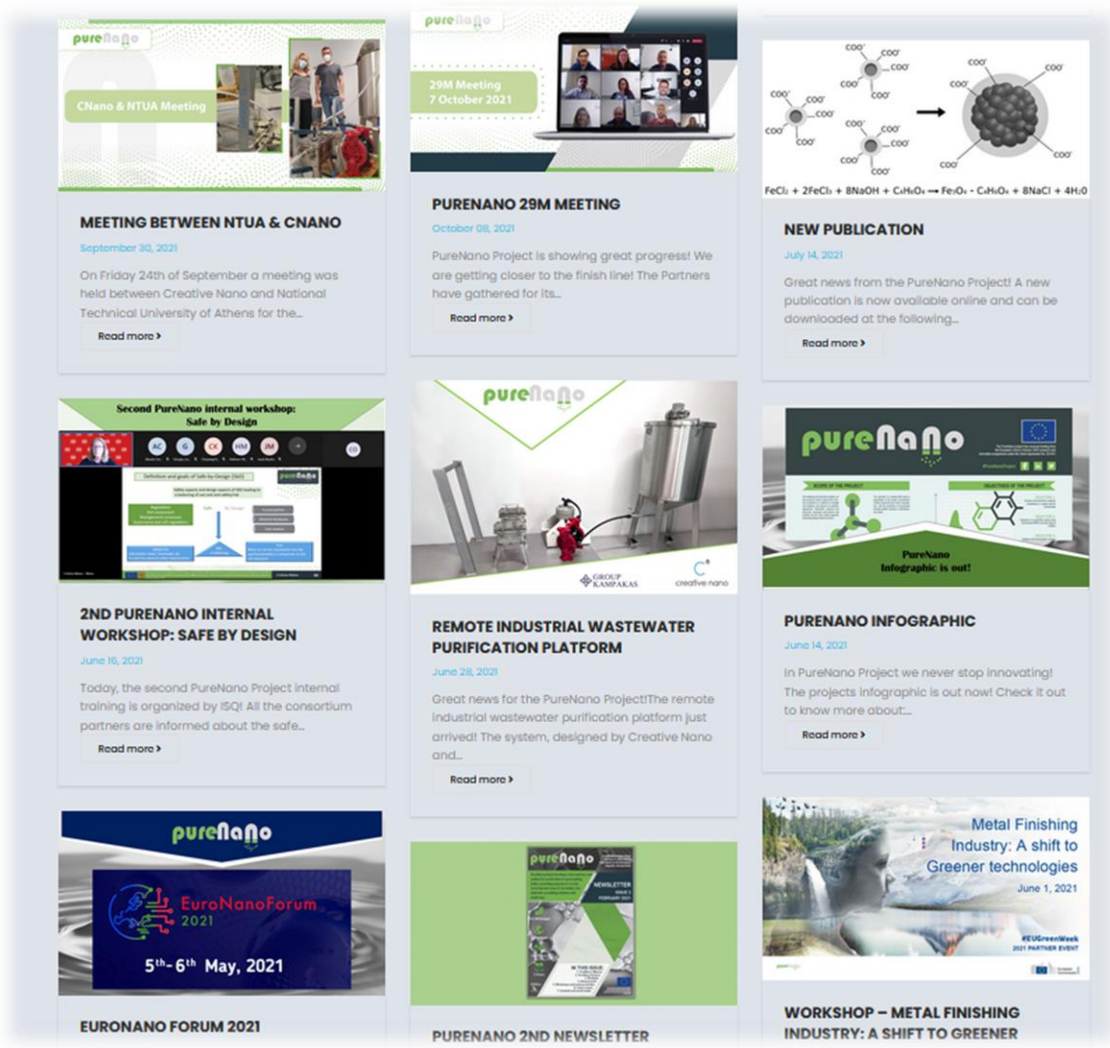
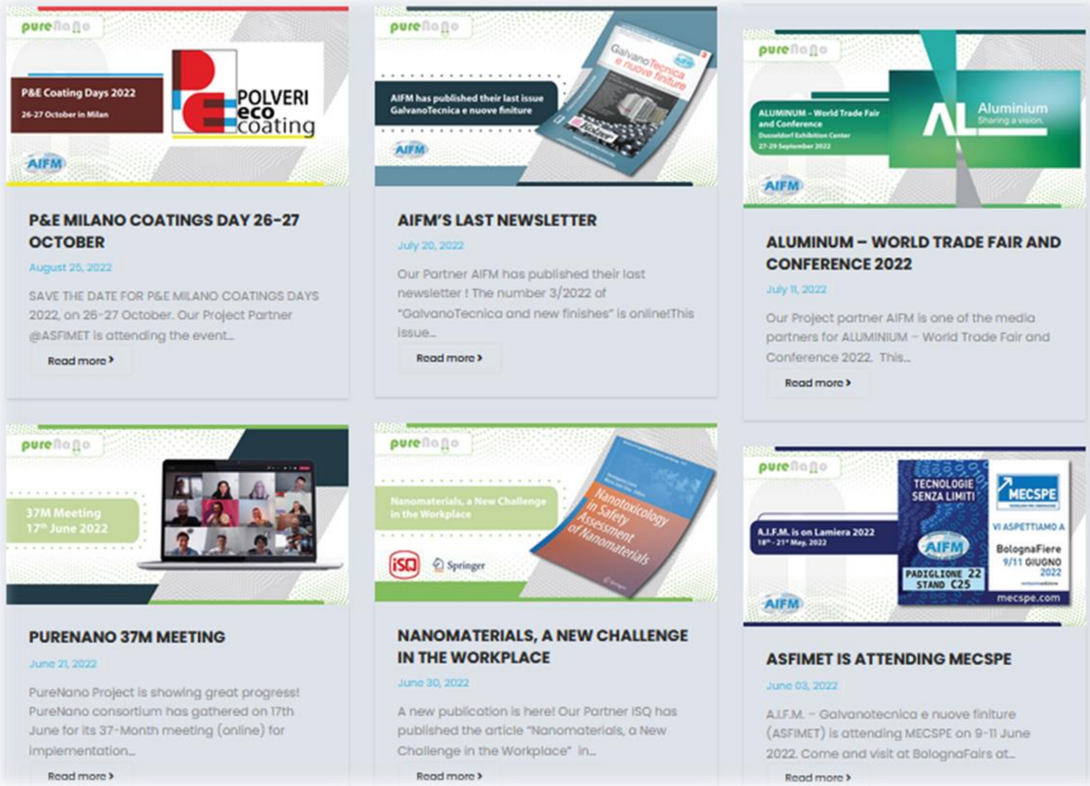


Figure 14. PureNano Infographic

Events promoted on PureNano Social Media

In the last year, many events were organised thanks to the slackening of the COVID-19 restrictions. The partners attended several conferences and workshops and each of these events was promoted on social media as reported in **Figure 15**.





P&E MILANO COATINGS DAY 26-27 OCTOBER

August 25, 2022

SAVE THE DATE FOR P&E MILANO COATINGS DAYS 2022, on 26-27 October. Our Project Partner @ASFIMET is attending the event...

Read more ›

AIFM'S LAST NEWSLETTER

July 20, 2022

Our Partner AIFM has published their last newsletter ! The number 3/2022 of "GalvanoTecnica and new finishes" is online!This issue...

Read more ›

ALUMINUM – WORLD TRADE FAIR AND CONFERENCE 2022

July 11, 2022

Our Project partner AIFM is one of the media partners for ALUMINIUM – World Trade Fair and Conference 2022. This...

Read more ›

PURENANO 37M MEETING

June 21, 2022

PureNano Project is showing great progress! PureNano consortium has gathered on 17th June for its 37-Month meeting (online) for implementation...

Read more ›

NANOMATERIALS, A NEW CHALLENGE IN THE WORKPLACE

June 30, 2022

A new publication is here! Our Partner ISQ has published the article "Nanomaterials, a New Challenge in the Workplace" in...

Read more ›

ASFIMET IS ATTENDING MECSPE

June 03, 2022

A.I.F.M. – Galvanotecnica e nuove finiture (ASFIMET) is attending MECSPE on 9-11 June 2022. Come and visit at BolognaFairs at...

Read more ›

AIFM IN IVS 2022

May 19, 2022

AIFM – Galvanotecnica e Nuove finiture is attending IVS-Industrial Valve Summit 2022 on 25th and 26th may 2022.IVS-Industrial Valve Summit...

Read more ›

AIFM IN LAMIERA 2022

May 19, 2022

AIFM – Galvanotecnica e Nuove finiture is attending LAMIERA 2022 in Milano on 18-21th May 2022 at Fiera Milano Rho,...

Read more ›

PURENANO 3RD NEWSLETTER

March 31, 2022

Great news for PureNano Project. Our 3rd Newsletter issue is out ! In this issue you will find: Electroplating towards...

Read more ›

ISQ RECENT POSTER

October 25, 2021

Great news for the PureNano Project! On 22nd October, our partners from ISQ, Cristina Matos presented their recent poster "Innovative...

Read more ›

LAST PRESS RELEASE

March 22, 2022

The Last Press release of the PureNano Project is here! This press release is focusing on: Trends of the surface...

Read more ›

NEW OPEN ACCESS PUBLICATION

December 03, 2021

Great news for PureNano Project Progress! A new open access publication is available to read and download online here: https://pubs.acs.org/doi/10.1021/acsomega.1c03142The...

Read more ›

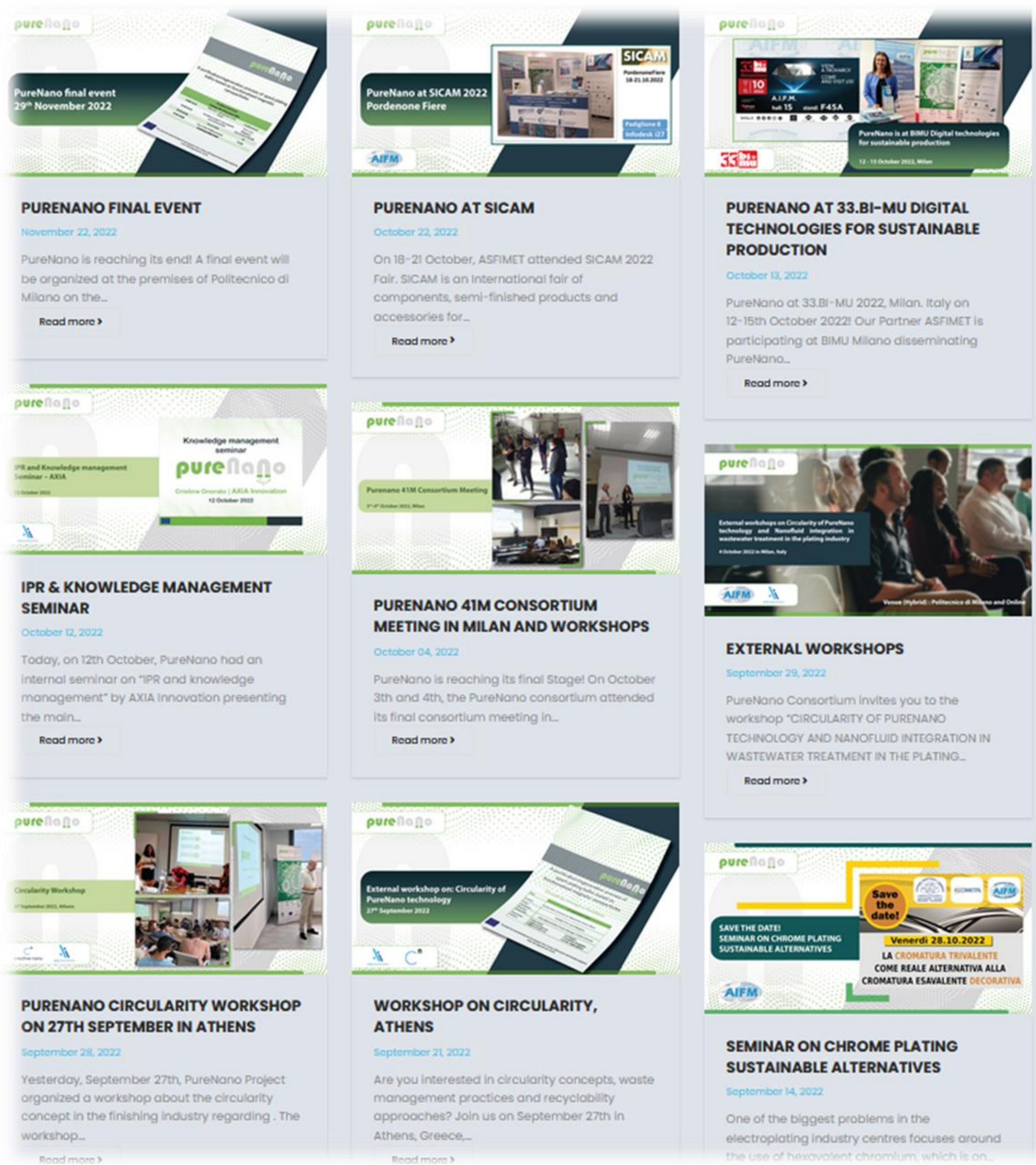


Figure 15. *Purenano dissemination events*

Workshops

In the framework of the project, different workshops were organized and promoted on social media as well. Table 12 shows the workshop organized in the last year.

__Table 12.__ PureNano training activities

Content	Responsible partner	Date/Type
Safe-by-Design	ISQ	June 2021 Internal
Circularity of PureNano technology -Athens	AXIA	September 2022 External
Nanomaterials safety: The PureNano technology	ISQ	September 2022 External
Circularity of PureNano technology - Milan	AXIA	October 2022 External
Nanofluid integration in wastewater treatment in the plating industry	ASFIMET	October 2022 External
IPR and Knowledge Management Seminar	AXIA	October 2022 Internal

Also, in this case the workshops were advertised on social media through dedicated posts which are shown in the following figures.

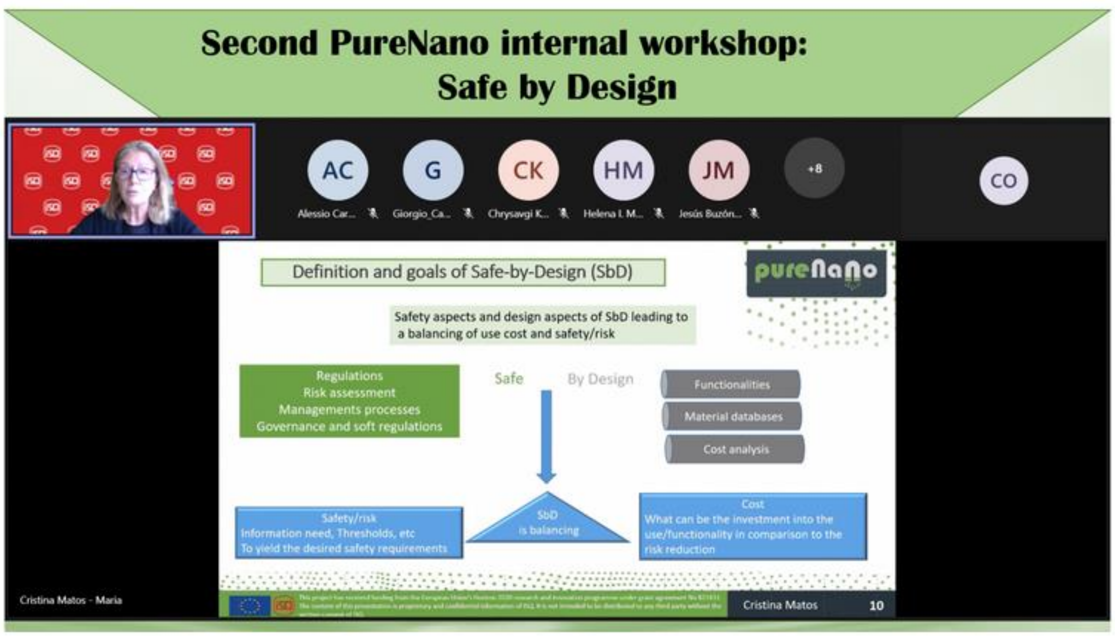


__Figure 16__. ISQ – Nanosafety Issue Workshop - Internal on 22 September 2022

***Figure 17**. AXIA– External Circularity Workshop on 27 September 2022, Athens*

***Figure 18**. AXIA– Consortium meeting, external Circularity Workshop and External Nanofluid integration in wastewater treatment in the plating industry on 4 October 2022, Milan*

Figure 19. AXIA– Internal IPR and Knowledge management Seminar on the 12th of October, 2022

Final video

The final PureNano video was published at the end of the project to show the last achievement of the project.

Figure 20. PureNano H2020 project Final video

The video is available in PureNano channels and youtube[3].

8.2.3 Task 9.3. Knowledge management and IPR protection

Within this task, several activities were performed during the project.

[3] https://www.youtube.com/watch?v=eFAwNvRbtw0

As mentioned above a **Knowledge management seminar** was organized to give an overview of the Rules and the Agreements in H2020 projects, define some important terms frequently used, highlight the importance of IPR protection and explain the legal tools available for protecting the IP. In the second part of the workshop, AXIA described the patent mapping procedure highlighting the steps already performed within the PureNano project. The workshop was recorded and is available for the partners for internal use only[4]

A **questionnaire** was distributed in the first year of the project to acquire information related to the KERs that the partners wanted to claim and the related protection intention. This questionnaire was shared several times during the project to update the partners' intentions. Figure 21 shows the exploitation plan for the KERs based on the answers from the partners. The research institute expressed mainly the intention to follow the scientific exploitation route, while the SMSs the market exploitation, provision of services and further exploitation within the company.

The Exploitation plan was supported by the activities performed within task 9.1 and a dedicated patent search developed in the area where the partners expressed the intention to file a patent, i.e. the functionalization method for the MNPs developed within the project.

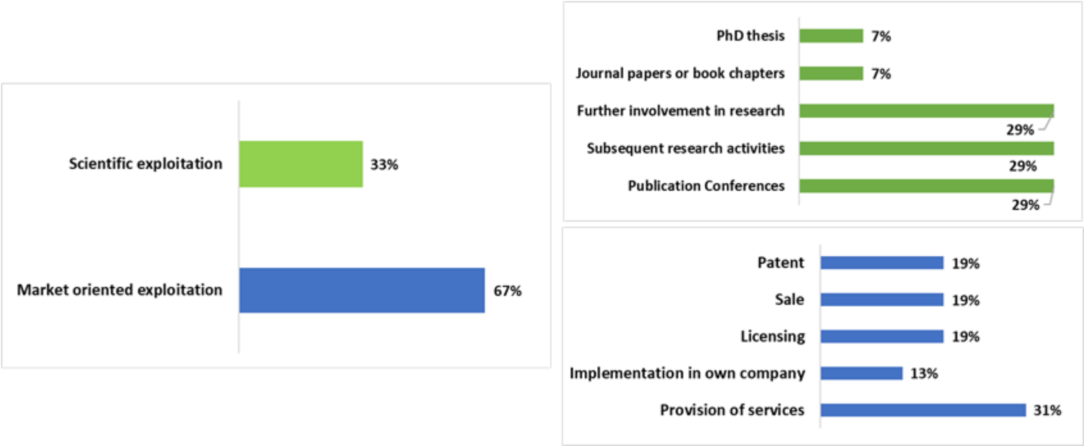


Figure 21. *Exploitation plan for the KERs*

Patent Mapping

Patent mapping allows an understanding of the weakness and the strength of an invention from a different point of view. The methodology applied in PureNano followed precise steps which are shown in **Figure 22**.

[4] https://www.youtube.com/watch?v=7XRlCjRxv9I

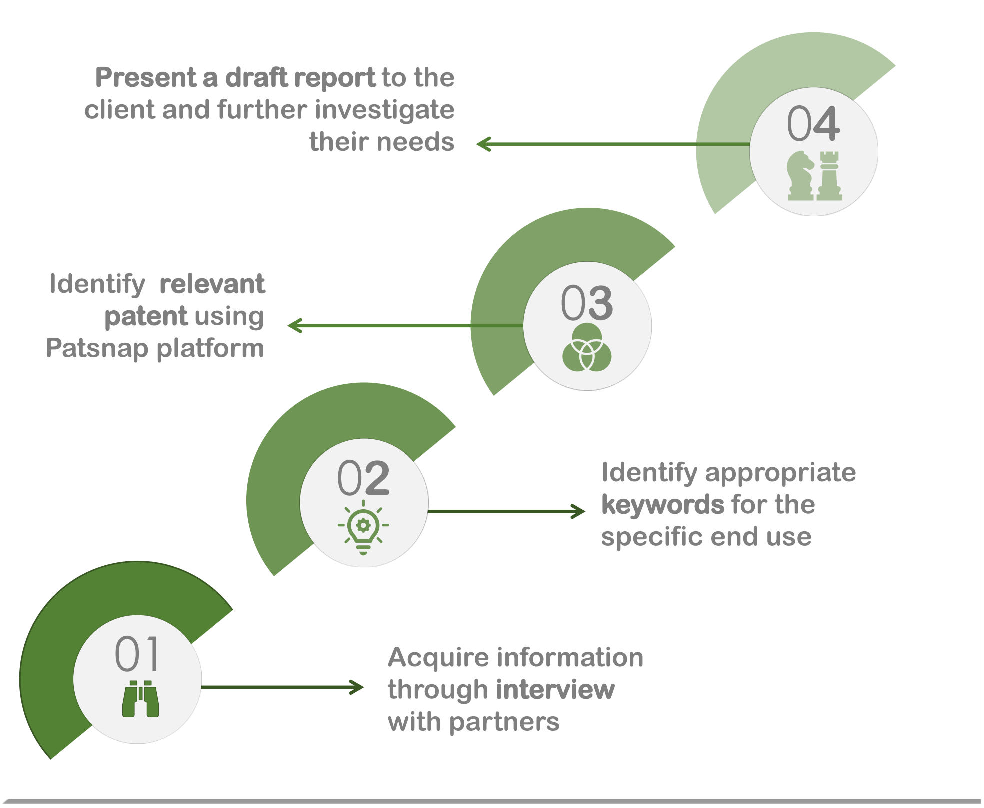


Figure 22 *Patent Mapping methodology*

The applied methodology was constituted by the following steps:

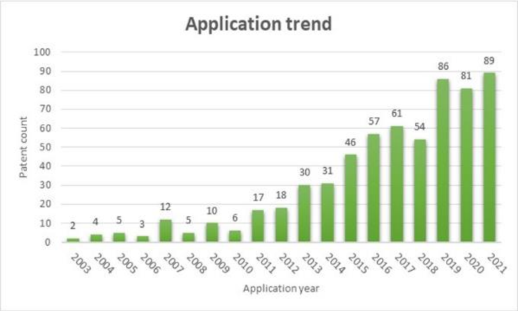
- A dedicated patent search questionnaire was developed by AXIA and distributed to the partners to acquire more information about their field of expertise identifying and defining the state of the art of the innovation.
- Keyword identification: The most relevant keywords were collected and included in the search through a licensed patent search platform, PatSnap[5].
- Patent Analysis: An initial search using the identified keywords was performed and refined to get the relevant patents.
- Detailed analysis of patents: A final report (included in D9.5) was delivered including a list of highly relevant patents, the number of patents over the time series, identified top competitors, categorization by country, etc.

The patent search was structured following the bottom-up approach. The first searches were made using the main expression "Magnetic Nanoparticles" and some other related keywords, although they did not bring consistent results. Thus, new searches were conducted using the main expression and filtered by relevant CPC codes afterwards this search was further refined including other keywords such as "functionalized" and "metal ions".

Some relevant figures were extracted such as the global application trend and the top global authorities as shown in Figure 23. In particular, the search showed that the interest in patent

[5] www.patsnap.com/

technologies related to MNPs has been rising in the last years, therefore this is a growing field with the potential for patenting new technologies.



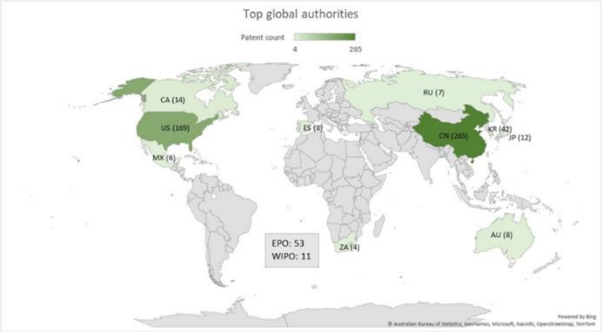


Figure 23 *Global application trend and the top global authorities*

A detailed patent list was compiled and included in Deliverable D9.5 "Knowledge management and IPR protection". In addition, to complete the whole analysis and further support the partners who are going to file a patent, AXIA provided a general overview of the steps to follow for the patent application.

8.2.4 Task 9.4: Innovation management

The activities within this task supported the development of the dissemination and exploitation plan. The actions consisted of the organization of training and seminars (such as the Stakeholder engagement training and the Knowledge management and IPR seminar), the distribution of questionnaires and the definition of the steps needed for the external and internal environmental analysis and development of the individual business plan.

The strategy developed allowed to have an idea of the opportunity and challenge that the partners will face to reach the commercialization of their results. The management of the innovation includes all the analyses performed in these years and will continue with the further exploitation of the results and collaboration with the partners and other external end users to reach higher TRLs.

Table 13. *WP9 Deliverables submitted*

Deliverable Number	Deliverable Description	Date
D9.4	Final plan for the Exploitation and Dissemination of Results – PEDR	30/11/2022
D9.5	Detailed report on knowledge management and IPR Protection	30/11/2022