Project title:

Development of a real-time information and monitoring system to support the risk assessment of engineered nanomaterials (ENMs) under REACH

Project Acronym: **NanoMONITOR**

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Deliverable

DA3. Report on reliable information sources on the concentration of ENMs in industrial, urban and environmental compartments

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Action Leader		ITENE	
Responsible Author		Name Beneficiary	E-mail Phone

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PROJECT CONSORTIUM INFORMATION

Beneficiary	Contact
ITENE (Packaging, Transport & Logistics Research Centre)	Carlos Fito cfito@itene.com Maida Domat maida.domat@itene.com
AXON Enviro-Group Ltd	Athena Progiou ap@axonenviro.gr
The Mediterranean Center for Environmental Studies (CEAM)	Jose Luis Palau joseluis@ceam.es
The REACH Centre	Judith Friesl / j.friesl@thereachcentre.com Stella Stoycheva / s.stoycheva@thereachcentre.com

List of acronyms

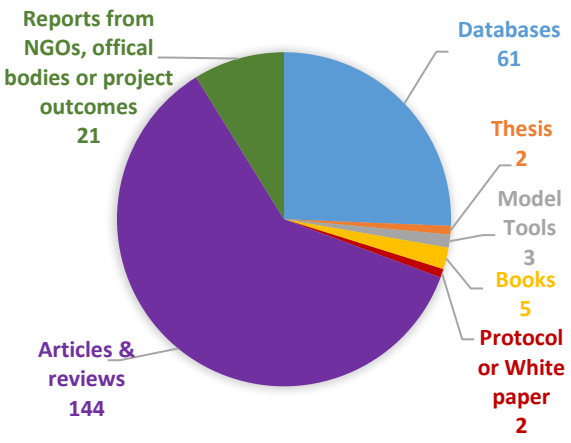
CES:	contributing exposure scenarios
ECHA:	European Chemicals Agency
EHS:	Environmental, health and safety
ENM:	Engineering nanomaterial
ES:	Exposure scenario
NM:	nanomaterial
OC:	Operative conditions
RA:	Risk Assessment
RMM:	Risk management measures
REACH:	Regulation on Registration, Evaluation, Authorisation and Restriction of Chemicals

Summary

Present deliverable **D.A3.a. "Report on reliable information sources on the concentration of ENMs in industrial, urban and environmental compartments"** aims to compile relevant exposure data information sources that should be taken in consideration for exposure information gathering in the context of REACH Regulation to assist risk assessors in order to meet the information requirements upon exposure assessment. It includes:

- A description of the methodology used to identify relevant information sources and reliability of data.
- A list of identified information sources with indications of which ones are relevant for this purpose.

This document will be focused on the definition of the information sources to be employed in the data gathering process, including databases used under the framework of environmental monitoring programs, scientific publication containing measured data on the concentration of ENMs, as well as scientific and technical reports and deliverables published as part of research and development projects.



To this end, the most relevant sources of information containing measured data on the concentration of ENMs, as well as relevant contextual data related with the information requirements and criteria defined in action A2 have been identified, and the gathered information compiled into Microsoft® excel spreadsheets, including the complete reference of the source (i.e. author, title, publication year, and abstract), as well as the URL address or direct link to download the source.

The classification of the complied sources of information is carried out in terms of relevance for each of the criteria and information requirements stablished within action A2, considering least aspects such as representability of the data included, reliability of the data published concerning the physicochemical properties of the ENMs, with special emphasis on data on the size distribution, particle diameter surface area and surface chemistry, relevance of the route of exposure, including inhalation, dermal and oral exposure, appropriateness of the doses/concentrations tested or identification of the critical parameters for risk assessment purpose within REACH.

Around 240 sources of information coming from different kinds of monitoring programs or studies were analysed, obtaining more than 60% of positive evaluation, from which more than 30% are fully reliable and can be used as they are and the rest need additional information to be employed in monitoring of ENM concentration in different environments.

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1. Scope and goal of the deliverable

Task A3 of the NanoMonitor project deals with the "Information gathering and analysis of the existing environmental monitoring data". Results from this task are presented in two deliverables, DA3a and DA3b, as described below.

Present deliverable, **DA3a "Report on reliable information sources on the concentration of ENMs in industrial, urban and environmental compartments"**, is focussed on the definition of a set of reliable exposure information accessible **sources**, with existing monitored data. These data are intended for using in the exposure estimation in the scope of the exposure assessment when undertaking the Risk Assessment process according REACH Regulation. With that aim, deliverable DA3a worked in the scope of Task A3, is based on the results of the sub-tasks as described below:

- Task A.3.1.: Compilation of information sources, in which a thorough compilation of existing information sources on the concentration of nanomaterials in the environmental, urban and industrial compartments was undertaken.
- Task A.3.2. Evaluation and classification of the sources, in which a detailed analysis of the necessary considerations for the classification of sources of published measured data as reliable or not was undertaken. The evaluation was done considering the score system developed in task A2 regarding the validity of an existing monitoring data. Most appropriate data sources were selected according the studied aspects.

Therefore, present deliverable contains:

- A description of the methodology used to identify relevant information sources and reliability of data;
- A list of identified information sources with indications of which ones are relevant.

In addition, and already in the scope of the Task A.3.3., an analysis and selection of reliable data on the concentration of nanomaterials in industrial, urban and environmental compartments was undertaken. As a result, an inventory of these data was developed, and results presented in deliverable **DA3b "Inventory of data on the concentration of ENMs in industrial, urban and environmental compartments**", recompiled into Microsoft® Excel spreadsheets.

2. Introduction: Required minimum information and quality of data to estimate exposure to nanomaterials

For risk assessment process, **exposure level** determination is a key step. Release and exposure estimation under REACH aims to quantify the expected exposure when the conditions of use as described in the exposure scenario are implemented. Such quantification enables concluding on whether the risks can be adequately controlled. For each studied scenario, a corresponding exposure data set (for the various environmental compartments or various route of exposure to humans) is to be derived[1].

2.1. According EC Regulation REACH

The REACH Regulation is the European Union's Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH) Regulation (EC) No 1907/2006[2]. For ensuring the safety, **REACH Regulation requires** to undertake a **risk assessment of chemicals**. Risk Assessment process is undertaken in three main steps which are:

1. Hazard assessment: identification and characterization
2. Exposure assessment: definition of exposure scenarios and exposure estimation
3. Risk Characterization

For each defined exposure scenario, expected exposure when the conditions of use as described in the exposure scenario are implemented is determined for risk characterization.

REACH Regulation requires that **existing adequately measured, representative exposure data** are taken into account in the exposure assessment, either on their own or in combination with modelled exposure estimates. Moreover, when dealing with nanomaterials, the use of simulation studies replicating the task or activity of concern should be taken into account when considering the use of measured data, especially taken into account the limitations of modelled estimates for nanomaterials. The risk assessor may then for example make use of monitoring data related to worker's exposure or releases to the environment from for example their own or of well-known customer site-specific information, and also from simulation studies and modelled estimates.

Considering that, the **hierarchy for the use of exposure data when dealing with nanomaterials** would be preferentially[3] to use as first option measured data (having quantified key exposure determinants) and when not available, to use appropriate analogous data, including data derived from simulation studies. As the last option would be to use modelled estimates.

[1] ECHA (2016). Guidance on Information Requirements and Chemical Safety Assessment. Part D: Framework for exposure assessment – Draft Version 2.0 (Public) April 2016.

[2] Regulation (EC) No 1907/2006 of the European Parliament and of the Council of 18 December 2006 concerning the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH), establishing a European Chemicals Agency, amending Directive 1999/45/EC and repealing Council Regulation (EEC) No 793/93 and Commission Regulation (EC) No 1488/94 as well as Council Directive 76/769/EEC and Commission Directives 91/155/EEC, 93/67/EEC, 93/105/EC and 2000/21/EC (OJ L 396, 30.12.2006).

[3] ECHA (2016). Guidance on information requirements and chemical safety assessment. Appendix R14-4 Recommendations for nanomaterials applicable to: Chapter R.14 Occupational exposure estimation.

When dealing with occupational and environmental exposure assessment in the context of REACH, sources of measured data which could be used are:

- measured data taken under the actual exposure settings for the exposure scenario to be developed (company data). For example, data generated to comply with other legislation or to evaluate the effectiveness of the RMMs in place. Measured data required for site licences and permits (with documented number/frequency of sampling, analytical methods, basic statistics) can be a good source of information for REACH.
- exposure information from monitoring databases with regulatory purposes, when information requirements enabling a robust assessment are fulfilled.
- Exposure information from peer reviewed publications, when information requirements enabling a robust assessment are fulfilled.
- biomonitoring data.
- Simulated process data

In all cases, it is essential that used documentation is available and referred to in the Chemical Safety Report. In particular, a description of the methodology applied (for measurements/data collection) should be available as well as a reasoning why the data are considered relevant for the release estimation from the specific use/contributing scenario[4].

The information needed to s**atisfactorily support the suitability and representativeness** of the used data, as **indicators of good quality**, are:

- ✓ reference to: quality schemes, standard sampling, and measurement methodologies;
- ✓ context: enough description to support the intended scope;
- ✓ clear description of monitored tasks;
- ✓ clear information on risk management measures in operation during sampling;
- ✓ details of duration and frequency of tasks and an assessment if the sampling duration is representative of full-shift exposure or only for the task duration;
- ✓ whether data are current rather than historical (i.e. sampling period to be reported);
- ✓ collection from a wide range of the sites and processes covered by the use description;
- ✓ statistical descriptors available.

Even in well-defined situations, available exposure data have substantial variability, and is strongly associated with implemented OC and RMM at the moment of measure. Both, **exposure variability** and representativeness (contextual, spatial, temporal) of the data to the settings to be assessed, need to be taken into account.

Measured data variability is reflected by the **spread of the distribution** of the individual exposure data points. This variability may be introduced through a number of factors, which include: differences in application of operational conditions, level of (substance) throughput, other local conditions, variability in performance of RMM, or behavioural differences between workers.

[4] ECHA (2016). Chapter R.16: Environmental exposure assessment. Version 3.0 – February 2016.

Exposure distributions can be reasonably described by the **geometric mean** (GM) and the **geometric standard deviation** (GSD). GM estimates the central tendency of the distribution, meanwhile GSD indicates the spread of the distribution.

On the other hand, **percentiles** show the percentage of the measured exposure levels that are at or below a certain value (e.g. the 90th percentile value indicates that 90% of the measured exposure levels are at or below that value). In general, the 90th percentile value of a distribution within a generally suitable dataset (i.e. a dataset corresponding to the conditions described in a contributing scenario) should be used as the exposure value for the risk characterisation. Under particular conditions, other percentiles may be applicable as well but a justification should be provided. High values as well as values under the detection limit should remain in the distribution unless there is a reasonable justification from the assessor.

Finally, when appropriate representative measured data are not available for the substance, an alternative is the use of measured data for analogous substances, always when the analogous substances have close enough physicochemical properties, or from analogous situations, a similar enough task, with justification, providing an appropriately conservative outcome.

A higher level of suitability, representativeness and quality of data shall be provided for higher concerns of hazard of the substance.

2.2. According to Environmental Monitoring Programs

Monitoring data is composed of numerical data and associated information, often referred to as meta-data[¡Error! Marcador no definido.].

Fundamental metadata required to support the monitoring data includes:

- *the target chemical,*
- *analytical method and performance information for the analysis;*
- *sampling protocol;*
- *sampling location and time;*
- *information on the nature of the sample;*
- *other relevant information*

Although some monitoring data are available, being collected for regulatory purposes or in the scope of different R&D&i projects, there exist several shortcomings for using them in exposure assessment and modelling purposes (application, calibration, validation), especially when dealing with chemicals substances at the nanoscale. The most **common critical deficiencies** related to the available current data are:

- Lack of information on the *context* in which the data were generated and clear objectives of the monitoring programme: representativeness (location, duration, frequency), address temporal variability of sources and system dynamics;
- The *quality of data* is not indicated and cannot be traced;
- Data presented are aggregated and *raw data* cannot be obtained;
- It is not clear whether the monitoring *data represent* hot spots or are representative of background conditions;

The identification of **the target chemical limit of detection and limit of quantification (defined by analytical method); sampling location and sampling time and frequency, are key elements**

for using the data confidently for exposure assessment[¡Error! Marcador no definido.]. Thus, it is highly recommended that these meta-data elements are collected when comparing data compiled from different sources.

Quality assurance and quality control are important for high quality monitoring data. **Key elements in assuring the quality of monitoring** data are: **utilising reference materials; conducting inter-laboratory studies; and reporting the quality assurance procedures used to collect the data**[56].

2.3. Particular considerations when dealing with environmental exposure data for nanomaterials

Apart from existing natural and accidentally produced nanomaterials, the production, use and disposal of engineered nanomaterials leads to the release of nanomaterials to the environment (industrial, urban and environment compartments) along their life-cycle. But nowadays, the exact amount of nanomaterials present in such compartments is not totally clear.

Measurement of the concentration of exposure to nanomaterials provides particular challenges. These include mainly the discrimination from background particles, collection and analysis of size information, effective high spatial and temporal variability, choice of metrics and measurement instruments, and measurement of high aspect ratio nanomaterials[7]. Other problems are related with:

- Hugh variety of existing nanomaterials (no grouping consensus)
- Lack of well stablished reference materials
- Not existent complete standardized protocols for calculation of stream concentration
- Not existent standardized measurement units for all nanomaterials: at least mass concentration (mg m^{-3}), but where possible also particle number (units m^{-3}) and/or surface area (m^2 m^{-3}) are given. The metric used to assess exposure to nanomaterials should be that which most closely links to any potential health effect.
- Not existent sensible and specific analytical methods neither techniques which can probe nanomaterials speciation

The state of knowledge on these issues is in constant development and shall be taken into account when using measured exposure data.

Taking into account that limitations, different exposure data generating methods exists giving relevant environmental exposure data for nanomaterials. These methods can be divided into the three categories: **analytical methods *in situ*; simulation (pilot and laboratory scale studies) measurements and extrapolations; material mass flow analysis and simple models;**

[5] UNEP (2004). Guidance for a Global Monitoring Program on Persistent Organic Pollutants, 1st Ed., UNEP.
[6] UNEP (2007). Guidance on the Global Monitoring Plan for Persistent Organic Pollutants, Preliminary version, amended in May 2007.
[7] ECHA (2016). Guidance on Information Requirements and Chemical Safety Assessment. Part D: Framework for exposure assessment – Draft Version 2.0 (Public) April 2016.

probabilistic mass flow analysis; and kinetic modelling[8] [9]**.** Up to date, different analytical measuring techniques are available in order to provide data on the concentrations of nanomaterials the environment. Techniques for measuring ultrafine particles and nanoparticles in air are most developed. Different works already investigates nanomaterials in water samples but still fewer work has been focused at nanomaterials concentration determination in sludge and soils.

Different simulation studies at laboratory/pilot plant scale have been undertaken in order to study the fate and behaviour of nanomaterials in different scenarios, and thus aiming to validate the analytical procedures for nanomaterials determination in different matrixes[9].

Regarding methods for modelling exposure to nanomaterials, probabilistic mass flow analysis treats the different parameters in the model as distributions. On the other hand, the computer simulations Monte Carlo and Markov Chain Monte Carlo are intended to generate estimates of sediment and groundwater concentration and also of emissions from production, manufacturing and recycling processes of nanomaterials and nanoproducts. Finally, kinetic models are those which specifically intends to reflect the dynamic behaviour and fate of nanomaterials in environmental compartments[8].

[8] Milieu Ltd (2012). Final Report Environmental Exposure to Nanomaterials – Data Scoping Study. Service Contract No.07.0307/2011/610874/ETU/D.3

[9] ECHA (2012). Guidance on information requirements and chemical safety assessment. Appendix R14-4 Recommendations for nanomaterials applicable to Chapter R.14 Occupational exposure estimation

3. Methodology

In order to work on the compilation and analysis of available information of the concentration of ENMs in industrial facilities, urban environments and relevant ecosystems, a throughout collection and review of the relevant sources of information, including relevant databases containing information on the concentration of particulate matter, scientific publications and published reports from project related with the scope of the project must be accomplished. Due to the quantity of information to be processed, some selection and classification criteria must be established and followed.

3.1. Compilation of information sources

This task was focused on the definition of the information sources to be employed in the data gathering process of the exposure assessment according REACH Regulation, including databases used under the framework of environmental monitoring programs, scientific publication containing measured data on the concentration of nanomaterials, as well as scientific and technical reports and deliverables published as part of research and development projects.

To this end, there were identified the most relevant sources of information containing measured data on the concentration of ENMs, as well as relevant contextual data related with the information requirements and criteria defined in action A2. Once identified, the information was compiled into Microsoft® Excel spreadsheets, including the different field to complete reference of the source (i.e. author, title, publication year, and abstract), as well as the URL address or direct link to download the source).

In order to define which information sources could be within the scope of the project, some criteria were defined and followed. The sources must contain verified information on the main parameters to be provided to the competent authority for the safe monitoring of NMs and nanoproducts. Thus, before applying the quality criteria of action A2, a pre-selection of sources is applied which requires a minimal set of meta information, such as the origin of the data set (governmental agency, research center, project outcomes...), publication year and scope or aim of the information compilation.

Once this information is available, the source is classified attending to some priority criteria: most recent studies are ranked before older ones, likewise, official studies form governmental bodies, universities or research organisms are given higher importance than individual studies. The completeness of the data set is also taken into account, finished studies, conclusive reports or updated datasets are ranked in first order.

Regarding the types of sources, several formats are analyzed:

- Books or book chapters
- Peer reviewed publications in scientific journals
- Conference papers and communications
- White papers / protocols /guidance
- Databases from research or official monitoring bodies
- PhDs or other kinds of research work
- Reports from project outcomes

In this sense, the base of data is formed by the most official or contrasted data sets, coming from official bodies or peer reviewed publications in order to confirm their reliability. Afterwards, protocols, white papers, book chapters and PhD theses are included, and finally the conference papers and reports from projects, since results can be not contrasted or completed.

Concerning the scope of the datasets, it is searched within all the scenarios of coverage of the project, that is, human exposure in industrial, environmental and urban environments and the release of materials and NMs to the three environmental compartments: water, air and soil, considering besides in all cases natural, incidental or intentional occurrence.

One important aspect, but not determinant for the inclusion of the dataset into the repository, is the availability of the information: whether it has public access or not, and similarly, the metadata extraction possibilities. While the first case, not being public access databases is not cause of exclusion of the compilation, the difficulty of extraction of the metadata could cause a degradation on reliability and quality classification of the dataset.

Based on the previous criteria, a repository of almost 250 different sources of datasets related with the concentration of ENMs in industrial, urban and environmental compartments is gathered and classified.

3.2. Evaluation and classification of the sources

After the first filter and selection of datasets, it must be worked on the classification of the sources of information complied in the previous task, identifying the main databases, scientific publication and reports for each compartment addressed within the project and assessing their completeness and reliability.

To achieve such objective, each of the sources were characterized in terms of relevance for each of the criteria and information requirements stablished within action A2. Each of the sources were evaluated, considering at least the following aspects:

- Representativity of the data included.
- Reliability of the data published concerning the physicochemical properties of the ENMs, with special emphasis on data on the size distribution, particle diameter surface area and surface chemistry.
- Relevance of the route of exposure, including inhalation, dermal and oral exposure
- Appropriateness of the doses/concentrations tested
- Identification of the critical parameters for risk assessment purpose within REACH

The evaluation will be conducted following a score systems based on the adequacy of the data included to the quality criteria defined in action A2.

In accordance to previous outcomes, it is stated that **existing adequately measured, representative** exposure data can be taken into account in the exposure assessment, either on their own or in combination with modelled exposure estimates[10]. The adequateness of the data is stated by a series of characteristics related with:

[10] REACH, Annex I Section 5.2.5.

- **Measured data** taken under the actual exposure settings for the exposure scenario. It requires information such number/frequency of sampling, analytical methods, basic statistics.
- Exposure information from **monitoring databases** with regulatory purposes, when information requirements enabling a robust assessment are fulfilled.
- Exposure information from **peer reviewed publications**, when information requirements enabling a robust assessment are fulfilled.
- **Biomonitoring data** (data from samples of living organisms (biota) may be used.

In all cases, it is essential that some basical quality criteria are fulfilled to use the existing dataset, which were selected and listed in DA2a and DA2b. Some of the main metadata from the dataset that must be present are:

- Objective of the programme
- Particulate and scenario
- Analytical method
- Units
- Limit of detection and quantification (LOD/LOQ)
- Background concentration
- Recovery
- Accuracy and Reproducibility
- Sampling protocol details
- One shot or mean
- Location
- Date and time of sampling
- Matrix characteristics
- Analytical method
- Proximity and influence of sources
- Discharge emission pattern and volume
- Flow and dilution of water body sampled
- Description of statistical evaluation of results

However, some problems arise when combining or comparing data from different databases, some of them related with the data quality: in many cases monitoring programmes/databases have no classification of data reliability; thus the importance of the application of the quality criteria for classification of sources. Another issue is related with the locations and periods of measurement of the sources: same process or NM in different countries, locations, laboratories or periods of time could lead to erroneous correlation of results, therefore clearly state date, time and location is important to follow the evolution of a monitorized data.

An aspect that is seldom if ever taken into account is the changes of instrumentation over time, either in the same dataset for long time trends (change of batteries, liquid feeding in case of CPCs or waste or decalibration of internal gears) or due to evolution of measurement instruments wih the outcome of new models and updates, which difficult the comparability of older measurements with recently ones. This is also related with the differences in sampling methods, units, correction methods, etc; either inter-instrumental and/or inter-procedural.

Thus, there is a need for information to understand and categorize the main emission sources (e.g. diffuse, point, wide dispersive) and measuring procedures.

Some actions and efforts that can be carried out in order to overcome the previous issues are related with the consistency of followed methodology and performance characteristics (e.g. precision, accuracy, sensitivity), try to follow a similarity of monitoring and sampling strategy, and state a consistency of units and reporting format, trying to group the data sources among these criteria in order to allow wider and reliable comparability.

4. Sources of information on the concentration of ENMs in industrial, urban and environmental compartments

In order to find the most recent and complete data sources of exposure of particulate material, and specially nanomaterial, several tools were employed in the process of analysis, which are listed in the Table 1, along with some of their descriptive characteristics, such whether it provides public access to its results, if is nano-specific and a brief analysis of some of their pros- and cons- for the application within the scope of the project.

Table 1: Tools and databases employed to search for sources of information.

Database	Specification	Free Access	Scope	Pros	Limitations
ACTRIS	General	Yes	Datasets	Easy access and visualization on maps	
CaNanoLab	Nanobiomedicine	Yes	Protocols, material characterization and literature		
CEINT protocols	Protocols nanomaterials	Yes	Protocols for testing nanomaterials		Limited at the moment
Eionet Reporting Obligations Database (ROD)	General	Yes	Repository of air quality information from EU Member States and other EEA member and co-operating countries, submitted according to Directives 2004/107/EC and 2008/50/EC.		Some reports out of date
EPO	General	Yes	Patents: Europe		
Espacenet	General	Yes	Patents: Spain and LATIPAT		
European Soil Data Centre (ESDAC)	General	No	Datasets, libraries, models, publications		Only soil
Google Patents	General	Yes	Patents: Only US at the moment		
Google Scholar	General	Yes	Papers, letters, notes, reviews, books	If the pdf is freely accessible, it is shown	-Difficult to organize searches, usually organized by Google
InterNano	Nanomaterials	Yes	Processes	-Data extracted in the database	-Very specific
Nanomaterial Registry	Nanomaterials	Yes	Nanomaterials characterization		Only physico-chemical characterization
NBI knowledgebase	Nanomaterials	Yes	Nanomaterials and biological interaction	-Data extracted in the database	

Database	Specification	Free Access	Scope	Pros	Limitations
NHECD	Nanomaterials	Yes	Papers, letters, notes, reviews, books	-Database shows what kind of data is interesting from the health, safety and environmental point of view -Data extracted in the database	Not completely actualized
PubMed	General	Yes	Papers, letters, notes, reviews, books		
Reaxys	General	No	Papers, letters, notes, reviews, books	Search by drawing (organic and organometalic molecules)	Centred in papers for chemists
SCIFinder	General	No	Papers, letters, notes, reviews, books	Search by drawing (organic and organometalic molecules)	Centred in papers for chemists
Scopus	General	No	Papers, letters, notes, reviews, books		
USPTO	General	Yes	Patents: US		
Web of Knowledge (WoK)	General	No	Papers, letters, notes, reviews, books		-Only peer-reviewed journals -Missing papers from newest journals (important in nanoworld)
WIPO Patentscope	General	Yes	Patents: WO and LATIPAT, EPO, ARIPO and some countries		
WISE	General	No	Models, projects and reports		For water bodies

Based on these search tools and repositories, the information sources found to be employed in the data gathering process include databases used under the framework of environmental monitoring programs, scientific publications containing measured data on the concentration of ENMs, as well as scientific and technical reports and deliverables published as part of research and development projects.

All the references were compiled in detail in an Excel sheet which is attached to this document, along with its main properties, URL and classification, although in Table 2 in Annex B can be found a summary of these sources sorted by publication type, year of release and complete reference. Following the selection criteria from previous section, there were found:

- 144 peer reviewed publications in form of articles and scientific papers,
- 61 databases or repositories containing datasets on particulate matter, ENMs, air, soil or water quality or human exposure,

- 21 reports from project outcomes, NGOs or official bodies,
- 5 books related with the monitorization of nanoparticles,
- 2 PhD theses,
- 2 white papers, modelling tools or protocol reports,
- 3 Modelling tools.

Each of the data sources was classified according to the environment being monitored, as it was scored in the action **A2**, that is:

- Occupational (worker)
  - Indoor
  - Outdoor
- Urban /Rural
  - Indoor
  - Outdoor
- Environmental
  - Air
  - Water
  - Soil
- Modellization

It must be taken into account that the same source could be analysing more than one kind of scenario, for example, the same study covering release of NPs measured and modelled in occupational surroundings and their spread to the neighbour environmental compartments through the life cycle would encompass 6 types of situations.

The results of the classification are shown in

Figure *1*, where the distribution of the urban, occupational and environmental scenarios is rather equitable, although in general the studies are focused on the airborne NMs and indoor occupational studies are the most popular.

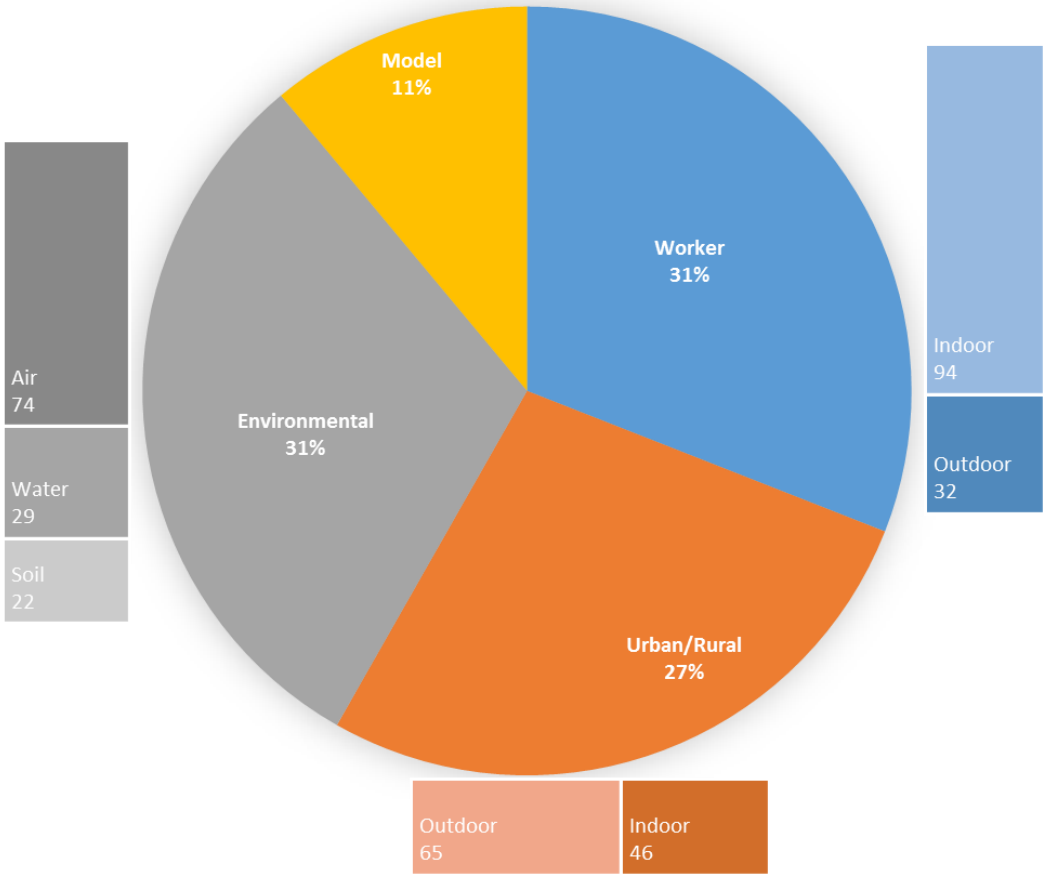


Figure 1: Classification of the data sources based on the type of scenario monitored.

This is probably due to several factors: workers are the first link of the chain in contact with the NMs, even to its bulk form. Also the inhalation is the preferred route of entrance of the NPs to the body[11,12], and the air the main way of transport of released NPs to other compartments. Likewise, the instrumentation necessary to measure airborne nanoparticles can provide results in real time, contrary to the measuring devices for water and soil, which require further treatment. Finally, despite the lack of specific legislation regarding NPs, the companies are interested in controlling the incidental and intentional releases, thus their participation in projects of monitoring rate is higher. Consequently, the popularity of these studies.

Regarding the kind of publication most prevalent within each category of setting, in Figure 2 can be seen a representation. It must be taken into account again that some types cover more than one category, thus they are counted repeatedly.

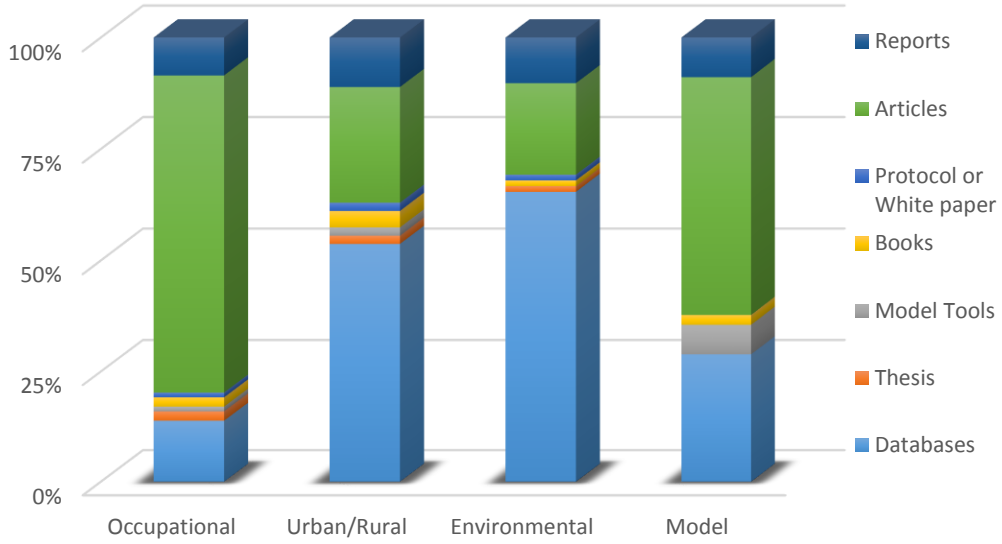
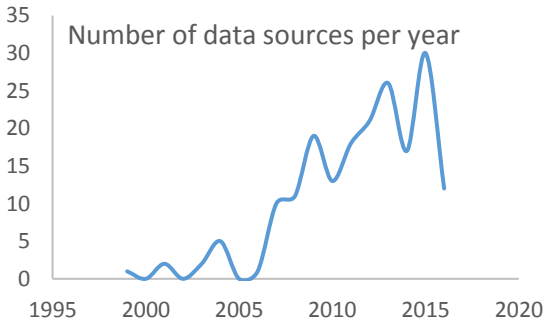


Figure 2: Ranking of the type of data source depending on their origin.

Scientific articles are the most common mean of publication of data regarding occupational and modelling studies, while the urban and environmental compartments are preferably monitored continuously through environmental programs which store results in databases. The number of reports, either form project outcomes or official bodies are similar in all fields, meaning that all the fields are similarly covered, but perhaps that other means of dissemination are preferred.



The list will be continuously revised and updated until the end of the project, since, as shown in the graph at the right, there has been a steep increase of studies in this field in the last 10 years, although their production is not constant.

[11] D.E. Evans, L.A. Turkevich, C.T. Roettgers, G.J. Deye, P.A. Baron, Dustiness of fine and nanoscale powders, Ann. Occup. Hyg. 57 (2013) 261–277.

[12] D. Stephenson, G. Seshadri, J.M. Veranth, Workplace exposure to submicron particle mass and number concentrations from manual arc welding of carbon steel, Aiha J. 64 (2003) 516–521.

5. Procedure for source reliability determination

Within REACH is required that **existing adequately measured, representative exposure data** are taken into account in the exposure assessment, either on their own or in combination with modelled exposure estimates. With the aim of providing reliable datasets and sources, collected data are sorted according to the requisites of information and data quality given by REACH Regulation (for measured exposure concentrations use) and main monitoring programs (for generated measured data incorporation in the databases).

To achieve such classification of the complied sources of information, each of the sources is characterized in terms of relevance for each of the criteria and information requirements stablished within action **A2**. Each of the sources has been evaluated considering at least the following aspects:

- Representativity of the data included.
- Consistency of the data published concerning the physicochemical properties of the ENMs, with special emphasis on data on the size distribution, particle diameter surface area and surface chemistry.
- Relevance of the route of exposure, including inhalation, dermal and oral exposure.
- Appropriateness of the doses/concentrations tested.
- Identification of the critical parameters for risk assessment purpose within REACH.

The evaluation has been conducted following a score systems based on the adequacy of the data included to the quality criteria defined in the Excel tool "*Reliability Assessment for Exposure Data.xlsm*" from action **A2**, extracting the background meta-information from each source in order to pass the test tool and obtain a reliability classification, shown by colours in the last column of Table 2 from Annex B and indicating the following:

Classification	Explanation	Colour code
NO VALID	Indicates that fundamental information is missing to ensure the completeness and reliability of the data set, and the data are weak or inconsistent to be used as part of a study.	
VALID WITH RESTRICTIONS	Complementary information would be required to ensure the completeness of the data.	
VALID	The data is reliable and complete and can be used with confidence within the REACH context to estimate the PEC or PNEL.	

From the 238 datasets analyzed, it was found that 103 were catalogued within the "*No Valid*" classification score, 104 of them are "*Valid With Restrictions*", mainly due to the lack of morphological studies or the solely use of models, and the remaining 31 datasets are completely reliable, being classified as "*Valid*" following the scoring system stated in action **A2** of the NanoMonitor project. Thus, the use of data for comparison with recent measurements must be subject to this classification.

5.1. Occupational studies

As stated previously, the occupational environment is the most largely studied, especially in indoor locations. From the 126 studies covering the workers' exposure to ENMs, 94 are inside

the company, and only 32 outside. In Figure 3 can be seen the classification of the reliability these studies attending to the meta-information accompanying on them.

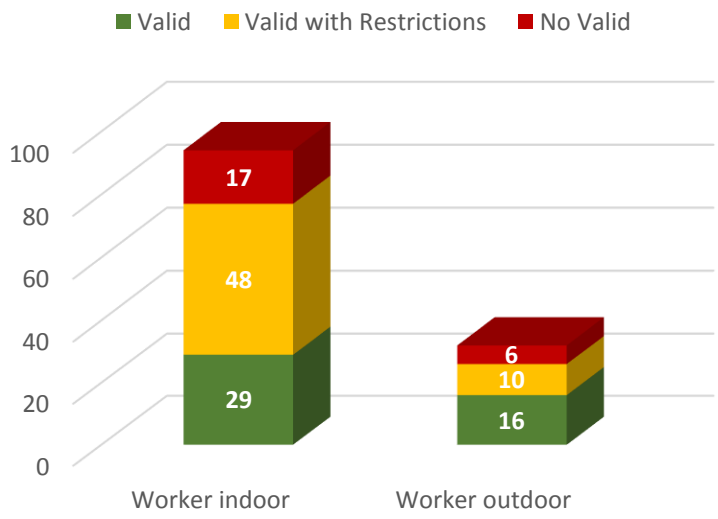


Figure 3: Scoring of the studies related to occupational exposure.

In both cases, for the majority of studies more information would be necessary, normally regarding to morphological analysis and chemical speciation of the NMs in focus, but also due to the use of models to predict results, which is performed in 8 of the cases. In any case, the ratio of fully reliable studies is rather high and can be used directly without any further consideration.

5.2. Urban / Rural studies

In the case of studies in the urban /rural areas, most of them are related with traffic emissions, thus they are performed outdoors. In Figure 4 can be seen the number of these studies classified by reliability, being the big majority not fully consistent due to again the lack of morphological information of the NMs and the use of modelled data, which are not qualitative but quantitative.

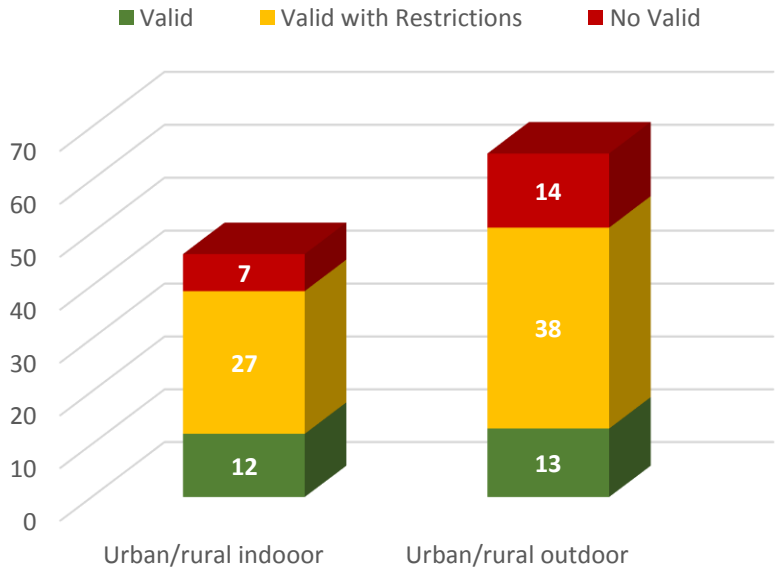


Figure 4: Scoring of the studies related to urban /rural exposure.

5.3. Environmental studies

Most of the environmental studies are performed from governmental or official bodies, which create platforms to continuously monitor the levels of different gases (see Figure 2), climatic conditions and particulate matter, mainly in the atmosphere as can be seen in Figure 5 but also the quality of water bodies and soil.

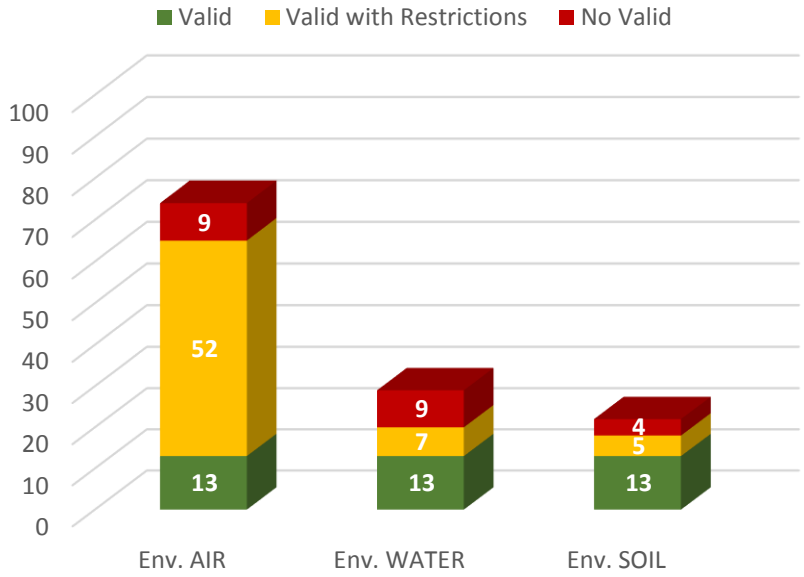


Figure 5: Scoring of the studies related to environmental exposure.

Similarly to the previous cases, since the long-term monitoring studies require autonomy of the measurement devices, morphological studies are seldom carried out, thus the completeness of the meta-information is compromised a the majority of the datasets are classified within the yellow band.

5.4. Modellization studies

The case of the studies based on models and modelling tools was analyzed in action **A2**, where it was deduced that due to the quantitative nature of the results and the lack of defined ranges of precision of the outcomes, the classification nof results due to sololy modelling would not achieve the fully reliability and not fall into the “green zone”. Thus, the classification of data sets from this kind of data is shown in

Figure 6.

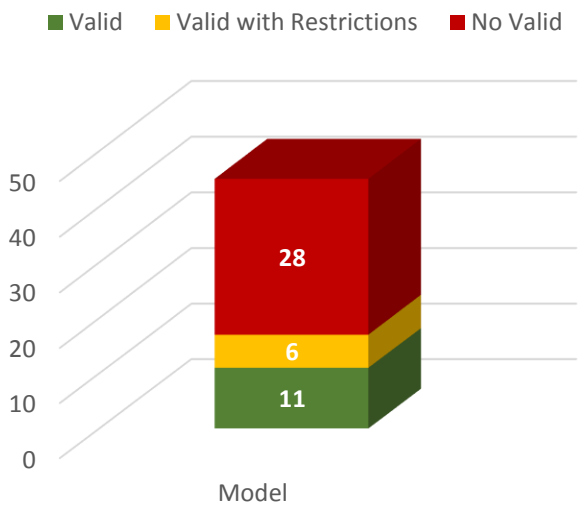
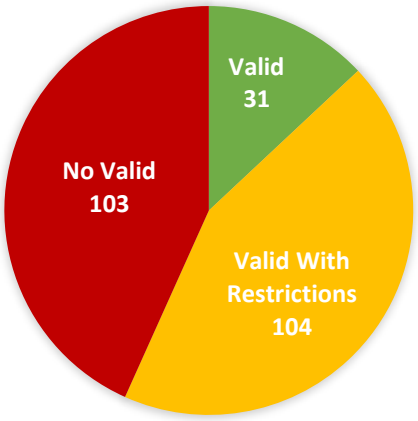


Figure 6: Scoring of the studies performed by modelling.

6. Conclusions

In the present deliverable **DA3a "Report on reliable information sources on the concentration of ENMs in industrial, urban and environmental compartments"**, a throughout compilation of available sources of information such as datasets, scientific publications and project reports is carried out. More than hundred references were extracted from scientific publications, project outcomes, official institutions' reports or databases, and mined and classified the information regarding to particulate matter and specially nanoparticle monitoring mainly on air, but also on other environmental and industrial and urban compartments.

Subsequently, it was undertaken an analysis of the necessary considerations for the reliability classification of sources of measured data on the concentration of nanomaterials in the environmental, urban and industrial compartments. These classification was assumed considering the requisites stated previously in the project and applying to the metainformation of the datasets.



The result of the classification is that 14% of the sources are completely reliable as they are, while 47% of them would need additional information to be fully consistent, being classified as valid with restrictions. On the other hand, 39% of the sources have fundamental information missing, thus completeness and reliability of the data set cannot be guaranteed, and the data are weak or inconsistent to be used as part of a study.

In any case, results from the analysis are positive, since more than half of the sources analysed (58,3%) can be used up to some extent for comparability and completeness of the mapping of the particulate matter and nanoparticle monitoring through different locations and scenarios in Europe.

Regardless of the classification, quantitative data from all the previous sources will be extracted and compiled identifying relevant information on the concentration of ENMs in industrial, urban and natural environments in the next task of the action A3.

Data gathered will be structured and organized following the structure required by REACH, as well as relevant standardized structures for reporting air quality information, such as NASA Ames Format for Data Exchange, or the Air Quality Data Exchange Module (DEM), WebDab and EBAS data reporting formats, key databases for using measured data in the evaluation of the impacts of pollutants in the environment.

7. Annex A

Link to the complete Excel Sheet "Dataset Source Gathering and Classification".

8. Annex B

Table 2 summarizing the outcomes from the Excel Sheet gathering and classification.

Title	Authors / Source	Year	Type of source	Journal	Vol	Issue	Pag	CLASSIFICATION
Measurements of the physical properties of particles in the urban atmosphere	Roy M. Harrison, Marcus Jones, Gareth Collins	1999	Article	Atmospheric Environment	33		309-321	**Valid With Restrictions**
Concentration of ultrafine, fine and PM 2,5 particles in three European cities	J. Ruuskanen, th. Tuch, H. Ten Brink, A. Peters, A. Khlystov, A. Mirme, G.P.A. Kos, B. Brunekreef, H.E. Wichmann, G. Buzorius, M. Vallius, W.G. Kreyling, J. Pekkanen	2001	Article	Atmospheric Environment	35		3729-3738	**Valid With Restrictions**
Nanoparticles: An occupational hygiene review	R.J. Aitken, K.S. Creely, C.L. Tran	2004	Report					**No Valid**
Exposure to carbon nanotube material: aerosol release during the handling of unrefined single-walled carbon nanotube material	Maynard AD, Baron PA, Foley M, Shvedova AA, Kisin ER, Castranova V	2004	Article	Journal of Toxicology Environmental Health	67	1	87-107	**Valid With Restrictions**
Characterization of urban and rural organic particulate in the Lower fraser Valley using two Aerodyne Aerosol Mass Spectrometers	M. Rami Alfarra, Hugh coe, James D. Allan, Keith N. Bower, Hacene Boudries, Manjula R. Canagaratna, Jose L. Jimenez, John T. Jayne, Arthur A. Garforth, Shao-Meng Li, Douglas R. Worsnop	2004	Article	Atmospheric Environment	38		5745-5758	**Valid With Restrictions**
What concentrations of	Nicole Müller	2007	Thesis					**No Valid**

Title	Authors / Source	Year	Type of source	Journal	Vol	Issue	Pag	CLASSIFICATION
nano titanium dioxide, carbon nanotubes and nano silver are we exposed to?								
Emission of ultrafine copper particles by universal motors controlled by phase angle modulation	Wilfried Szymczak, Norbert Menzel, Lothar Keck	2007	Article	Aerosol Science	38		520-531	**No Valid**
Ultrafine Aerosol Emission from the Free Fall of TiO2 and SiO2 Nanopowders	N. Ibaseta and B. Biscans	2007	Article	KONA Powder and Particle Journal	25		190-194	**No Valid**
Particle concentration and characteristics near a major freeway with heavy-duty diesel traffic	Leonidas Ntziachristos, Zhi Ning, Michael D. Geller, Constantinos Sioutas	2007	Article	Environmental Science and Technology	41		2223-2230	**Valid With Restrictions**
Indoor air quality for chemical and ultrafine particle contaminants from printers	Naoki Kagi, Shuji Fujii, Youhei Horiba, Norikazu Namiki, Yoshio Ohtani, Hitoshi Emi, Hajime Tamura, Yong Shik Kim	2007	Article	Building and Environment	42		1949-1954	**Valid With Restrictions**
Potential occupational exposure to manufactured nanoparticles in Italy	Fabio Boccuni, Bruna Rondinone, Carlo Petyx, Sergio Iavicoli	2008	Article	Journal of Cleaner Production	16		949-956	**No Valid**
Temporal Evolution of Nanoparticle Aerosols in Workplace Exposure	M. Seipenbusch, A. Binder, G. Kasper	2008	Article	The Annals Occupational Hygiene	52	8	707-716	**No Valid**
Effectiveness of Local Exhaust Ventilation in Controlling Engineered Nanomaterial Emissions During Reactor Cleanout Operations	Mark M. Methner	2008	Article	Journal of Occupational and Environmental Hygiene	5		63-69	**Valid With Restrictions**
Exposure to manufactured nanostructured	Evangelia Demou, Philippe Peter,	2008	Article	The Annals Occupa	52	8	695-706	**No Valid**

Title	Authors / Source	Year	Type of source	Journal	Vol	Issue	Pag	CLASSIFICATION
particles in an industrial pilot plant	Stefanie Hellweg			tional Hygiene				
Characterization of Airborne Particles During Production of Carbonaceous Nanomaterials	Behnoush Yeganeh, Christy M. Kull, Matthew S. Hull, Linsey C. Marr	2008	Article	Environmental Science and Technology	42		4600-4606	**Valid With Restrictions**
Measurement of the physical properties of aerosols in a fullerene factory for inhalation exposure	Fujitani Y., Kobayashi T., Arashidani K., Kunugita N., Suemura K.	2008	Article	Journal of Occupational Environmental Hygiene	5	6	380-389	**Valid**
Particle exposure levels during CVD growth and subsequent handling of vertically-aligned carbon nanotube films	Dhimiter Bello, A. John Hart, Kwangseong Ahn, Marilyn Hallock, Namiko Yamamoto, Enrique J. García, Michael J. Ellenbecker, Brian L. Wardle	2008	Article	Carbon	46		974-981	**Valid**
Airborne Nanoparticle Release Associated with the Compounding of Nanocomposites using Nanoalumina as Fillers	Su-Jung Tsai, Ali Ashter, Earl Ada, Joey L. Mead, Carol F. Barry, Michael J. Ellenbecker	2008	Article	Aerosol and Air Quality Research				**Valid With Restrictions**
Synthetic TiO2 nanoparticle emission from exterior facades into the aquatic environment	R. Kaegi, A. Ulrich, B. Sinnet, R. Vonbank, A. Wichser, S. Zuleeg, H. Simmler, S. Brunner, H. Vonmont, M. Burkhardt, M. Boller	2008	Article	Environmental Pollution	156		233-239	**No Valid**
Sampling and Analysis of Nanomaterials in the Environment: A State-of-the-Science Review	Eastern Research Group Inc.	2008	Report					**No Valid**
Nanomaterials: Risks and Benefits	Igor Linkow, Jeffery Steevens	2009	Book	NATO Science for Peace and				**No Valid**

Title	Authors / Source	Year	Type of source	Journal	Vol	Issue	Pag	CLASSIFICATION
				Security Series C: Environmental Security				
Characterization of exposure to silver nanoparticles in a manufacturing facility	Junsu Park, Byoung Kyu Kwak, Eunjoo Bae, Jeongjin Lee, Younghun Kim, Kyunghee Choi, Jongheop Yi	2009	Article	Journal of Nanoparticle Research	11		1705-1712	**No Valid**
Workplace exposure to nanoparticles	Simon Kaluza, Judith Kleine Balderhaar, Bruno Orthen, Bertrand Honnert, Elzbieta Jankowska, Piotr Pietrowski, Maria Gracia Rosell, Celia Tanarro, José Tejedor, Agurtzane Zugasti	2009	Report	Agencia Europea de Seguridad y Salud en el Trabajo				**No Valid**
Sanding dust from nanoparticle-containing paints: physical characterisation	I.K. Koponen, K.A. Jensen, T. Schneider	2009	Article	Journal of Physics				**No Valid**
Nanoparticles monitoring in workplaces devoted to nanotechnologies	Laura Manodori, Alvise Benedetti	2009	Article	Journal of Physics	170			**Valid With Restrictions**
Exposure to nanoscale particles and fibers during machining of hybrid advanced composites containing carbon nanotubes	Dhimiter Bello, Brian L. Wardle, Namiko Yamamoto, Roberto Guzman deVilloria, Enrique J. Garcia, Anastasios J. Hart, Kwangseong Ahn, Michael J. Ellenbecker, Marilyn Hallock	2009	Article	Journal of Nanoparticle Research	11		231-249	**Valid**

Title	Authors / Source	Year	Type of source	Journal	Vol	Issue	Pag	CLASSIFICATION
Airborne monitoring to distinguish engineered nanomaterials from incidental particles for environmental health and safety	T.M. Peters, S. Elzey, R. Johnson, H. Park, V.H. Grassian, T. Maher, P. O'shaughnessy	2009	Article	Journal of Occupational Environmental Hygiene	6	2	73-81	**Valid With Restrictions**
Characterization and Evaluation of Nanoparticle Release during the Synthesis of Single-Walled and Multiwalled Carbon Nanotubes by Chemical Vapor Deposition	Su-Jung, Mario Hofmann, Marilyn Hallock, Michael Ellenbecker	2009	Article	Environmental Science and Technology	43	6017-6023		**Valid With Restrictions**
Measurement of nanoparticle removal by abrasion	Arnaud Guiot, Luana Golanski, François Tardif	2009	Article	Journal of Physics	170	1		**Valid With Restrictions**
Workplace exposure to engineered nanoparticles	Sabine Plitzko	2009	Article	Inhalation Toxicology	21	S1	25-29	**Valid**
Occupational exposure assessment for nanoparticles	Ji Young Park	2009	Thesis					**Valid With Restrictions**
Ultrafine Particle Characteristics in Seven Industrial Plants	Karine Elihn, Peter Berg	2009	Article	The Annals Occupational Hygiene	53	5	475-484	**Valid With Restrictions**
Workplace exposure at nanomaterial production processes	Carsten Möhlmann, Johannes Welter, Martin Klenke, Jürgen Sander	2009	Article	Journal of Physics	170			**Valid**
Exposure to manufactured nanoparticles in different workplaces	Derk Brouwer	2010	Article: Review	Toxicology	269		120-127	**Valid With Restrictions**
Exposure assessment of carbon nanotube manufacturing workplaces	Ji Hyun Lee, Seung-Bok Lee, Gwi Nam Bae, Ki Soo Jeon, Jin Uk Yoon, Jun Ho Ji, Jae Hyuck Sung, Byung Gyu Lee, Jong Han Lee, Jung Sun yang,	2010	Article	Inhalation Toxicology	22	5	369-381	**Valid**

Title	Authors / Source	Year	Type of source	Journal	Vol	Issue	Pag	CLASSIFICATION
	Hyeon Yeong Kim, Chang Soo Kang, Il Je Yu							
Nanoparticles-containing spray can aerosol: characterization, exposure assessment, and generator design	Bean T. Chen, Aliakbar Afshari, Samuel Stone, Mark Jackson, Diane Schwegler-Berry, David G. Frazer, Vincent Castranova, Treye A. Thomas	2010	Article	Inhalation Toxicology	22	13	1072-1082	**No Valid**
Aerosol Monitoring during Carbon Nanofiber Production: Mobile Direct-Reading Sampling	Douglas E. Evans, Bon Ki Ku, M. Eileen Birch, Kevin H. Dunn	2010	Article	The Annals Occupational Hygiene	54	5	514-531	**Valid With Restrictions**
Characterizing Exposures to Airborne Metals and Nanoparticle Emissions in a Refinery	Arthur Miller, Pamela L. Drake, Patrick Hintz, Matt Habjan	2010	Article	The Annals Occupational Hygiene			001-10	**Valid With Restrictions**
Ultrafine particles at three different sampling locations in Taiwan	Sheng-Chien Chen, Chuen-Jinn Tsai, Charles C.-K. Chou, Gwo-Dong Roam, Sen-Sung Cheng, Ya-Nan Wang	2010	Article	Atmospheric Environment	44		533-540	**Valid With Restrictions**
NBI knowledgebase	ONAMI & Oregon State University.	2010	Database					**No Valid**
Engineered nanomaterials in rivers - Exposure scenarios for Switzerland at high spatial and temporal resolution	F. Gottschalk, C. Ort, R.W. Scholz, B. Nowack	2011	Article	Environmental Pollution	159		3439-3445	**No Valid**
Nanoparticle exposure at nanotechnology workplaces: A review	Thomas A.J. Kuhlbusch, Christof Asbach, Heinz Fissan, Daniel Göhler, Michael Stintz	2011	Article	Particle and Fibre Toxicology	8	22		**No Valid**
Characterization and Control of Airborne Particles emitted During	Lorenzo G. Cena, Thomas M. Peters	2011	Article	Journal of Occupational	8	2	86-92	**Valid**

Title	Authors / Source	Year	Type of source	Journal	Vol	Issue	Pag	CLASSIFICATION
Production of Epoxy/Carbon Nanotube Nanocomposites				Environmental Hygiene				
Potential for exposure to engineered nanoparticles from nanotechnology-based consumer spray products	Yevgen Nazarenko, Huajun Zhen, Taewon Han, Paul J. Lioy, Gediminas Mainelis	2011	Article	Journal of Exposure Science and Environmental Epidemiology	21		515-528	**No Valid**
Estimation of surface area concentration of workplace incidental nanoparticles based on number and mass concentrations	J.Y. Park, G. Ramachandran	2011	Article	Journal of Nanoparticle Research	13		4897-4911	**Valid With Restrictions**
Exposure assessment of workplaces manufacturing nanosized TiO2 and silver	Ji Hyun Lee, Miran Kwon, Jun Ho Ji, Chang Soo Kang, Kang Ho Ahn, Jeong Hee Han, Je Yu	2011	Article	Inhalation Toxicology	23	4	226-236	**Valid**
Exposure assessment of nano-sized and respirable particles at different workplaces	Chuen-Jinn Tsai, Cheng-Yu Huang, Sheng-Chieh Chen, Chi-En Ho, Cheng-Hsiung Huang, Chun-Wan Chen, Cheng-Ping Chang, Su-Jung Tsai, Michael J. Ellenbecker	2011	Article	Jounal of Nanoparticle Research	13		4161-4172	**Valid With Restrictions**
Exposure and Emissions Monitoring during Carbon Nanofiber Production - Part I: Elemental Carbon and Iron - Soot Aerosols	M. Eileen Birch, Bon-Ki Ku, Douglas E. Evans, toni A. Ruda-Eberenz	2011	Article	The Annals Occupational Hygiene	55	9	1016-1036	**Valid**
Comparison of dust released from sanding conventional and nanoparticle-doped	Ismo Kalevi Koponen, Keld Alstrup Jensen, Thomas Schneider	2011	Article	Journal of Exposure Science and	21		408-418	**No Valid**

Title	Authors / Source	Year	Type of source	Journal	Vol	Issue	Pag	CLASSIFICATION
wall and wood coatings				Environmental Epidemiology				
Nanoparticles from Printer Emissions in Workplace		2011	Report					**Valid With Restrictions**
Life cycle assessment of engineered nanomaterials: State of the art and strategies to overcome existing gaps	Roland Hischier, Tobias Walser	2012	Article	Science of the Total Environment	425		271-282	**No Valid**
Potential for Inhalation Exposure to engineered Nanoparticles from Nanotechnology-Based Cosmetic Powders	Yevgen Nazarenko, Huajun Zhen, Taewon Han, Paul J. Lioy, Gediminas Mainelis	2012	Article	Environmental health perspectives	120	6	885-592	**No Valid**
Task-based exposure assessment of nanoparticles in the workplace	Seunghon Ham, Chungsik Yoon, Euiseung Lee, Kiyoung lee, Donguk Park, Eunkyo Chung, Pilje Kim, Byoungcheun Lee	2012	Article	Journal of Nanoparticle Research	14	9		**Valid**
Workplace exposure to naoparticles and the application of provisional nanoreference values in times of uncertain risks	Pieter van Browkhuizen, Fleur van Broekhuizen, Ralf Cornelissen, Lucas Reijnders	2012	Article	Journal of Nanoparticle Research	14	4		**Valid With Restrictions**
Potential Scenarios for Nanomaterial Release and subsequent Alteration in the environment	Bernd Nowack, James F. Ranville, Stephen Diamond, Julian A. Gallego, Chris Metcalfe, jerome Rose, Nina Horne, Albert A. Koelmans, Stephen J. Klaine	2012	Article	Environmental Toxicology and Chemistry	31	1	50-59	**No Valid**
Exposure to CeO2 nanoparticles	Maija Leppänen, Jussi	2012	Article	Nanotoxicology	6	6	643-651	**Valid**

Title	Authors / Source	Year	Type of source	Journal	Vol	Issue	Pag	CLASSIFICATION
during flame spray process	Lyyränen, Merja Jävelä, Ari Auvinen, Jorma Jokiniemi, Joe Pimenoff, Timo Tuomi							
Final Report: Environmental Exposure to Nanomaterials - Data Scoping Study	Milieu Ltd	2012	Report					**No Valid**
Continuous 3-day exposure assessment of workplace manufacturing silver nanoparticles	Ji Hyun Lee, Kangho Ahn, Sun Man Kim, Ki Soo Jeon, Jong Seong Lee, Il Je Yu	2012	Article	Journal of Nanoparticle Research	14			**Valid With Restrictions**
Industrial worker exposure to airborne particles during the packing of pigment and nanoscale titanium dioxide	A.J. Koivisto, J. Lyyränen, A. Auvinen, e. Vanhala, K. Hämeri, T. Tuomi, J. Jokiniemi	2012	Article	Inhalation Toxicology	24	12	839-849	**Valid With Restrictions**
Mobile monitoring of particle number concentration and other traffic-related air pollutants in a near-highway neighbourhood over the course of a year	Luz T. Padró Martínez, Allison P. Patton, Jeffrey B. Trull, Wig Zamore, Doug Brugge, John L. Durant	2012	Article	Atmospheric Environment	61		253-264	**Valid With Restrictions**
Environmental concentrations of engineered nanomaterials: Review of modelling and analytical studies	Fadri Gottschalk, Tian Yin Sun, Bernd Nowack	2013	Article: Review	Environmental Pollution	181		287-300	**No Valid**
An Occupational Exposure Assessment for Engineered Nanoparticles Used in Semiconductor Fabrication	Michele Noble Shepard, Sara Brenner	2013	Article	The Annals Occupational Hygiene	58	2	251-265	**No Valid**
Global life cycle releases of engineered nanomaterials	Arturo A. Keller, Suzanne McFerran, Anastasiya Lazareva, Sangwon Suh	2013	Article	Journal of Nanoparticle Research	15	6		**No Valid**
Characterization and control of occupational	Maximilien Debia, Charles Beaudry, Scott	2013	Report	Chemical Susbsta				**Valid With Restrictions**

Title	Authors / Source	Year	Type of source	Journal	Vol	Issue	Pag	CLASSIFICATION
exposure to nanoparticles and ultrafine particles	Weichenthal, Robert Tardif, André Dufresne			nces and Biological Agents - Studies and Research Projects				
Characterization of exposures to nanoscale particles and fibres during solid core drilling of hybrid carbon nanotube advanced composites	Dhimiter Bello, Brian L. Wardle, Jie Zhang, Namiko Yamamoto, Christopher Santeufemio, Marilyn Hallock, M. Abbas Virji	2013	Article	International Journal of Occupational and Environmental Health	16	4	434-450	**Valid**
Elastic CNT-polyurethane nanocomposite: synthesis, performance and assessment of fragments released during use	Wendel Wohlleben, Matthias W. Meier, Sandra Vogel, Robert Landsiedel, Gerhard Cox, Sabine hirth, Zeljko Tomovic	2013	Article	Nanoscale	5		369-380	**No Valid**
Atmospheric nanoparticles and their impacts on public health	Klara Slezakova, Simone Morais, Maria do Carmo Pereira	2013	Book Chapter	Current Topics in Public Health	Chapter 23			**Valid With Restrictions**
Commission for the Investigation of Health Hazards of Chemical Compounds in the Work Area	Deutsche Forschungsgemeinschaft	2013	Report					**Valid With Restrictions**
Exposure assessments of nanoparticles in aquatic environments - considerations, review and recommendations	Swedish Chemicals Agency	2013	Report					**No Valid**
Building exposure scenarios for safety management of engineered nanomaterials	Lucie Sikorova, Martie Van Tongeren, Pavel Danihelka, Araceli Sánchez	2014	Article	Nanocon				**No Valid**

Title	Authors / Source	Year	Type of source	Journal	Vol	Issue	Pag	CLASSIFICATION
	Jiménez, Sarka Bernatikova							
Application of a quantitative weight of evidence approach for ranking and prioritising occupational exposure scenarios for titanium dioxide and carbon nanomaterials	Danail R. Hristozov, Stefania Gottardo, Marco Cinelli, Panagiotis Isigonis, Alex Zabeo, Andrea Critto, Martie Van Tongeren, Lang Tran, Antonio Marcomini	2014	Article	Nanotoxicology	8	2	117-131	**No Valid**
Framework for LCI modelling of releases of manufactured nanomaterials along their life cycle	Roland Hischier	2014	Article	The International Journal of Life Cycle Assessment	19	4	838-849	**No Valid**
Comparison of nanoparticle exposures between fumed and sol-gel nano-silica manufacturing facilities	Sewan OH, Boowook KIM, Hyunwook KIM	2014	Article	Industrial Health	52		190-198	**Valid With Restrictions**
The exposure to coarse, fine and ultrafine particle emissions from concrete mixing, drilling and cutting activities	Farhad Azarmi, Prashant Kumar, Mike Mulheron	2014	Article	Journal of Hazardous Materials	279		268-279	**Valid With Restrictions**
Assessment of nanoparticle exposure in nanosilica handling process: including characteristics of nanoparticles leaking from a vacuum cleaner	Boowook KIM, Hyunwook KIM, Il Je YU	2014	Article	Industrial Health	52		152-162	**Valid With Restrictions**
Range-Finding Risk Assessment of Inhalation Exposure to Nanodiamonds in a Laboratory Environment	Antii J. Koivisto, Jaana E. Palomäki, Anna Kaisa Viitenen, Kirsi M. siivola, Ismo k. Koponen, Mingzhou Yu, Tomi S. Kanerva,	2014	Article	International Journal of Environmental Research and Public Health	11	5	5382-5402	**Valid With Restrictions**

Title	Authors / Source	Year	Type of source	Journal	Vol	Issue	Pag	CLASSIFICATION
	Hannu Norppa, Harri T. Alenius, Tareq Hussein, Kai M. Savolainen, Kaarle J. Hämeri							
Are there generalizable trends in the release of airborne synthetic clay nanoparticles from a jet milling process?	Ehsan Majd Faghihi, Darren Martin, Samuel Clifford, Grant Edwards, Congrong He, Christof Asbach, Lidia Morawska	2015	Article	Aerosol and Air Quality Research	15		365-375	**Valid With Restrictions**
Occupational exposure to nanoparticles at commercial photocopy centers	Jonh Martin, Dhimiter Bello, Kristin Bunker, Martin Shafer, David Christiani, Susan Woskie, Philip Demokritou	2015	Article	Journal of Hazardous Materials	298		351-360	**Valid With Restrictions**
Measurement of nanoscale TiO2 and Al2O3 in industrial workplace environments - methodology and results	Heinz Kaminski, Mathias Beyer, Heinz Fissan, Christof Asbach, Thomas A.J. Kuhlbusch	2015	Article	Aerosol and Air Quality Research	15		129-141	**Valid With Restrictions**
Research and development - where people are exposed to nanomaterials	Chantal Imhof, Katherine Clark, Thierry Meyer, Kaspar Schmid, Michael Riediker	2015	Article	Journal of Occupational Health	57		179-188	**Valid With Restrictions**
Exposure to nanomaterials from the Danish Environment	Poul bo Larsen, Jesper Kjolholt	2015	Project Reports					**Valid With Restrictions**
Exposure assessment of nanomaterials in consumer products	Poul Bo Larsen, Frans Christensen, Keld Alstrup Jensen, Anna Brinch, Sonja Hagen Mikkelsen	2015	Project Reports					**No Valid**
Occupational Exposure to Airborne Nanomaterials: An	Sara A. Brenner, Nicole M. Neu-Baker, Cihan	2015	Article	Journal of Occupational	12		469-481	**Valid With Restrictions**

Title	Authors / Source	Year	Type of source	Journal	Vol	Issue	Pag	CLASSIFICATION
Assessment of Worker Exposure to Aerosolized Metal Oxide Nanoparticles in Semiconductor Wastewater Treatment	Caglayan, Igor G. Zurbenko			and Environmental Hygiene				
Influence of relative humidity and physical load during storage on dustiness of inorganic nanomaterials: implications for testing and risk assessment	Marcus Levin, Elena Rojas, Esa Vanhala, Minnamari Vippola, Biase Liguori, Kirsteni. Kling, Ismo K. Koponen, Kristian Molhave, Timo Tuomi, Danijela Gregurec, Sergio Moya, Keld A. Jensen	2015	Article	Journal of Nanoparticle Research	17	8		**Valid With Restrictions**
Characterization of engineered TiO2 nanomaterials in a life cycle and risk assessments perspective	Véronique Adam, Stéphanie Loyaux-Lawniczak, Gaetana Quaranta	2015	Article	Environmental Science and Pollution Research	22		11175 - 11192	**No Valid**
Workplace exposure to airborne alumina nanoparticles associated with separation and packaging processes in a pilot factory	Mingluan Xing, Hua Zou, Xiangjing Gao, Bing Chang, Shichuan Tang, Meibian Zhang	2015	Article	Environmental Science Processes & Impacts	17		656-666	**Valid**
Cellulose nanomaterials: life cycle risk assessment, and environmental health and safety roadmap	Jo Anne Shatkin, Baram Kim	2015	Article	Environmental Science Nano	2		477-499	**No Valid**
Consumer exposures to laser printer-emitted engineered nanoparticles: A case study of life-cycle implications from nano-enabled products	Sandra V. Pirela, Georgios A. Sotiriou, Dhimiter Bello, Martin Shafer, Kristin Lee Bunker, Vincent Castranova, Treye Thomas,	2015	Article	Nanotoxicology	9	6	760-768	**No Valid**

Title	Authors / Source	Year	Type of source	Journal	Vol	Issue	Pag	CLASSIFICATION
	Philip Demokritou							
Nanotechnology and Environmental Health Laboratories	Association of Public Health Laboratories	2015	White Paper	Association of Public Health Laboratories				**No Valid**
Determination of nanoscale particles in the air of working zone at the metallurgical production	T.S. Ulanova, M.V. antipyeva, M.I. Zabirova, M.V. Volkova	2015	Article	Journal "Health Risk Analysis"		1	63-66	**Valid With Restrictions**
Strategi for the lowering and the assessment of exposure to nanoparticles at workspace - Case of study concerning the potential emission of nanoparticles of Lead in an epitaxy laboratory	Sébastien Artous, Eric Zimmermann, Paul-Antoine Douissard, Dominique Locatelli, Sylvie Motellier, Samir Derrough	2015	Article	Journal of Physics	617			**No Valid**
Process-generated nanoparticles from ceramic tile sinteering: Emissions, exposure and environmental release	A.S. Fonseca, A. Maragkidou, M. Viana, X. Querol, K. Hämeri, I. de Francisco, C. Estepa, C. Borrell, V. Lennikov, G.F. de la Fuente	2016	Article	Science of the Total Environment	565		922-932	**Valid**
Airborne engineered nanomaterials in the workplace - a review of release and worker exposure during nanomaterial production and handling processes	Yaobo Ding, Thomas A.J. Kuhlbusch, Martie Van Tongeren, Araceli Sánchez Jiménez, Ilse Tuinman, Rui Chen, Iñigo Larraza Álvarez, Urszula Mikolajczyk, Carmen Nickel, Jessica Meyer, Heinz Kaminsky, Wendel Wohlleben, Burkhard	2016	Article: Review	Journal of Hazardous Materials				**No Valid**

Title	Authors / Source	Year	Type of source	Journal	Vol	Issue	Pag	CLASSIFICATION
	Stahlmecke, Simon Clavaguera, Michael Riediker							
Systematic design analysis and risk management on nanoparticles occupational exposure	Francisco Silva, Pedro Arezes, Paul Swuste	2016	Article	Journal of Cleaner Production	112		3331-3341	**No Valid**
Current scenarios of biomedical aspect of metal-based nanoparticles on gel dosimetry	Deena Titus, E. James Jebaseelan Samuel, Selvaraj Mohana Roopan	2016	Article	Applied Microbiology and Biotechnology	100		4803-4816	**No Valid**
Exposure Scenarios in the Workplace and Risk Assessment of Carbon Nanomaterials	Rui Chen, Chunying Chem	2016	Book Chapter	Biomedical Applications and Toxicology of Carbon Nanomaterials			515-534	**No Valid**
Comparative modeling of exposure to airborne nanoparticles released by consumer spray products	Christian Riebeling, Andreas Luch, Mario Enrico Götz	2016	Article	Nanotoxicology	10	3	343-351	**No Valid**
Measuring the Size of Nanoparticles in Aqueous Media Using Batch-Mode Dynamic Light Scattering	V.A. Hackley, J.D. Clogston	2007 (rev.2015)	Protocol	NIST Special Publication, NIST-NCL Joint Assay Protocol	1200-6			**No Valid**
NANEX			Database					**No Valid**
NHECD			Database					**No Valid**
CEINT protocols			Database					**No Valid**
Nanomaterial Registry	U.S. Department of Health & Human Services - National		Database					**No Valid**

Title	Authors / Source	Year	Type of source	Journal	Vol	Issue	Pag	CLASSIFICATION
	Institutes of Health							
CaNanoLab	U.S. Department of Health & Human Services - National Cancer Institute		Database					**No Valid**
InterNano	National Science Foundation CMMI-1025020, Center for Hierarchical Manufacturing		Database					**Valid With Restrictions**
AirBase	European Environmental Agency (EEA); EUROAIRNET-European Air Quality monitoring and information network (Managed by the European Topic Centre on Air Quality)		Database					**Valid With Restrictions**
NILU	Database hosted by the Software group of the Norwegian Institute for Air Research (NILU)		Database					**Valid With Restrictions**
WebDab	EMEP - European Monitoring and Evaluation Programme		Database					**Valid With Restrictions**
EBAS	EMEP - European Monitoring and Evaluation Programme		Database					**Valid With Restrictions**
GHO / ENHIS	WHO programme on Air Quality and Health		Database					**Valid With Restrictions**
AMAP	Arctic Monitoring and Assessment		Database					**Valid With Restrictions**

Title	Authors / Source	Year	Type of source	Journal	Vol	Issue	Pag	CLASSIFICATION
	Programme (AMAP)							
AEMET	Monitoring program of the AEMET Meteorological Agency		Database					**Valid With Restrictions**
SEPA	National Swedish Environemntal Monitoring Programme		Database					**Valid With Restrictions**
NERI	The Danish air quality monitoring programme		Database					**Valid With Restrictions**
ASPA	Assotiation pour la sourveillance et l'Etude de la Pollution Atmospherique en Alsacie		Database					**Valid With Restrictions**
Qualitat de l'aire a Andorra	Govern d'Andorra		Database					**Valid With Restrictions**
GAINS	IIASA - Atmospheric Pollution Programme - International Institute for Applied Systems Analysis		Model tool					**No Valid**
irCELine	Belgian Interregional Environment Agency (IRCEL - CELINE)		Database					**Valid With Restrictions**
SLB analys	Stockholm - Uppsala County Air Quality Management Association		Database					**Valid With Restrictions**
LUBW / UMEG	Monitoring program of the Baden-Württemberg State Agency (LUBW)		Database					**Valid With Restrictions**
eNanoMapper	eNanoMapper - A Database and Ontology Framework for Nanomaterials	2014	Database					**Valid**

Title	Authors / Source	Year	Type of source	Journal	Vol	Issue	Pag	CLASSIFICATION
	Design and Safety Assessment (FP7-604134)							
iNanoTool	European project, (LIFE+2012 Programme) to develop an interactive tool for the implementation of environmental legislation in nanoparticle manufacturers.	2013-2015	Project Reports					**No Valid**
Opensense	OpenSense project funded by nano-tera.ch	2009-2013	Database					**Valid With Restrictions**
Opensense2	OpenSenseII project funded by nano-tera.ch	2013-2017	Database					**Valid With Restrictions**
Nanex	Development of Exposure Scenarios for Manufactured Nanomaterials (FP7-247794)	2009-2010	Database					**Valid**
Copernicus (ECMWF)	Copernicus: European Earth observation programme (GMES / Atmosphere)		Database					**Valid**
MARINA: Managing Risks on Nanomaterials	EU Seventh framework programme FP7-263215	2011-2015	Database					**No Valid**
Nanofate	Seventh Programme for research, technological development and demonstration under grant agreement No CP-FP 247739 NanoFATE	2010-2014	Project Reports					**Valid**
Sirena	SIRENA-SIMULATION OF THE RELEASE OF	2013-2016	Project Reports					**No Valid**

Title	Authors / Source	Year	Type of source	Journal	Vol	Issue	Pag	CLASSIFICATION
	NANOMATERIALS FROM CONSUMER PRODUCTS FOR ENVIRONMENTAL EXPOSURE ASSESSMENT LIFE 11 ENV/ES/596							
NANOTRANSPORT	The Behaviour of Aerosols Released to Ambient Air from Nanoparticle Manufacturing FP6- 33371	2006-2008	Project Reports					**Valid With Restrictions**
Sun	Sustainable technologies project (FP7-604305)	2013-2016	Project Reports					**Valid**
SmartNano	Sensitive Measurement, detection and identification of engineered nanoparticles in complex matrices (FP7 - NMP.2011.1.3-1 - Contract n°280779)	2012-2016	Project Reports					**No Valid**
NanoMICEX	Mitigation of risk and control of exposure in nanotechnology based inks and pigments (FP7-280713)	2012-2015	Project Reports					**Valid**
GuideNano	Project funded from the European Union´s Seventh Framework Programme (FP7-604387)	2013-2017	Model tool					**Valid**
Nanosolutions	Biological Foundation for the Safety Classification of Engineered Nanomaterials (ENM): Systems	2013-2017	Model tool					**No Valid**

Title	Authors / Source	Year	Type of source	Journal	Vol	Issue	Pag	CLASSIFICATION
	Biology Approaches to Understand Interactions of ENM with Living Organisms and the Environment (FP7-309329)							
Citi-Sense	collaborative project co-funded by the European Union's Seventh Frame-work Programme for Research, Technological Development and Innovation, grant agreement no 308524.	2012-2016	Database					**Valid With Restrictions**
Working with nanoparticles: Exposure registry and health monitoring	Health Council of the Netherlands (Gezondheidsraad)	2012	Book	Health Council of the Netherlands (Gezondheidsraad)				**Valid**
Measurements of Particle Emissions from Nanotechnology Processes, with Assessment of Measuring Techniques and Workplace Controls	Prof. Lidia Morawska, Mr Peter McGarry, Dr Howard Morris, Dr Luke Knibbs, Dr Thor Bostrom and Dr Andrea Capasso	2012	Book	The International Laboratory for Air Quality and Health, Queensland University of Technology				**Valid**
Elastic CNT-polyurethane nanocomposite: synthesis, performance and assessment of	Wendel Wohlleben, Matthias W. Meier, Sandra Vogel, Robert Landsiedel, Gerhard Cox,	2013	Article	Nanoscale	5		369-380	**No Valid**

Title	Authors / Source	Year	Type of source	Journal	Vol	Issue	Pag	CLASSIFICATION
fragments released during use	Sabine hirth, Zeljko Tomovic							
Range-Finding Risk Assessment of Inhalation Exposure to Nanodiamonds in a Laboratory Environment	Antii J. Koivisto, Jaana E. Palomäki, Anna Kaisa Viitenen, Kirsi M. siivola, Ismo k. Koponen, Mingzhou Yu, Tomi S. Kanerva, Hannu Norppa, Harri T. Alenius, Tareq Hussein, Kai M. Savolainen, Kaarle J. Hämeri	2014	Article	International Journal of Environmental Research and Public Health	11	5	5382-5402	**Valid With Restrictions**
Characterizing Manufactured Nanoparticles in the Environment: Multimethod Determination of Particle Sizes	Rute F. Domingos, Mohamed A. Baalousha, Yon Ju-Nam, M. Marcia Reid, Nathalie Tufenkji, Jamie R. Lead, Gary G. Leppard, and Kevin J. Wlikinson	2009	Article	Environmental Science and Technology	43	19	7277-7284	**No Valid**
The release of engineered nanomaterials to the environment	Gottschalk F., Nowack B.	2011	Article	Journal of Environmental Monitoring	13		1145-1155	**No Valid**
Environmental and health effects of nanomaterials in nanotextiles and façade coatings	Som C., Wick P., Krug H., Nowack B	2011	Article	Environment International				**No Valid**
Analysis of currently available data for characterising the risk of engineered nanomaterials to the environment and human health--lessons learned from four case studies	Aschberger K., Micheletti C., Sokull-Kluttgen B., Christensen F.M	2011	Article	Environment International	37		1143-1156	**No Valid**
Sources and concentration of nanoparticles (<10	Ji Ping Shi, Douglas E Evans, A.A	2001	Article	Atmospheric Environment	35	7	1193-1202	**No Valid**

Title	Authors / Source	Year	Type of source	Journal	Vol	Issue	Pag	CLASSIFICATION
nm diameter) in the urban atmosphere	Khan, Roy M Harrison							
On-line measurements of diesel nanoparticle composition and volatility	Hiromu Sakurai, Herbert J. Tobias, Kihong Park, Darrick Zarling, Kenneth S. Docherty, David B. Kittelson Peter H. McMurry, Paul J. Ziemann	2003	Article	Atmospheric Environment	37	9-10	1199-1210	**No Valid**
Titanium dioxide nanoparticles: occupational exposure assessment in the photocatalytic paving production	Andrea Spinazzè, Andrea Cattaneo, Marina Limonta, Valentina Bollati, Pier Alberto Bertazzi and Domenico M. Cavallo	2016	Article	Jounal of Nanoparticle Research	18	6		**Valid With Restrictions**
Contribution of indoor-generated particles to residential exposure	C.Isaxon, A. Gudmundson, EZ Nordin, L.Lönnblad, A. Dahl, G. Wieslander, M. Bohgard, A. Wierzbicka	2015	Article	Atmospheric Environment	106		458-466	**No Valid**
Method for the characterization of the abrasion induced nanoparticle release into air from surface coatings	Manuel Vorbau, Lars Hillemann, Michael Stintz	2009	Article	Journal of Aerosol Science	40	3	209-217	**No Valid**
New method for the characterization of abrasion-induced nanoparticle release into air from nanomaterials	L.Golanski, A.Guiot, D.Braganza and F.Tardif	2010	Article	NSTI-Nanotech	1		720-723	**No Valid**
Exposure to engineered nanoparticles: Model and measurements for accident situations in laboratories	Tobias Walser, Stefanie Hellweg, Ronnie Juraske, Norman A. Luechinger, Jing Wang and Martin Fierz	2012	Article	Science of the Total Environment	420		119-126	**Valid With Restrictions**

Title	Authors / Source	Year	Type of source	Journal	Vol	Issue	Pag	CLASSIFICATION
Evaluation of the diffusion size classifier (meDiSC) for the real-time measurement of particle size and number concentration of nanoaerosols in the range 20-700 nm	Bau S., Jacoby J. and Witscherg O.	2012	Article	Journal of Environmental Monitoring	14		1014-1023	**No Valid**
A laboratory study of the performance of the handheld diffusion size classifier (DiSCmini) for various aerosols in the 15-400 nm range	Bau S., Zimmermann B., Payet R. and Witscherg O.	2015	Article	Environmental Sciences: Processes &Impacts	17		261-269	**No Valid**
Field measurement of particle size and number concentration with the Diffusion Size Classifier (DiSC)	M. Fierz, H. Burtscher, P. Steigmeier and M. Kasper	2008	Article	Society of Automotive Engineers				**No Valid**
Comparative Testing of a Miniature Diffusion Size Classifier to Assess Airborne Ultrafine Particles Under Field Conditions	Reto Meier, Katherine Clark and Michael Riediker	2013	Article	Aerosol Science and Technology	47	1	22-28	**No Valid**
Design, Calibration, and Field Performance of a Miniature Diffusion Size Classifier	M. Fierz, C. Houle, P. Steigmeier and H. Burtscher	2011	Article	Aerosol Science and Technology	45		1-10	**No Valid**
Monitor for detecting and assessing exposure to airborne nanoparticles	Johan Marra, Matthias Voetz and Heinz-Jürgen Kiesling	2010	Article	Journal of Nanoparticle Research	12	1	21-37	**No Valid**
Using the Aerasense NanoTracer for simultaneously obtaining several ultrafine particle exposure metrics.	Johan Marra	2011	Article	Journal of Physics Conference Series	304	1		**No Valid**
Comparability of Portable Nanoparticle Exposure Monitors	Christof Asbach, Heinz Kaminski, Daniel von Barany, Thomas A.J. Kuhlbusch,	2012	Article	Annals in Occupational Hygiene	56	5	606-621	**No Valid**

Title	Authors / Source	Year	Type of source	Journal	Vol	Issue	Pag	CLASSIFICATION
	Christian Monz, Nico Dziurowitz, Johannes Pelzer, Katja Vossen, Knut Berlin, Silvio Dietrich, Uwe Götz, Heinz-Jürgen Kiesling, Rudolf Schiert and Dirk Dahmann							
Comparison of the DiSCmini Aerosol Monitor to a Handheld Condensation Particle Counter and a Scanning Mobility Particle Sizer for Submicrometer Sodium Chloride and Metal Aerosols	Jessica B. Mills, Jae Hong Park and Thomas H. Peters	2013	Article	Journal of Occupational and Environmental Hygiene	10	5	250-258	**No Valid**
Metrological Performances of a Diffusion Charger Particle Counter for Personal Monitoring	Giorgio Buonanno, Rohan E. Jayaratne, Lidia Morawska and Luca Stabile	2014	Article	Aerosol and Air Quality Research	14		156-167	**No Valid**
Field comparison of portable and stationary instruments for outdoor urban air exposure assessments	M. Viana, I. Rivas, C. Reche, A.S. Fonseca, N. Pérez, X. Querol, A. Alastuey, M. Álvarez-Pedrerol and J. Sunyer	2015	Article	Atmospheric Environment	123 Part A		220-228	**No Valid**
Influential parameters on particle exposure of pedestrians in urban microenvironments	G. Buonanno, F.C. Fuoco and L. Stabile	2011	Article	Atmospheric Environment	45		1434-1443	**Valid With Restrictions**
Assessment of Personal Exposure to Airborne Nanomaterials	Christof Asbach, Asmus Meyer-Plath, Simon Clavaguera, Martin Fierz, Dirk Dahmann, Laura MacCalman, Carla Alexander, Ana	2016	Project Reports	Project nanoInDEx				**No Valid**

Title	Authors / Source	Year	Type of source	Journal	Vol	Issue	Pag	CLASSIFICATION
	Maria Todea and Ivo Iavicoli							
Comparison of four scanning mobility particle sizers at the Fresno Supersite	John G. Water, Judith C. Chow, David A. Sodeman, Douglas H. Lowenthal, M.-C. Oliver Chang, Kihong Park, Xiaoliang Wang	2011	Article	Particuology	9		204-209	**Valid With Restrictions**
Measurements of ultrafine particle size distribution near Rome	Fenjuan Wang, Francesca Costabile, Hong Li, Dong Fang, Ivo Alligrini	2010	Article	Atmospheric Research	98		69-77	**Valid With Restrictions**
Partitioning of trace elements and metals between quasi-ultrafine, accumulation and coarse aerosols in indoor and outdoor air in schools	M. Viana, I. Rivas, X. Querol, A. Alastuey, M. Álvarez-Pedrerol, L. Bouso, C. Sioutas and J. Sunyer	2015	Article	Atmospheric Environment	106		392-401	**Valid With Restrictions**
Development of PM0.1 Personal Sampler for Evaluation of Personal Exposure to Aerosol Nanoparticles	Thunyapet Thongyen, Mitsuhiko Hata, Akira Toriba, Takuji Ikeda, Hiromi Koyama, Yoshio Otani, Masami Furuuchi	2015	Article	Aerosol and Air Quality Research	15		180-187	**No Valid**
Assessing variations in roadside air quality with sampling height	Stephen Stratton, David Hector, David Sykes, Brian Stacey, Stuart Sneddon	2015	Report					**Valid With Restrictions**
Metrological Assessment of a Portable Analyzer for Monitoring the Particle Size Distribution of Ultrafine Particles	Luca Stabile, Emanuele Cauda, Sara Marini and Giorgio Buonanno	2014	Article	Annals in Occupational Hygiene	58	7	860-876	**No Valid**
Perspectives in Biological Monitoring of Inhaled Nanosized Particles	Mickael Rinaldo, Pascal Andújar, Aude Lacourt, Laurent Martinon,	2015	Article	Annals in Occupational Hygiene	59	6	669-680	**No Valid**

Title	Authors / Source	Year	Type of source	Journal	Vol	Issue	Pag	CLASSIFICATION
	Mireille Canal Raffin, Pascal Dumortier, Jean-Claude Pairon and Patick Brochard							
Spatial and temporal variability of incidental nanoparticles in indoor workplaces: impact on the characterization of point source exposures	Jianjun Niu, Pat E. Rasmussen, Robert Magee and Gregory Nilsson	2015	Article	Environmental Sciences: Processes & Impacts	17		98-109	**No Valid**
Demonstration of the equivalence of PM2.5 and PM10 measurement methods in Helsinki 2007–2008	Jari Waldén, Timo Mäkelä, Risto Hillamo, Sisko Laurila and Minna Aurela	2010	Report	Finnish Meteorological Institute				**No Valid**
Nanotechnology: The Next Big Thing, or Much Ado about Nothing?	Andrew D. Maynard	2007	Article	Annals in Occupational Hygiene	51	1	1-12	**No Valid**
Estimating Aerosol Surface Area from Number and Mass Concentration Measurements	Andrew D. Maynard	2003	Article	Annals in Occupational Hygiene	47	2	123-144	**No Valid**
Relationships Among Particle Number, Surface Area, and Respirable Mass Concentrations in Automotive Engine Manufacturing	William A. Heitbrink, Douglas E. Evans, Bon Ki Ku, Andrew D. Maynard, Thomas J. Slavin and Thomas M. Peters	2009	Article	Journal of Occupational and Environmental Hygiene	6		19-31	**No Valid**
Lung deposited surface area size distributions of particulate matter in different urban areas	Heino Kuuluvainen, Topi Rönkö, Anssi Järvinen, Sampo Saari, Panu Karjalainen, Tero Lähde, Liisa Pirjola, Jarko V. Niemi, Risto Hillamo, Jorma Keskinen	2016	Article	Atmospheric Environment	136		105-113	**No Valid**

Title	Authors / Source	Year	Type of source	Journal	Vol	Issue	Pag	CLASSIFICATION
Lung-deposited surface area concentration measurements in selected occupational and non-occupational environments	Otmar Geiss, Ivana Bianchi, Josefa Barrero-Moreno	2016	Article	Journal of Aerosol Science	96		24-37	**Valid With Restrictions**
Assessment of Two Portable Real-Time Particle Monitors Used in Nanomaterial Workplace Exposure Evaluations	Yuewei Liu, Catherine C. Beaucham, Terri A. Pearce, Ziqing Zhuang	2014	Article	PLoS One	9	8		**No Valid**
Evaluation of Quantitative Exposure Assessment Method for Nanomaterials in Mixed Dust Environments: Application in Tire Manufacturing Facilities	Marisa L. Kreider, William D. Cyrs, Melissa A. Tosiano and Julie M. Panko	2015	Article	Annals in Occupational Hygiene	59	9	1122-1134	**No Valid**
Cutaneous exposure scenarios for engineered nanoparticles used in semiconductor fabrication: a preliminary investigation of workplace surface contamination	Michele Noble Sheperd and Sara Brener	2014	Article	International Journal of Occupational and Environmental Health	20	3	247-257	**No Valid**
Particle number size distribution in the eastern Mediterranean: Formation and growth rates of ultrafine airborne atmospheric particles	I. Kopanakis, S.E. Chatoutsidou, K. Torseth, T. Glytsos and M. Lazaridis	2013	Article	Atmospheric Environment	77		790-802	**No Valid**
Experimental Evaluation of a Markov Multizone Model of Particulate Contaminant Transport	Rachel M. Jones and Mark Nicas	2014	Article	Annals in Occupational Hygiene	58	8	1032-1045	**No Valid**
A comparison of two nano-sized particle air filtration tests in the diameter range of	Daniel A. Japuntich, Luke M. Franklin, David Y. Pui, Thomas H. Kuehn and	2007	Article	Jounal of Nanoparticle Research	9	1	93-107	**No Valid**

Title	Authors / Source	Year	Type of source	Journal	Vol	Issue	Pag	CLASSIFICATION
10 to 400 nanometers	Seom Chang Kim							
Experimental Comparison of Two Portable and Real-Time Size Distribution Analysers for Nano/Submicron Aerosol Measurements	Ta-Chih Hsiao, Yao-Chuan Lee, Ke-Ching Chen, Wei-Cheng Ye, Khajornsak Sopajaree, Ying I. Tsai	2016	Article	Aerosol and Air Quality Research	16		919-929	**No Valid**
Exposure and Emission Measurements During Production, Purification, and Functionalization of Arc-Discharge-Produced Multi-Walled Carbon Nanotubes	Maria Hedmer, Christina Isaxon, Patrick T. Nilsson, Linus Ludvigsson, Maria E. Messing, Johan Genberg, Vidar Skaug, Mats Bohgard, Håkan Tinnerberg and Joakim H. Pagels	2014	Article	Annals in Occupational Hygiene	58	3	355-379	**Valid With Restrictions**
Occupational Exposure Assessment in Carbon Nanotube and Nanofiber Primary and Secondary Nanotube and Nanofiber Primary and Secondary Manufacturers: Mobile Direct-Reading Sampling	Matthew M. Dahm, Douglas E. Evans, Mary K. Schubauer-Berigan, M. Eileen Birch and James A. Deddens	2012	Article	Annals in Occupational Hygiene	57	3	328-344	**Valid With Restrictions**
Personal Exposure to Ultrafine Particles in the Workplace: Exploring Sampling Techniques and Strategies	Derk H. Brouwer, José H.J. Gijsbers and Marc W.H. Lurvink	2004	Article	Annals in Occupational Hygiene	48	5	439-453	**No Valid**
Exposure Limits for Nanoparticles: Report of an International Workshop on Nano Reference Values	Pieter van Broekhuizen, Wim Van Veelen, Willem-Henk Streekstra, Paul Schulte and Lucas Reijnders	2012	Article	Annals in Occupational Hygiene	56	5	515-524	**No Valid**

Title	Authors / Source	Year	Type of source	Journal	Vol	Issue	Pag	CLASSIFICATION
Comparison between two different nanoparticle size spectrometers	F. Belosi, S. Ferrari, V. Poluzzi, G. Santachiara and F. Prodi	2013	Article	Journal of the Air & Waste Management Association	63	8	918-925	**No Valid**
A laboratory study of the performance of the handheld diffusion size classifier (DiSCmini) for various aerosols in the 15-400 nm range	S. Bau, B. Zimmermann, R. Payet and O. Witschger	2015	Article	Environment Sciences: Processes & Impacts	17		261-269	**No Valid**
Characteristics of size distributions at urban and rural locations in New York	M.-S. Bae, J.J. Schwab, O. Hogrefe, B.P. Frank, G.G. Lala and K.L. Demerjian	2010	Article	Atmospheric Chemistry and Physics	10		4521-4535	**No Valid**
A Model of Deposition of Hygroscopic Particles in the Human Lung	B. Asgharian	2004	Article	Aerosol Science and Technology	38		938-947	**No Valid**
Estimating number emission rates of nanoparticle sources by "Concentration Peaking" method	S. Anand, Manish Joshi, Balvider K. Sapra, Yelia S. Mayya	2016	Article	Aerosol and Air Quality Research	16		1541-1547	**No Valid**
Valencian network for control and surveillance of atmospheric pollution	Generalitat Valenciana		Database					**Valid With Restrictions**
Community of Madrid Air Quality Network	Community of Madrid		Database					**Valid With Restrictions**
Community of Castilla y León Air Quality Network	Autonomous Government of Castilla y León		Database					**Valid With Restrictions**
Community of Aragón Air Quality Network	Autonomous Government of Aragón		Database					**Valid With Restrictions**
Network for surveillance and foresight of atmospheric pollution	Generalitat de Catalunya		Database					**Valid With Restrictions**
Air Quality (Region of Murcia)	Autonomous Government of Murcia		Database					**Valid With Restrictions**

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Meteogalicia Air Quality	Xunta de Galicia		Database					Valid With Restrictions
Air Quality Network monitoring (Asturias)	Government of the Principality of Asturias		Database					Valid With Restrictions
Air Quality in Cantabria	Government of Cantabria		Database					Valid With Restrictions
Air Quality in Euskadi	Basque Government		Database					Valid With Restrictions
Network for control and surveillance of Air Quality	Autonomous Government of Castilla La Mancha		Database					Valid With Restrictions
			Database					No Valid
Air Quality in Andalucía	Autonomous Government of Andalucía		Database					Valid With Restrictions
Network for protection and research of the Air Quality in Extremadura	Government of Extremadura		Database					Valid With Restrictions
Emissions to the Atmosphere and Air Quality	Government of Illes Balears		Database					Valid With Restrictions
Air Quality (Canary Islands)	Government of the Canary Islands		Database					Valid With Restrictions
Air Quality	Government of Navarra		Database					Valid With Restrictions
			Database					No Valid
Air Quality	Government of La Rioja		Database					Valid With Restrictions
European Environment Agency	European Union		Database					Valid With Restrictions
Department for Environment, Food and Rural Affairs	UK government		Database					Valid With Restrictions
AirNow	US government		Database					Valid With Restrictions
NanoMiner — Integrative Human Transcriptomics Data Resource for Nanoparticle Research	LingjiaKong, Soile Tuomela, Lauri Hahne, Helena Ahlfors, Olli Yli-Harja, Bengt Fadeel, Riitta Lahesmaa and Reija Autio	2013	Article	PLoS One	8	7		Valid With Restrictions
Integration of data: the Nanomaterial Registry project and data curation	K.A. Guzan, K.C. Mills, V. Gupta, D. Murry, C.N. Scheier, D.A. Willis and M.L. Ostraat	2013	Article	Computational Science & Technology	6	1		Valid With Restrictions

Title	Authors / Source	Year	Type of source	Journal	Vol	Issue	Pag	CLASSIFICATION
Nanoinformatics: Emerging Databases and Available Tools	Suresh Panneerselvam and Sangdun Choi	2014	Article	International Journal of Molecular Sciences	15		7158-7182	**Valid With Restrictions**
The Nanomaterial Registry: facilitating the sharing and analysis of data in the diverse nanomaterial community	Michele L. Ostraat, Karmann C. Mills, Kimberly A. Guzan and Damaris Murry	2013	Article	International Journal of Nanomedicine	8	1	7-13	**Valid With Restrictions**
NanoE-Tox: New and in-depth database concerning ecotoxicity of nanomaterials.	Juganson K., Ivask A., Blinova I., Mortimer M. and Kahru A.	2015	Article	Beilstein Journal of Nanotechnology	6		1788-1804	**Valid With Restrictions**
Nanotechnology in the real world: Redeveloping the nanomaterial consumer products inventory	Marina E. Vance, Todd Kuiken, Eric P. Vejerano, Sean P. McGinnis, Michael F. Hochellar Jr., Davis Rejeski and Matthew S. Hull	2015	Article	Beilstein Journal of Nanotechnology	6		1769-1780	**Valid With Restrictions**
The eNanoMapper database for nanomaterial safety information	N. Jeliazkova, C. Chomenidis, P. Doganis, B. Fadeel, R. Grafström, B. Hardy, J. Hastings, M. Hegi, V. Jeliazkov, N. Kochev, P. Kohonen, C. R. Munteanu, H. Sarimveis, B. Smeets, P. Sopasakis, G. Tsiliki, D. Vorgrimmler and E. Willighagen	2015	Article	Beilstein Journal of Nanotechnology	6		1609-1634	**Valid**
Environmental impacts of nanomaterials: providing comprehensive	Dana Kühnel, Clarissa Marquardt, Katja Nau, Harald F. Krug,	2014	Article	Environmental Science Europe	26	21		**Valid With Restrictions**

Title	Authors / Source	Year	Type of source	Journal	Vol	Issue	Pag	CLASSIFICATION
information on exposure, transport and ecotoxicity - the project DaNa2.0.	Björn Mathes and Christoph Steinbach							
caNanoLab: data sharing to expedite the use of nanotechnology in biomedicine	Sharon Gaheen, George W. Hinkal, Stephanie A. Morris, Michal Lijowski, Mervi Heiskanen and Juli D. Klemm	2013	Article	Computational Science & Technology	6	1		**Valid With Restrictions**
Experiences in supporting the structured collection of cancer nanotechnology data using caNanoLab	Stephanie A. Morris, Sharon Gaheen, Michael Lijowski, Mervi Heiskanen and Juli Klemm	2015	Article	Beilstein Journal of Nanotechnology	6		1580-1593	**Valid With Restrictions**
ISA-TAB-Nano: a specification for sharing nanomaterial research data in spreadsheet-based format	Thomas D.G., Gaheen S., Harper S.L., Fritts M., Klaesing F., Hahn-Dantona E., Paik D., Pan S., Stafford G.A., Freund E.T., Klemm J.D. and Baker N.A.	2013	Article	BMC Biotechnology	13	2		**Valid With Restrictions**
NanoMiner	Nanommune project (European Union FP7)	2007-2013	Database					**Valid**
NANoREG	European Union framework 7 Program	2007-2013	Project Reports					**Valid**
NANOMATERIAL Registry	RTI International	2013	Database					**Valid**
NanoE-Tox	Katre Juganson, Angela Ivask, Irina Blinova, Monika Mortimer, Anne Kahru	2015	Database	Laboratory of Environmental Toxicology of NICPB (www.kbfi.ee)				**Valid**
NanoToxdb	ENVIS Centre Distributed Information Centre (DIC) on		Database					**Valid**

Title	Authors / Source	Year	Type of source	Journal	Vol	Issue	Pag	CLASSIFICATION
	Toxic Chemicals (Indian Institute of Toxicology Research)							
The Project on Emerging Nanotechnologies	Wilson Centre (Virginia Tech)		Database					**Valid With Restrictions**
eNanoMapper prototype database. A substance database for nanomaterial safety information	European Union framework 7 Program	2007-2013	Database					**Valid With Restrictions**
The Nanodatabase	DTU Environment - Danish Ecological Council - Danish Consumer Council	2012	Database					**Valid**
Nanowerk			Database					**No Valid**
DaNa$^{2.0}$ (Data and knowledge on Nanomaterials)	Christoph Steinbach		Database					**Valid**
InterNano	National Manofacturing Network		Database					**Valid With Restrictions**
NIL	NIOSH	2009	Database					**No Valid**

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