Forum: Environmental Committee

Issue: Limiting the impact of engineered nanomaterials (ENMs)

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INTRODUCTION

Progress in science shows that nanostructured materials can be found practically everywhere in the nature, and that natural nanoscale processes at the cellular level are indispensable for life. Nanotechnology has advanced very fast as the technological revolution that deals with the manipulation of matter on an atomic and molecular scale makes progress. Scientists have manipulated chemical atoms and molecules for fabrication of macro scale products with a large range of applications. These products are known as engineered nanomaterials (ENMs) and their applications have spread in important technological fields, particularly in medicine and pharmaceutical products. The use of engineered nanomaterials (ENMs) pertains to the improvement of food production, energy generation or the removal of pollutants from water[1]. Nevertheless, the use of ENMs and their eventual release into the environment also generate concerns related to some undesirable effects once they enter the water, soil and air. A significant amount of controversial results related to the role of ENMs and their potential side effects have been published, with the consequent lack of clarity and increased misinformation. This study is devoted to reviewing the role of ENMs at the nexus of food, energy, and water (FEW) including some examples of their newest applications specifically based on food production —further discussing their potential effects on the FEW nexus.

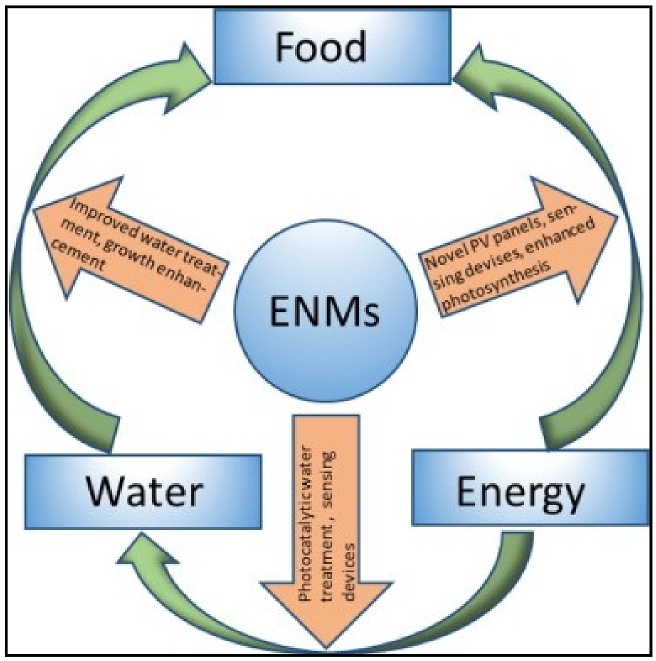


Image 1 —The role of ENMs in the food, energy, and water (FEW) nexus.

[1] IMAGE 1 https://www.sciencedirect.com/science/article/pii/S2589299118300879#f0005

DEFINITION OF KEY-TERMS

Engineered nanomaterials

"Engineered nanomaterials are chemical substances or materials that are engineered with particle sizes between 1 to 100 nanometers in at least one dimension. It is well established that engineered nanomaterials derive many functional advantages from their unique physical and chemical properties. These novel properties have spurred tremendous interest in innovations across many industrial, commercial and medical sectors."[2]

Nanotechnology

Nanotechnology is the study and application of extremely small things and can be used across all the other science fields, such as chemistry, biology, physics, materials science, and engineering. Nanotechnology deals with the manipulation of matter with dimensions sized from 1 to 100 nanometers (1 nm=1×10^{-9} m).[3]

FEW (food, energy, and water) NEXUS

According to the Food and Agriculture Organization of the United Nations (FAO) the water, energy and food security nexus means that water, energy and food security are very much linked to one another. Water, energy and food are essential to human well-being, poverty reduction and sustainable development. Global projections indicate a continuous demand for freshwater, energy and food, which, over the next decades, will, under the pressure of population growth, significantly increase economic development, cultural and technological changes, and climate.[4]

Risk Assessment:

[2] The Toxics Use Reduction Institute (TURI) at UMass Lowell https://www.turi.org/Our_Work/Toxic_Chemicals/Chemicals_by_Name/Engineered_Nanomaterials

[3] https://www.nano.gov/nanotech-101/what/definition

[4] "THE WATER-ENERGY-FOOD NEXUS A NEW APPROACH IN SUPPORT OF FOOD SECURITY AND SUSTAINABLE AGRICULTURE" BY FAO (THE FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS)
http://www.fao.org/3/a-bl496e.pdf

The Risk Assessment is a systematic process of evaluating the potential risks that may be involved in an activity. In the case of nanomaterials, risk assessment refers to the risk of a chemical, which is defined as the product of hazard and exposure-risk = hazard (i.e. toxicity).

BACKGROUND INFORMATION

Characterization of ENMs

ENMs can be characterized using different techniques. Microscopy has been exceptionally helpful in providing data regarding the size and morphology of nanomaterials. Scanning and transmission electron microscopy (SEM and TEM), atomic force microscopy (AFM), scanning probe microscopy (SPM) and scanning tunneling microscopy (STM) have all been very often used to observe morphological and structural features of a large range of nanomaterials. SEM is a flexible technique that determines the morphology [5], while TEM is used for observing the finest details of the internal structure of materials.[6]

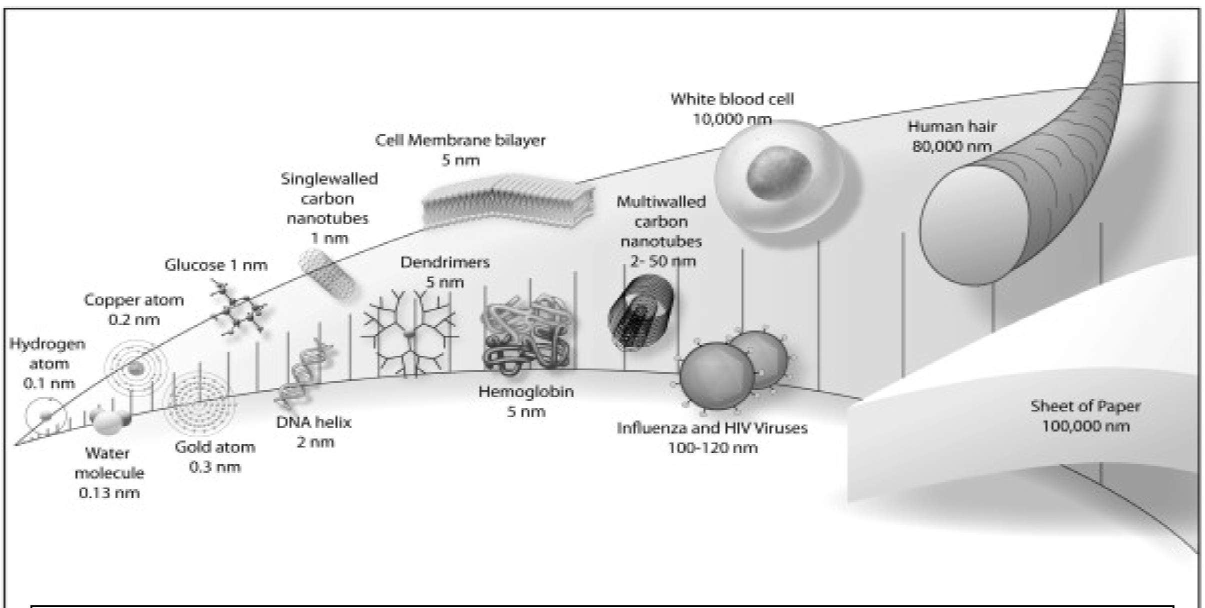


Image 2 —The sizes and shapes of some ENMs compared to more familiar materials. Shown for comparison are materials that are below, within, and above the nanoscale range, to put ENM size in perspective.

Working with engineered nanomaterials

[5] The branch of biology that deals with the form of living organisms and the relationships between their structures.

[6] IMAGE 2 https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3071337/

Nanomaterial-enabled products, such as nanocomposites, surface coated materials, and materials comprised of nanostructures (for instance integrated circuits), are unlikely to pose a risk of exposure during their handling and use as materials of non-inhalable size. However, some of the processes used in their production may lead to exposure to nanomaterials. Maintaining the production systems (including cleanup and disposal of materials from dirt assortment systems) is probably going to lead to exposure to nanoparticles if deposited nanomaterials area units are disturbed. These work tasks could increase the danger to nanoparticles: operating with nanomaterials in liquid media not using adequate protection (e.g., gloves); working with nanomaterials in liquid form throughout pouring and/or mixing operations; generating nanoparticles in non-enclosed systems, cleaning of dust collection systems used to capture nanoparticles, machining, sanding, drilling, or other mechanical disruptions of materials containing nanoparticles.

Nanomaterials and environment

Improved hardness, strength, increased electrical conductivity, different catalytic efficiency and new thermal properties are typical features that make engineered nanomaterials (ENMs) beneficial when incorporated into batteries, computers, cosmetics, sports equipment, building materials, coatings or medical devices. Many such applications may be of benefit to the environment, such as new environmentally friendly construction materials and improved energy storage. In environmental applications, engineered nanomaterial-based technologies offer great potential for innovations that could be beneficial for the environment, such as photocatalytic[7] surfaces that degrade environmental contaminants, efficient water cleaning technologies and nanoparticles for remediation of contaminated soil and groundwater, and may also have an indirect beneficial effect on the environment by optimizing product lifecycle or efficiency.

Ecological and health impacts

The effects of many engineered nanomaterials on human health and the environment are not yet well understood. Not all nanomaterials possess hazardous properties. Some studies show their biocompatibility, while others prove their potentially hazardous nature (e.g., carbon nanotubes). The potential risks of these materials also depend on their solubility, size, shape and agglomeration among other physicochemical parameters (e.g., crystallinity, redox potential, etc.).

Nanomaterials for human health applications

[7] Adjective form of photocatalysis: the acceleration of a chemical reaction by light.

The development and study of nanomaterials for medical applications is a key focus of nanomedicine[8] research and development. They are suitable for delivering therapies that overcome problems with conventional drugs. In medical technology, engineered nanomaterials are widely used for in vitro diagnostics, in particular for point-of-care diagnostic tests and molecular diagnostics. In the pharmaceuticals industry, nanomaterials have led to targeted therapies for severe diseases. Nanomaterials offer improved efficacy and reduced toxicity enabling clinical molecular imaging for earlier and more accurate diagnosis. [9]

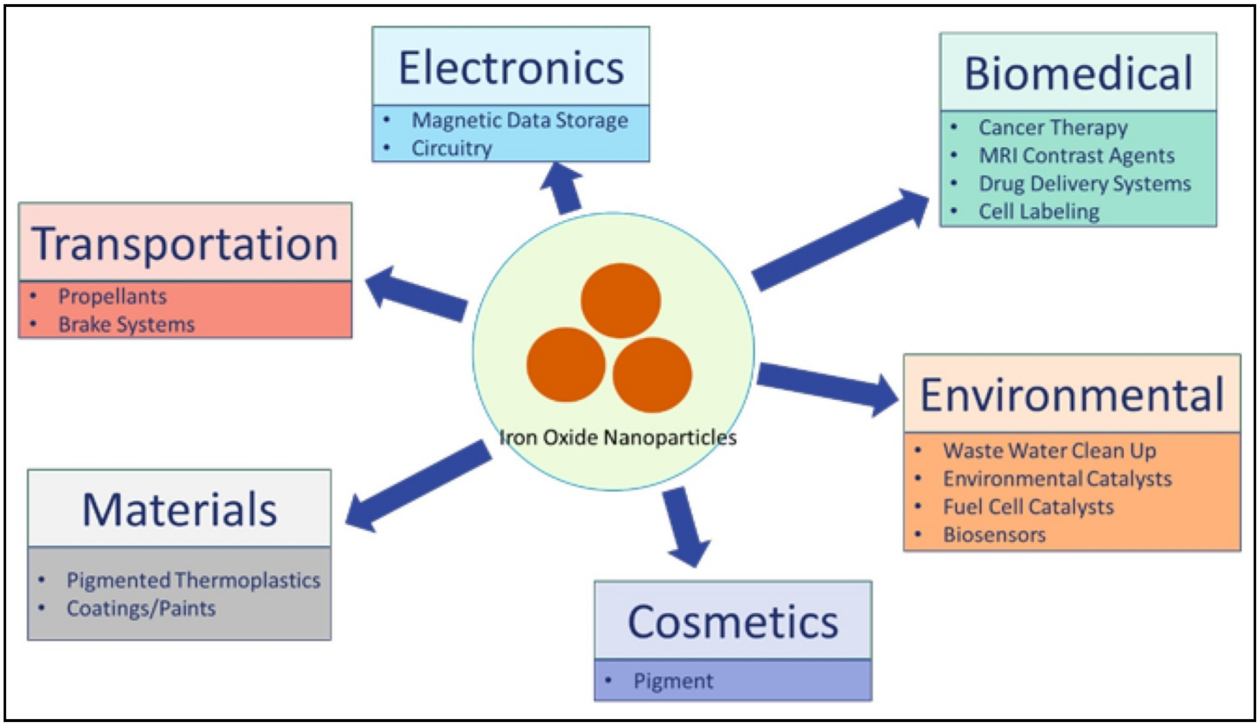


Image 3 —The use of the nanomaterial, iron oxide nanoparticles in different fields

Safety aspects and risk assessment

[8] Denotes the use of nanoscience methods, materials and tools to the benefit of human health

[9] IMAGE 3-https://www.mdpi.com/2079-4991/7/10/307

It is well known that nanomaterials may lose their specific properties after their release into the environment due to the simultaneous occurrence of numerous potential transformation processes. Life cycle considerations are an important aspect for the safe use of new materials in general, including nanomaterials. The rapidly increasing number of newly discovered and synthesized nanomaterials in various fields of application, and the growing number of scientific methods that are suitable for studying the safety and risks associated with a given material, are producing a large body of knowledge in this field. However, not every available analytical method can be applied to every material. As this is a rapidly evolving field, standardization and development of testing guidelines for nanomaterials constitute an ongoing activity in international organizations.[10]

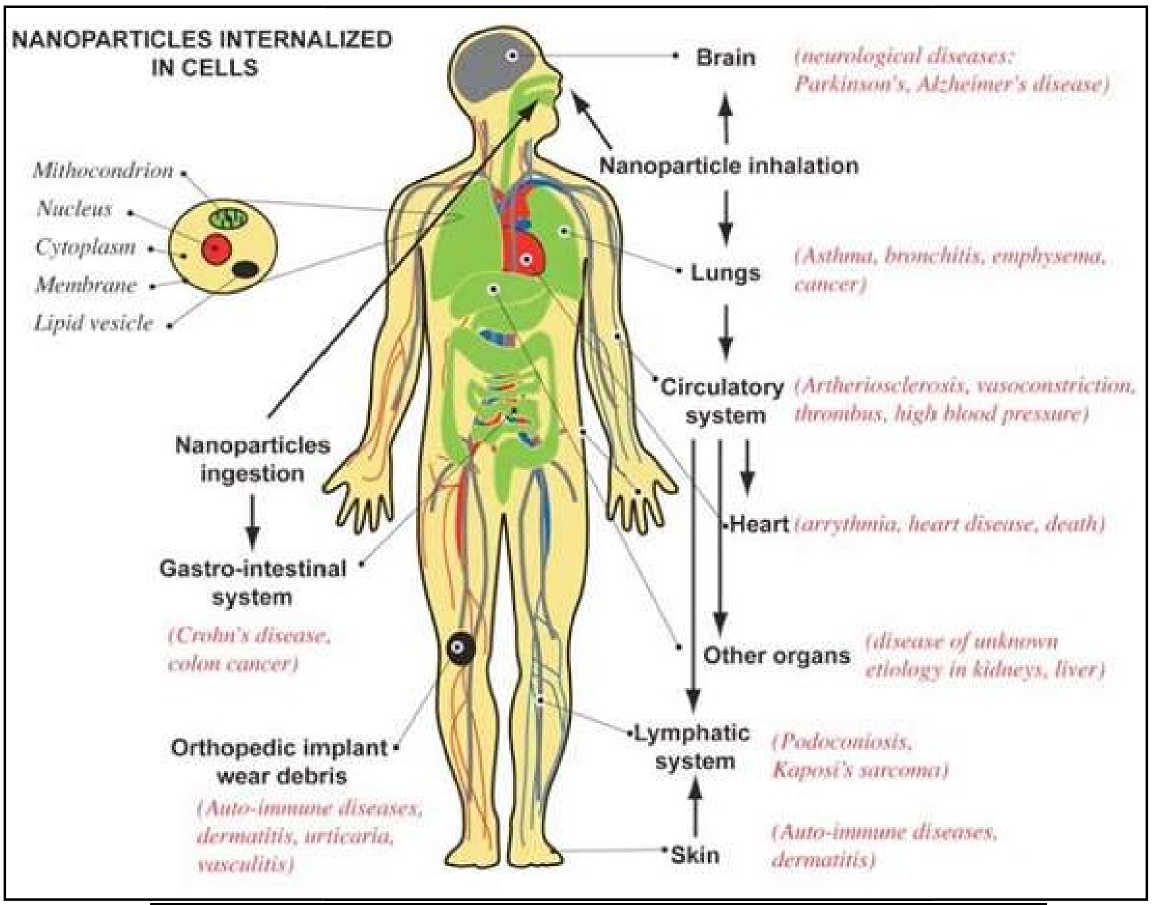


Image 4 — Nanomaterials are able to pass through cell membranes in organisms and may interact with biological systems leading to different diseases and making them dangerous

[10] IMAGE 4 https://www.news-medical.net/life-sciences/Safety-of-Nanoparticles.aspx

MAJOR COUNTRIES AND ORGANIZATIONS INVOLVED[11]

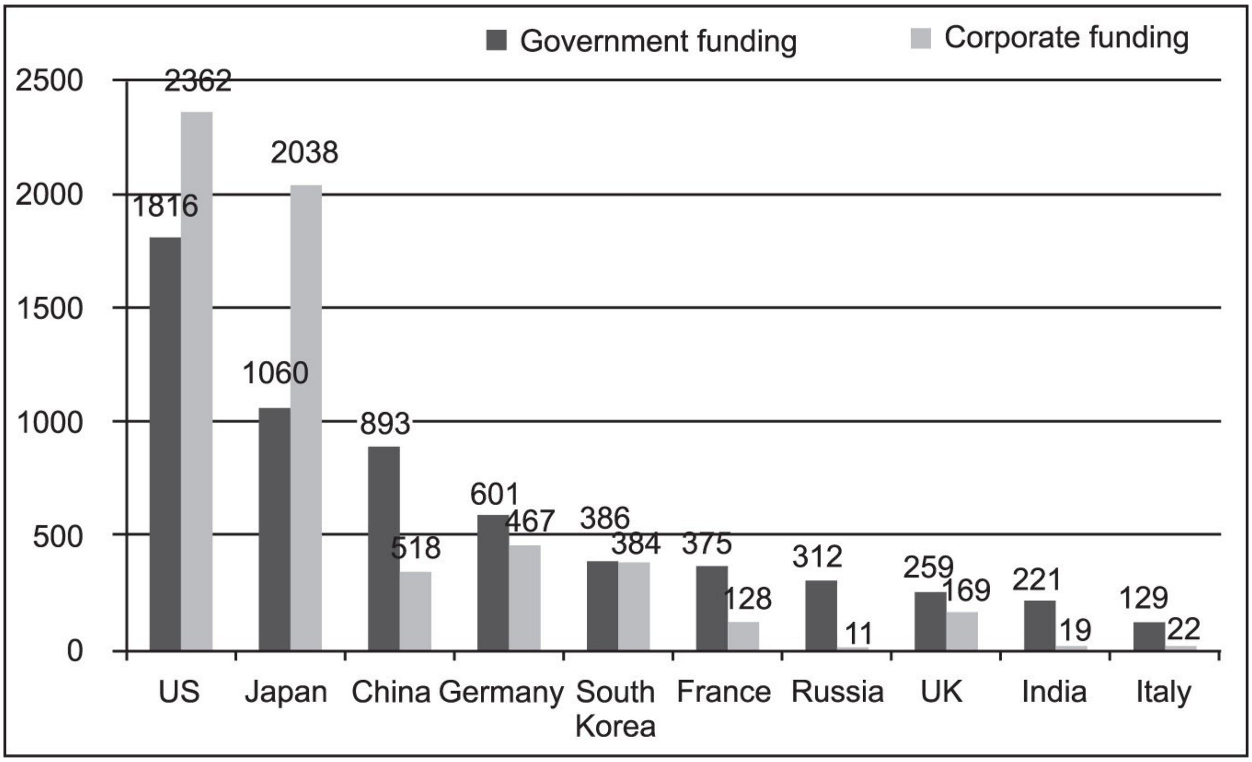


Image 5 —2014 countries on funding nanotechnology

USA (United States of America)

The industrial sector in the USA in concert with the government established the National Nanotechnology Initiative (NNI, 2000), which is the central point of communication, cooperation, and collaboration for all Federal agencies engaged in nanotechnology research, bringing together the expertise needed to advance this broad and complex field. Because of the variety of potential industrial and military applications, governments in developed countries have invested billions in nanotechnology research. Through NNI, the USA has invested $3.7 billion to estimate the environmental and

[11] IMAGE 5 https://www.google.com/url?sa=i&rct=j&q=&esrc=s&source=images&cd=&ved=2ahUKEwj_vcCyg57jAhVKDewKHfVPAMgQjRx6BAgBEAU&url=https%3A%2F%2Fwww.cambridge.org%2Fcore%2Fbooks%2Fnanotechnology-and-development%2Fplacing-bets-on-nanotech-case-studies-of-emerging-countries%2F94122C6CFDFC60A49BF4FCBD800A7C65%2Fcore-reader&psig=AOvVaw2mTWDC9FsBMNMdXhcWD7rV&ust=1562407342844876

human health risks associated with ENM exposure, information about their size, shape, and the dose-response relation is required.

Switzerland

In Switzerland, cooperation between the regulatory authorities, universities and industry has been a pioneering approach aimed at securing the safe industrial translation of engineered nanomaterials. Switzerland has various internationally relevant organizations (e.g., the International Society of Nanomedicine) and organizes special events (e.g., the CLINAM conference for nanomedicine, Swiss Nano Convention), while Swiss research is contributing to major international initiatives, such as the NanoSafety Cluster, the OECD Working Party on Manufactured Nanomaterials

Organization for Economic Co-Operation and Development (OECD) Working Party on nanotechnology and Working Party on Manufactured Nanomaterials (WPMN)

The OECD main objectives include supporting economic growth and contributing to growth in world trade. It was the first international organization to address the subject of nanotechnology. In September 2006, the OECD formed the Working Party on Manufactured Nanomaterials (WPMN) as a subsidiary body of its Chemicals Committee. The declared aim of this Working Party is to "promote international co-operation in human health and environment safety related aspects of manufactured nanomaterials in order to assist in their safe development."

The OECD WPMN consists of 30 OECD members, 66 the European Union, and a number of observers. Observers include: the ISO Technical Committee 229, 67 the World Health Organization (WHO), the United Nations Environmental Program (UNEP), the Business and Industry Advisory Committee to the OECD (BIAC), the Trade Union Advisory Committee to the OECD (TUAC), environmental NGO representatives, and representatives from a number of non-OECD countries. The OECD WPMN currently has eight different projects:

•**Development of an OECD Database on Human Health and Environmental Safety (EHS) Research** —research projects addressing EHS issues associated with manufactured nanomaterials.

•**EHS Research Strategies on Manufactured Nanomaterials (including Occupational Health and Safety)** —it aims to improve information exchange and identify common research needs to help address EHS issues associated with manufactured nanomaterials and then undertake the task to meet those research needs.

•**Safety Testing of a Representative Set of Manufactured Nanomaterials —**the aim of this project is to agree on a representative set of manufactured nanomaterials to be tested for their safety using appropriate test methods.

•**Manufactured Nanomaterials and Test Guidelines —**they have been created in order to review existing OECD test guidelines for adequacy in addressing manufactured nanomaterials and to also identify the needs for the development of new or improved existing test guidelines.

•**Co-operation on Voluntary Schemes and Regulatory Programs** —it aims to identify common elements of the various national information gathering initiatives, to identify applicable current and proposed regulatory regimes and to share data on existing or planned steerage documents on practices to lower environmental exposure to, or on releases of manufactured nanomaterials.

•**Co-operation on Risk Assessment** —the aim of this project is to evaluate risk assessment that approaches manufactured nanomaterials through information exchange and identify opportunities to strengthen and enhance risk assessment capacity.

•**The Role of Alternative Methods in Nano toxicology** —it aims at evaluating and, where applicable, validating in vitro and other methodologies.

•**Exposure Measurement and Exposure Mitigation** —the objective of this project is to develop tips on exposure activity and exposure mitigation focusing on occupational settings.

The OECD's objectives include boosting employment, supporting sustainable economic growth, contributing to growth in world trade, and maintaining financial stability.

International Organization for Standardization Technical Committee 229 (ISO TC 229)

ISO is a legal association, whose members are the national standardization bodies of 158 countries, which are supported by a Central Secretariat located in Geneva, Switzerland. Objectives of ISO/TC 229 are to support the sustainable and responsible development of nanotechnologies, to facilitate global trade in nanoenabled products and systems, improve quality, safety, security, consumer and environmental protection, together with the rational use of natural resources and promote good practice in the production, use and disposal of nanomaterials and nanoenabled products.

The International Electrotechnical Committee (IEC)

IEC has created a technical group modeled after the ISO TC 229: the IEC Technical Committee 113 (TC 113). The purpose of this technical committee, which consists of 15 participating members and 11 observer members and is chaired by the German National Committee, is to deal with relevant nanotechnological experiments when developing generic standards for electrical and electronic activity.

The European Committee for Standardization (CEN)

CEN defines itself as a facilitator in Europe that tries to remove trade barriers for European industry and consumers. It defines its mission as fostering the European economy as a part of global trade, the well-being of European citizens, and the protection of environment. Through its services, it provides a platform for the strengthening of European standards and other technical specifications. CEN created a technical group (TC 352) at the end of 2005, dedicated to developing standards addressing various aspects of nanotechnology and nanomaterials.

ASTM (American Society for Testing and Materials) International's Committee E56 (Nanotechnology)

ATSM E56 is a committee that deals with problems based on standard materials for nanotechnology & nanomaterials, as well as the coordination of an existing ASTM standardization related to nanotechnology needs. This coordination includes specific requests for nanotechnology standards through ASTM's existing committee base, as well as the maintenance of appropriate global liaison relationships with activities (internal and external) concerning this subject area.

TIMELINE OF EVENTS

DATE	DESCRIPTION OF EVENT
2000	The industrial sector in the USA and the government established the National Nanotechnology Initiative (NNI, 2000).
2002-2003	The Globally Harmonized System of Classification and Labeling of Chemicals (GHS) was agreed in December 2002 by an UN Committee of Experts and formally adopted by UN ECOSOC2 in July 2003.
2005	ISO established Technical Committee 229 (TC 229) to produce standards for classification, terminology and nomenclature, basic metrology, calibration and certification, and environmental issues with respect to nanotechnology.

2005	ASTM Committee E56 on Nanotechnology was formed
September 2006	Establishment of the global Working Party on Manufactured Nanomaterials (WPMN) an initiative of the Organization for Economic Cooperation and Development (OECD), where the Mutual Acceptance of Data in the Assessment of Chemicals[7] is an essential agreement.
2006	UNESCO Expert Group on Nanotechnology published a study in 2006 entitled "Ethics and Politics of Nanotechnology."
2009	The Federal Council commissioned the Swiss National Science Foundation to implement a national five-year programme focusing on the opportunities and risks of nanomaterials: NRP 64.The goal of NRP 64 was to deliver the scientific basis for a deepened understanding of the potential benefits and undesirable effects of nanomaterials.
2012	Communication on the Second Regulatory Review on Nanomaterials describes the Commission's plans to improve EU law and its application to ensure their safe use.
14 June 2017	On 14 June 2017, ECHA European Chemicals Agency launched the first version of the European Union Observatory for Nanomaterials (EUON).

RELEVANT UN RESOLUTIONS, TREATIES AND EVENTS

The Globally Harmonized System of Classification and Labeling of Chemicals (GHS)

The Globally Harmonized System of Classification and Labeling of Chemicals (GHS) was founded in December 2002 by a UN Committee of specialized consultants and formally adopted by UN ECOSOC (The United Nations Economic and Social Council) in July 2003.Therefore, nanomaterials that fulfill the standards for classification as hazardous on classification, labeling and packaging (CLP) of substances and mixtures should be classified and labeled.

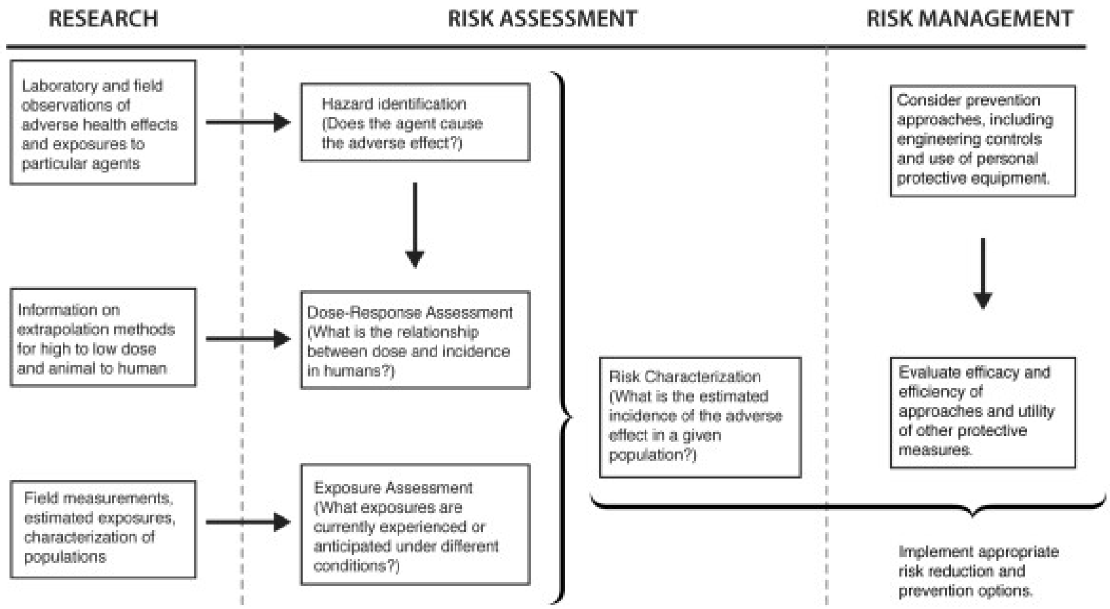
UNITAR(The United Nations Institute for Training and Research)

Since 2009, UNITAR has implemented a spread of activities to help developing countries in raising awareness on nanosafety issues and take into consideration the implications of nano-based and nano-containing products traded across borders, while working under the Inter-Organization Programme for the Sound Management of Chemicals (IOMC). The main sponsor for these activities has been the Government of Switzerland.

The Risk Assessment/Risk Management framework

The Risk Assessment/Risk Management framework, as originally named in the U.S. National Research Council report the "Risk Assessment in the Federal Government: Managing the Process", also known as the Red Book, principally deals with chemical threats to health. The framework is depicted in **IMAGE 6**[12]:

[12]Image 6
https://www.google.com/url?sa=i&rct=j&q=&esrc=s&source=images&cd=&ved=2ahUKEwjI2JG0h57jAhWQJVAKHdHLDuIQjRx6BAgBEAU&url=https%3A%2F%2Fwww.nap.edu%2Fread%2F13152%2Fchapter%2F7&psig=AOvVaw1FzlQdbsLbOM236ctz7HSd&ust=1562425687413185



National Institute of Environmental Health Sciences

Developed an interagency agreement with NCI's (National Cancer Institute) Nanotechnology Characterization Laboratory in order to provide NIEHS (National Institute of Environmental Health Sciences) grantees common engineered nanomaterials (ENMs) and characterize the physical and chemical properties of the materials. This allows the grantees to have standardized characterization of the materials they are using so as they can more easily compare results across studies.

PREVIOUS ATTEMPTS TO SOLVE THE ISSUE

REACH (Registration, Evaluation, Authorization and Restriction of Chemicals)

Companies, which import or distribute nanomaterials into the European Union territory, must act in accordance with the Registration, Evaluation, Authorization and Restriction of Chemicals (REACH). Two sector-based regulations and three EU member states force them to register substances, mixtures and articles containing nanomaterials. In addition to uncertainty concerning the legal definition of nanomaterials, the European Union has no coherent framework for registration at the moment.

The National Nanotechnology Initiative (NNI)

The National Nanotechnology Initiative (NNI) is a federal, multi-agency program dedicated to expediting high category nanotechnology research and improvement, to foster the transfer of the latest technology for industrial and public benefits, to develop and strengthen a skilled workforce and to help responsible development of nanotechnology.

The National Research Programme "Opportunities and Risks of Nanomaterials" (NRP 64)

In the scope of NRP 64, the promise of innovative solutions based on nanomaterials was analyzed including consideration of their potential risks. For example, the use of nanoparticles in materials for medical implants led to an in-depth study on their biodegradation. NRP 64, «Opportunities and Risks of Nanomaterials», was thus a timely effort to deepen the understanding of these important issues. It yielded an array of complementary information in the areas of healthcare, protection of the environment, energy, food and construction materials.

United States National Research Council

The methodology recommended by the United States National Research Council proposes four steps for accomplishing environmental and human health risk assessment (EHHRA) of chemicals and metals:

(i) hazard identification,
(ii) exposure assessment,
(iii) dose-response assessment, and
(iv) risk characterization.

POSSIBLE SOLUTIONS

The lack of strict policies and laws in regard to the use and disposal of nanotechnology, as well as to the recycling of nanomaterial-containing products, is a crucial problem. Nanowaste is notoriously tough to be contained and monitored, because of its tiny size that can spread in water systems or become airborne causing harm to human health and the environment.

One of the most important things in order to solve this problem is raising awareness of the occupational safety and health issues being identified in the rapidly moving and changing science involving implications and applications of nanotechnology. We should use the best information available to make recommendations on occupational safety and health practices in the production and use of nanomaterials (These recommendations will be updated appropriately in order to reflect new information. They will address key components of occupational safety and health, including exposure monitoring, engineering controls, personal protective equipment, and administrative controls. Throughout the development of these guidelines, the utility of a hazard-based approach to risk assessment and control should be evaluated and, where appropriate, recommendations be provided.

Moreover, facilitating an exchange of information from ongoing research, including success stories, applications, and case studies and responding to requests from industry, labor, academia, and other partners, who are seeking science-based, authoritative guidelines, would help identify information gaps, where few or no data exist and where research is needed.

Consumers and the broader community must understand that, while nanotechnology can successfully confront many current challenges, when used inappropriately or irresponsibly, it can have serious, often irreversible, consequences to human health and the environment.

LINKS FOR FURTHER RESEARCH:

"Chegg.com." *Q S C I V E P H T I R K K P O E E K B D F V H Z G ... | Chegg.com*, www.chegg.com/homework-help/questions-and-answers/q-s-c-v-e-p-h-t-r-k-k-p-o-e-e-k-b-d-f-v-h-z-g-g-p-v-r-e-o-y-q-q-m-k-r-n-c-g-l-n-g-h-t-w-d--q2065001.

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