# Access to Safe Water for the Bottom of Pyramid: Strategies for Disseminating Technology Research Benefits

## Consultation Summary

## March 2011

***Organised by***

Development Alternatives

***In collaboration with***

Department of Science and Technology
Ministry of Science & Technology, Govt. of India, New Delhi

DFID Department for International Development

IIT Bombay

## Contents



## Background

Access to clean water is the foundation of development. Food, health, hygiene, habitat, education, employability, productivity are all dependent upon access to water. Without clean water, none of these is possible and poverty is inevitable. Over the years, India has made improvements to both the availability and quality of municipal drinking water systems. However the exponentially growing population has stressed existing water systems and resources. The pressures of urbanization have stretched government solutions. Rural areas are still left out. Many water sources are contaminated with both bio and chemical pollutants, and over 21% of the country's diseases are water-related. Nanotechnology has a large scope in terms of taking ameliorative action in this scenario.

The Department for International Development (DFID) leads the UK Government's fight against global poverty. To take this agenda forward DFID is establishing a research programme to help engage with those new and emerging technologies with the potential to impact on poverty in a way that enables developing countries to take advantage of what they have to offer.

Through this research, the Development Alternatives group (DA) seeks to identify key challenges and barriers that may reduce the impact of Nanotechnologies for providing clean drinking water reaching the underprivileged in developing countries, its possible environmental implications and remedial measures.

One day consultation workshops on "***Access to Safe Water for the Bottom of Pyramid: Strategies for Disseminating Technology Research Benefits***" were organised by Development Alternatives (DA) Group in association with the Department of Science and Technology - GoI, the UK Department for International Development (DFID) and the Indian Institute of Technology – Bombay; in Bengaluru on 4th March 2011 and Mumbai on 8th March 2011 respectively.

Department of Science & Technology (DST) was established in May 1971, with the objective of promoting new areas of Science & Technology and to play the role of a nodal department for organising, coordinating and promoting S&T activities in the country. DST, in October 2001, launched the Nano Science and Technology Initiative (NSTI). Currently, the Department of Science and Technology is the nodal agency for implementing the Nano Mission, launched by the Government of India in May 2007 following the NSTI. The Nano Mission is an umbrella programme for capacity building which envisages the overall development of this field of research in the country and to tap some of its applied potential for the nation's development.

The consultations were primarily sharing and learning events on the current concepts and literature on nanotechnologies of water purification in India initiatives to promote nanotechnologies in the waters sectors while attaining poverty alleviation. The consultations saw active participations from both industry as well as academic players. The purpose of the workshops was to initiate dialogue with the participants to:

- Arrive at a consensus on market and policy barriers affecting large scale roll out of nanotechnologies in the water sector to the bottom of pyramid market in India
- Prioritise Action and Initiatives to promote nanotechnologies in the water sector while attaining poverty alleviation and MDGs in the developing world.

DFID is the part of the UK government that manages Britain's aid to poor countries and works to get rid of extreme poverty. DFID is working to reach the Millennium Development Goals (MDGs), the international targets agreed by the United Nations (UN) to halve world poverty by 2015. DFID works with governments of developing countries as well as charities, businesses and international bodies, including the World Bank, UN agencies and the European Commission. All our partners share our ambition to achieve the MDGs.

## Key Issues Identified

- One in eight people in the world today lack access to clean drinking water. A child dies every 15 seconds from a lack of clean water. One in four children who die before age five worldwide, die of a water related disease. Most people without access to clean water live right above it. In many cases the only thing preventing access to clean water is money. Access to clean water is the foundation of development. Food, health, hygiene, habitat, education, employability, productivity are all dependent upon access to water. Without clean water, none of these is possible and poverty is inevitable. Majority of these people are in the developing world.

- Over the years, India has made improvements to both the availability and quality of municipal drinking water systems. However the exponentially growing population has stressed existing water systems and resources. The pressures of urbanization have stretched government solutions. Rural areas are still left out. Many water sources are contaminated with both bio and chemical pollutants, and over 21% of the country's diseases are water-related.

- There is a key role for research to help anticipate and respond to future trends. New and emerging cutting edge technologies like nanotechnology are being developed, albeit for industrialised markets, that could have a real relevance to the needs of poor people. Research is needed to explore the most effective, safe and affordable approaches to applying these new technologies in developing country situations and to ensuring the benefits are derived by the poorest. This research has the potential to impact poverty in a way that enables developing countries to take advantage of what scientists have to offer.

IIT Bombay was established in 1958, at Powai, a northern suburb of Mumbai. Today the Institute is recognised as one of the centres of academic excellence in the country. Over the years, there has been dynamic progress at IIT Bombay in all academic and research activities, and a parallel improvement in facilities and infrastructure, to keep it on par with the best institutions in the world. The Department of Metallurgical Engineering and Materials Science is devoted to the design, creation and fundamental understanding of materials that are capable of enhancing the human experience.

- Nanotechnology has introduced a new generation of water filters and purification systems and water quality sensors. Research on Carbon nanofilteration membranes and nano catalysts like iron, silver and titanium dioxide for water treatment applications is a fast growing field. Universities like Stanford, Aberdeen, Rice, etc. as well as their Indian counterparts like the Indian Institutes of Technology, Benares Hindu University, Indian Institute of Science etc. are actively involved in nanotechnology research focused on the water technology. Some technologies have recently also been introduced in the market by companies like Eureka Forbes Limited, TATA Chemicals, etc. for point of use application.

The consultations strived to answer these questions

- What parameters enhance the acceptability of a technology?
- What are the main barriers/ gaps / challenges that impede widespread market dissemination of nanotechnologies in the water sector?
- What market drivers can fast track acceptance of nanotechnologies in the water sector?
- Perceived roles of different stakeholders – public and private sectors, and Donors

The Development Alternatives Group, often referred to as DA Group, comprises of the Society for Development Alternatives (DA), Technology and Action for Rural Advancement (TARA), and its social enterprises. Established in 1982, with the overall mandate of creating sustainable livelihoods in large numbers, the DA Group activities broadly cover the three primary areas that underline any form of sustainable development process: the design and large-scale dissemination of appropriate technologies, rationale environmental management systems, and equitable people oriented institutions and policies.

## The Consultations

The consultations were designed to be interactive to invite maximum participation and inputs from the stakeholders. The day was divided into four sessions on Nanotechnology: **Potential** in Bottom of Pyramid Markets, **Market Barriers** for Nanotechnologies, **Risk Mapping** of Nanotechnologies in the Water Sector and **Action** and **Initiatives** for Nanotechnologies in the Water Sector respectively.

The consultations opened with a welcome address by **Dr K Vijaya Lakshmi, DA,** introducing the program, the study and the partners. This was followed by a round of introduction by the participants.

The tone of the consultations was set by an overview presentation by Ms Kriti Nagrath, DA. The overview presented the context of the study given the current safe drinking water crisis in the developing world. It highlighted the objectives of the current study i.e. to identify key challenges and barriers that may reduce the impact of technologies such as nanotechnologies for providing clean drinking water reaching the under privileged in developing countries, with a focus on :

- Possible environmental implications and remedial measures
- Successful service delivery models
- Absorptive capacities of the population

### *Nanotechnology: Potential in Bottom of Pyramid Markets*

The first session focused on the potential of nanotechnology in bottom of pyramid (BoP) markets. The session began with an introduction on BoP markets and indicators for assessing potential by Dr Uzma Nadeem, DA, followed by a moderated discussion and group exercise.

Participants were invited to share what they perceived as indicators for assessing the potential of a technology for water purification in the context of reaching the masses.

The main indicators that were identified with regard to the technology and the Bottom of the pyramid market were Awareness, durability, ease of use, recyclability of device/units, cost effective, runs without power. The main indicators that were identified with regard to

the technology and the Bottom of the pyramid market were Awareness, manufacturability, ease of use, application and end of use.

One of the key indicators that emerged from the discussion was the awareness or the lack of **awareness** as determining the practice and attitude of the end users. Awareness has two important dimensions; the awareness towards the **need for clean drinking water** and the awareness about **nanotechnology**.

Discussion threw up that there is a need for increased awareness among the researchers to understand the potential and risks associated with Nanotechnology. This was further deliberated in the session on risk mapping. Often rules are flouted due to lack of awareness about the consequences. Adaptation of technology should be relevant to the particular geographical location as all technologies may not be applicable everywhere.

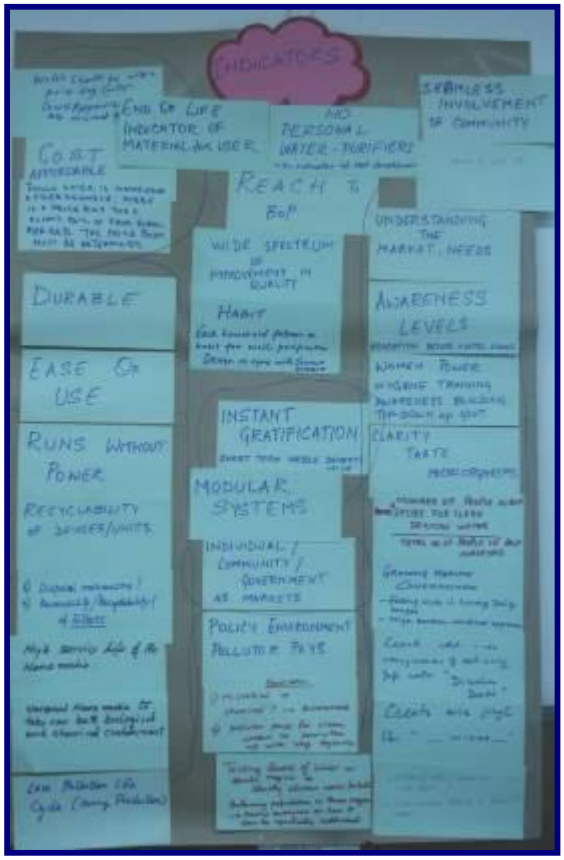
Secondly, the perception of people with respect to safe water is very diverse. They are not aware of the risks of consuming contaminated water hence it is important to create awareness despite the technology adapted. The water and health-hygiene connect is very strong and can be used as a leverage point for awareness generation.


**Indicators, Bengaluru**

Growing health consciousness and an understanding of costs and expenditure related to diseases act as a push towards realizing the need for clean drinking water. Women especially have a key role to play given the influence they exert on domestic issues. Before and after studies for interventions targeted towards providing safe drinking water will help build the evidence base on which concrete action can be taken. Local media involvement in highlighting the dangers and spreading awareness is very crucial.

There is also a need to understand the target audience and market and adequately assess their needs. Interventions should be molded on their needs. Water purifiers are

not very popular consumer goods especially in our focused target group. Reports claim only about 12% of the population use them. The bottom of the pyramid market barely occupies any share in this estimate. Exchanging field experiences, it was noted that people do not like to pay for water. However they have been using purifiers in certain locations due to the presence of external agencies like research institutes and CSOs. Creating awareness is one method of creating this market. However different service models, including those run by communities and governments need to be explored so safe drinking water is available to the people. There was also an opinion that, people are not willing to pay for the water purification but NGOs are pushing them to adopt the water purification products.




Another set of indicators allude to the **reach** of the technology in the target market. The supply of material in required amounts at required purity is a concern for scaling up processes. A proper mechanism for availability of material in markets needs to be established.

Given there is an appropriate technology and there is a demand for the same, there is still a concern of the services reaching the people. The ability of a technology or device to be **mass produced** at low costs and **minimum risks** is a good indicator of its potential. Post sale or delivery **service infrastructure** is often a cause of concern especially in rural markets and is indicative of the success in markets.

Another important aspect is the **disposal** or end of life treatment of these devices. This applies to both the toxic chemical residues and the e-waste generated from the device. Disposal of toxic materials should be done through proper routes. Also less polluting materials across their life cycle are preferred. While research is being done on the technology application, there is limited focus on the harmful impact of nanomaterial

disposal. On the demand side there is a need to make people aware about dumping of contaminants and on the supply side, disposal has to be cost effective.

A very important set of indicators that came up during the discussions were those related to end user **specifications** and **preference**. End users look for **instant gratification**. This is a very important indicator in assessing the potential of a prospective technology. Water is a sector where providing instant gratification is often tough since health benefits are seen over medium and long terms. However there should be some visible result that the user can appreciate and that leads to an attitude change towards purifiers.

- Cost is an important indicator as it dictates the movement of the device in the market. Though water is considered as a free resource, there is a price point that allows rural markets to purchase or rent. The price point must be determined.

- Water storage and usage habits are peculiar to households and often dictated by region and culture. The purifier design should take into account this parameter and be easy to use.


**Bangalore Participants discussing nanotechnologies**

- The products for water purification should not be contaminant specific that means one product can be used for purification of all the type of contaminants.

- Discussion threw up that community level applications may be more suited for remote villages that actually suffer from the problems of poor water quality.

During further interactions, different usability attributes of a purifier that attract customers and form good indicators of potential were identified.

- Products that run without **electricity** are preferred especially in rural areas.

- **Low maintenance** over setup and operation was also mentioned as a desirable quality

- No change in spare parts
- **Durability** of a product i.e. Long service life is an important consideration.
- Recyclability or **reusability** of filters
- Easy indication of end of life of filters enables consumers to change filters at appropriate intervals.
- Easy **Disposal** of used devices taking into account logistics as well as environmentally safe disposal mechanisms.

An understanding of market needs and manufacture processes is essential to designing delivery models. The needs at an individual, community and Government market are different and require differential approaches.

This requires investments to be made by the public and private sector. There is a need to define the range of application according to business interest of the investor. The government already has made huge investments especially in the rural sector. Cross subsidizing water costs can be an effective tool in making safe drinking water available to them.

**Group Work for Ranking the Technologies, Bengaluru**

After identification of the key indicators of potential of technologies, the groups were engaged in an exercise to rank the nanotechnologies. Key nanotechnology principles - Hydrotalcite, Nanoceramics, Nanocomposites, Nanofilteration, Metal oxides, Noble metals, Carbon nano tubes, semi conducting Nanomaterials etc. - were highlighted in a presentation by Ms Kriti Nagrath to offer a staring point to the discussion. Various nanotechnologies in different stages of development were put up on a board and the group was asked to prioritize their best options for water purification keeping in mind the BoP populations. The technologies were ranked based on their removal efficiency of

arsenic, fluoride, pesticides and pathogens (bacteria and Viruses) from water since the aim was to look at technology best suited for water purification.

Magnetic Nanoparticles were voted the best choice for Arsenic removal followed by metal oxides. Nanocomposite membranes, ceramics and polymers are also a viable option for arsenic removal when embedded with the appropriate Nanomaterials.

Fluoride removal is best undertaken by metal oxides, especially when coupled with Nanocomposite membranes or other nanoporous materials. Nobel metals might also offer some scope in this area. There was one very pointed input about no nanotechnology explored today being effective for fluoride removal.


**Technologies ranked by the participants, Mumbai**

Noble metals offer the best options for organic contaminants like pesticides as well as for microbial contamination. Titanium dioxide is also used to effectively remove microbial contamination. Other options selected were nanoceramics, charged nanofilteration and nanoporous materials.

Nano carbons offer maximum potential when dealing with organic contaminants like pesticides. Metal oxides also have potential in this area. Carbon nanotube based technology offers limited potential for arsenic, fluoride and organic contaminants. However this technology is in a very nascent stage and field prototypes are not expected soon.

## *Market Barriers for Nanotechnologies*

The second session focused on the market barriers that prevent the large scale roll out of nanotechnology based products for water purification. A presentation by Dr Uzma helped orient the discussion by throwing light on the major gaps and barriers that exist today. She initiated the discussion by raising three key questions.

- What are the factors with regard to the technology applied in Nano water filters which impede its uptake and usability?

- Are the current policy, environment and implementation structures adequate for reaching the BoP Market?

- What is obstructing the maximum reach of water purifiers in terms of affordability, safety and effectiveness?

**Dr Uzma introducing the concept of market barriers**

The group work and ensuing discussion brought out that some of the key barriers were in terms of awareness, productize research, toxicity research, finance, capital cost, logistics, policy, technology and cultural issues.

- One of the foremost barriers identified was the **lack of awareness**. People do not realize the importance of safe drinking water and the related health impacts. Hence they do no aspire for purifiers and related products. Only if people understand and value safe drinking water, will they adopt purification techniques and practices. There is a lack of studies on economic benefits of clean water.

- **Lack of adequate and appropriate communication tools** is another reason for low awareness. These need to be used to reach the BoP populations and convey the message to them. Media is an effective tool and should be integrated into strategy plans. Communication should be focused on changing behaviour to adopt purification techniques especially low cost and simplified methods like boiling, solar disinfection etc. thinking on low cost and effective marketing and media vehicles to reach BoP is required.

- Devices need to be designed keeping in mind user preferences and cultural and traditional practices to enhance adoptability. Water purifiers require regular maintenance and service. The **lack of adequate, appropriate and timely technical support** alienates rural communities from easily adopting the purifiers. There is a need to train more people and create a maintenance supply chain.

- Most research in the field is at the level of laboratories – testing the technology. Only a few have been prototyped and tested. There is a **lack of emphasis** on the

**incubation phase** that enables research and proven technologies to be marketable. The current **ability** of technologies to **scale up** is very **limited**. It is important to get various stakeholders together on a common platform like industrialists, researchers and promoters to be able to market the researched technology

- Most of the purifiers have **short term utility.** There is need of a product which can be used for a longer duration. Continuous monitoring of removal efficiency of technology is required because after some time **removal efficiency of water purifiers drop down**.

- There is a need to develop understanding on existence of any potential **risk** to the **environment or humans**. There is a **lack of knowledge** regarding **toxicity concerns** including **Species mutation**[1] and appropriate disposal of wastes (especially water that may contaminate ground water) from manufacturing units. Lack of scientific document for **safety** is also a gap behind the research and development of these kinds of products. It is important to treat the water within the plant and also explore options for recovery and reuse. Constant monitoring through the lifecycle of the material / device is needed before it is released in the market.

- The **cost of manufacturing Nanomaterials** is quite high presently; hence research needs to focus on finding alternative cost effective processes (using biopolymers, activated carbon, graphene etc).

- However, it was discussed that cost reduction will not help reach community unless the **value of safe drinking water** is proven to them. Unilever bought down the cost but still there is limited acceptance. This is because people don't value products of water purification.


**Market Barriers identified by participants, Mumbai**

[1] Due to inefficient disposal practices, microbial species are exposed to varying doses of materials and can develop resistance by mutation; affecting the removal efficiency of the purifiers.

- There is a **lack of investment** in both **research** and **incubation** of technologies. There is a gap that can be filled by efforts of both industry and government players. Lack of corporate contribution to R & D, ownership by government /NGOs, incubation support, investment in pilot incentive from government and synergy of supply chain are the other issues which were discussed.

- Awareness and **understanding of the market** is **not adequate** especially in the BoP sector. There is a need to survey the existing market with respect to products available in market and how much do people spend for those products. It is also important to understand the meaning of cost at scale to understand delivery systems e.g. Bottled drinking water is very popular not only in the urban sector but also the rural due to its affordability. Cross subsidization is another approach to reach the last mile.

- The discussion was focused on the **lack of interest** displayed by **Government** agencies towards this issue. There is need to provide **risk support** to the research **enterprises** and for the policy to establish and promote **entrepreneurship** and scale up **facilities** in institutes.

### *Risk Mapping of Nanotechnologies in the Water Sector*

The post lunch session was on risk mapping of the nanotechnologies. Understanding risks is an important part of any technology that will be placed in the public domain. Nanotechnology is a new and emerging technology with lots of gaps in understanding toxicity and management risks. Hence mapping is essential to understand which areas need attention.

Risk mapping of nanotechnologies with regard to impact – a function of severity and probability - was carried out through a group exercise to explore the risks associated with the identified technologies. Various technologies were plotted on this graph. The various stages of the technology from manufacturing to operation and disposal were discussed and their respective risks were plotted.

The discussion threw up that information on risk understanding and analysis was not a strong suit. Researchers working in the field of nanotechnology have not strongly focused on the risk factors. Not enough thought has been given to the kinds or severity

of risks that can occur while working on these technologies. However researchers also claimed that not all Nanomaterials are toxic because they can be converted to less toxic forms when treated with another material or compound for example Mg can be treated with water to form a hydroxide.


**Risk Mapping, Mumbai**

One of the high risk areas identified was the manufacturing of Nanomaterials. The danger here is either through ingestion, dermal uptake or inhalation of the particles. Nanoparticles of any size are dangerous when inhaled thus the safety and insurance of workers must be ensured. Risk associated with Nanomaterials is particularly high when the quality of raw materials is substandard. Probability and severity of risks is largely dependent on the scale of the unit, the process adopted for manufacture and the safety and management procedures followed. Though severity is quite high, probability of occurrence can range from very low to negligible when good management practices are followed to very high probability of risk particularly in case of small and informal units.

Manufacturing processes should also look at working towards production of nanoparticles in an aqueous base and various other technologies like laser ablation can be looked at to achieve the desired particle size. The **Sol Gel Method** is followed by most manufacturing units where the risks are minimized. If the technology is adapted from other countries there may be production risks. It is important that consumers are aware of the technology so as to make an informed choice about the product.

The next step in the life cycle is transportation. In this case the risk probability is low and intensity is high as nanoparticles are affected by humidity and vibration. To address this there is a need for specific storage instruction, like the use of moisture barrier packing materials and ensuring they are handled in a dry area.

Risks during operation were not perceived to be very severe or probable. Most devices have checks to prevent leaching. Also the materials used in products that have already

been marketed are not seen as potential dangers to the human system in the given concentrations.

Disposal is a cause of concern for risk mapping both of the devices at the end of their life and of the manufacturing wastes. There is probability of biomagnifications of nano toxic wastes generated while synthesis and production. In the case of waste material produced the severity is low however the probability is high because liquid based waste will include washing and spillage. It was however pointed that the materials are recovered before disposal. Similarly gaseous waste that are released the probability is high due to the risk of bioaccumulation, however the severity risk is low because of the minute quantities of such waste are released into the atmosphere.

Some of the Nanomaterial wastes require treatment processes and the probability of risk varies depending upon the manufacturers. Also when disposed in the environment the nanoparticles will not remain in the nano form hence the risk is low but there is no research or proof in this area hence government policies are important in the responsible manufacture and monitoring of nano materials in the country. Care also has to be taken during the purification of nano particles which can lead to toxic residues in the reaction mix, capping material etc. These need to be contained. The companies manufacturing must also take responsibility in adapting all required safety measures so that the risk from these materials at the disposal stage is minimized. Here again the scale, process and management procedures followed dictate the impact of the risk.

**Participants in Mumbai engage in discussions**

The discussion also focused on specific technology and their potential risks which are elaborated below. The technologies preempted for discussed were noble metals, nano particles, metal oxides, polymers, nano carbon tubes, nano ceramics, nano composite membranes, semi conductors and synthetic technologies.

There is no understanding of the level of concentration that may lead to toxicity. While applying standards used for larger particles of the same elements, the probability is perceived to be low and severity is high.

By and large **noble metals** are understood to be non toxic; though high concentration of noble materials is harmful for example silver above a concentration is harmful. The probability is high when there is high activity and hence the impact might be more. **Metal oxides** risks are low as all oxides are by themselves non toxic. Similarly **polymers, Nano ceramics** and **Nano composite membranes** have a low risk probability since there is no leaching.

**Nano carbon tubes** may have high risks on consumption, hence the severity is high and the probability is moderate. However these may be harmful when employed in device.

## *Action and Initiatives for Nanotechnologies in the Water Sector*

In this last session, participants were asked to first identify the different actors involved in nanotechnology in the Water sector and then define the potential actions and initiatives that can be undertaken by them. The actors identified were Researchers, Incubators, Industries, Policy Makers, CSO's, Media and Users.


**Key Actors and their roles, Mumbai**

During the workshops, it was observed that while there were many **researchers** working in the field of nanotechnology, there was a disconnect between them and knowledge sharing was very limited. Need based research should be further promoted and funded for the technology to have a wider impact. Gaps in their funding requirements were seen as a barrier to achieve this. Besides developing technology there was also a need for the researcher to focus on studying the risks pertaining to these technologies on both humans and the

environment. There is a need to understand conventional technologies like ultra filtration, magnetic and ceramic methods to understand what worked and what did not and also focus on developing indigenous technologies.

Additionally, a need for a focused researcher/ champion who carries through all the research regarding a particular technology idea was discussed. Between developing a technology and marketing it for public use, there is a very crucial role to be played by an incubator or a technologist to initiate a lab to land connect by packaging the technology and getting a prototype for field testing. This **Incubators/Technologist** was identified as a major gap in the Nanotechnology space today. This key actor ensures that the products developed should be in tune with the practices followed by the end user to enable their mass production. In order to achieve sustainable scaled up models, there is a need to influence behaviour as well as design products that enhance adoptability by catering to local traditional practices. Continuous monitoring of removal efficiency of a technology is required because removal efficiency of water purifiers drops with time.

**Industries** were identified as an important actor that could address the huge gap in the funding process. This could be done through their active support to Research and Development (R&D) processes as well as through providing linkages between researchers and industries to avoid overlapping of research. It was stated that supply chain management strategies need to be put in place to ensure movement and storage of raw materials, work-in-process inventory, and finished goods from point of origin to point of consumption. Industries need to take the lead in identifying and packing the technology for the market to ensure that research lying in the lab actually reaches the masses.

There is a need for financial institutions and governments for rural development and identification of mass production technology that will reduce capital cost and have an effective service delivery system to reach large numbers. Micro-finance can play a role in promoting a product by helping people avail loans to purchase the product.

There is also a gap between industry and research. Events like workshops and conferences for increased awareness of all researchers engaged in nanotechnology need to be organized more frequently. These will provide a platform for discussion and display solutions developed by researchers. The **government** should play a major role in brining together researchers, funding agencies, industries and all other stakeholders

on a common platform for better dissemination of knowledge and technology. A multi - stakeholder approach is needed.

With the move of advanced economies from a resource-based to a knowledge-based production, many national governments have increasingly recognized "knowledge" and "innovation" as significant driving forces of economic growth. Thus, the role of **policy makers** becomes increasingly significant in promoting research and encouraging knowledge transfer. A web based platform needs to be created that can display all the solutions developed by researchers. While technical details need not be put up, the platform will help avoid duplication and create a knowledge base for the country. It is also important that agencies like DST have policies that can enhance interactions and also enable find suitable industries that may be able to fund the R & D process and take the research forward.

Policy makers also need to focus on setting up standards and regulations for disposal of Nanomaterials by laboratories as well as industries. There is a need to have standards for the technology similarly to ISO 14000 etc. so that all the risks associated can be minimized at the manufacturing levels. Policies for environmental polluters – precautionary principle and polluter pays - need to apply to this area also

**CSO's / NGO's** can contribute towards creating demand for the products through encouraging behavior change, for instance by encouraging communities at risk to treat their water before drinking. They can also help create awareness about the products – their availability as well as the risks or any precautions to be taken by end users. They can contribute to understanding the demographics of end users for product development as well and assist in the wider dissemination of technology. They are also instrumental in applying pressure to bring about policy change. The **Media** similarly, needs to create awareness on the various technologies available and publicize the products for end users.

Finally, the end **Users** need to be made aware of both surface water and ground water contamination that leads to disease. While people have been coping with the impacts of water pollution through indigenous knowledge and sometimes unknowingly for instance by eating *Chuna*, a supplement of calcium that reduces the impact of fluoride and mitigates flurosis; people need to incorporate other water purification techniques like boiling water etc. into their daily practices. The discussion threw light on the fact that

overall efforts need to be made to address the quality of water and Nanotechnology is only a part of the solution when we look at various other solutions for long term sustainability. It is hence very important to educate and aware the people about the drinking water quality, what is potable water and we should have to know that what they actually want. It is important to promote technologies that can solve issues by interacting with differ stakeholders to see that the technology is marketed. Seamless involvement of community across the development of the product is integral to the successful adoption of the technology.

**Participants, Bengaluru**


**Participants, Mumbai**

## Key Learnings

Some conclusions from the exercise were a need to understand the ground realities in order to perform better.

- Nanotechnology research in India has grown at a very fast rate, with an emphasis on water and energy sectors. The government has invested in creating infrastructure and training scientists to encourage this trend. Noble metal (Silver) based nanotechnology for water purification has been productized and reached markets.

- Nanotechnology is still a nascent science. There isn't enough understanding or agreement on impacts on health and environment. Even among the research community, there is no obvious sharing of experiences and findings. There is a need to establish a common platform (events / online database) for bringing about greater synergy in research.

- Risk mapping exercises showed that there is no clear understanding on the health and environmental impacts of the technologies. Maximum risk was perceived during production and disposal. While both the severity and the probability of the risks is a direct factor of the management practices adopted by the industry. Thus there is a stress on standardizing these processes. Operation related risks were perceived to be minimal.

- There is huge disconnect between researchers and industry. This leads to innovation remaining in papers and not seeing the light of day. Interactions between these two key stakeholders need to be facilitated by means of online showcases, open houses, workshops etc.

- Incubators or Technologists, who form a connect between a proven technology and its field application are missing. There is a need to nurture and develop this cadre to ensure that benefits of research reach the masses.

- The Government needs to play a major role in bridging the incubation divide especially bodies like the Department of Science and Technology. Inclusion of members from various academic streams, industries, corporates, funding agencies and government bodies need to congregate to enable a holistic understanding of the technology and its implications on the health and environment.

- Lack of awareness is a major barrier to large scale penetration of water purification practices in the BoP population. There is a lack of information available to the community on understanding the status and threats posed to and by their common property resources like water. Responsible media can play a pivotal role in creating awareness.

- Logistic reach to the BoP populations needs to be improved in terms of supply, disposal mechanisms as well as servicing and maintenance. Lack of reach is another major barrier to dissemination of benefits

- Prohibitively high costs prevent the technology from reaching the BoP populations. There is a potential to lower costs by tweaking production and distribution systems.

- Innovative and affordable service delivery models are the need of the hour. There is a need to explore case studies from other sectors to learn how BoP populations can be tapped. Models should be piloted initially on small scales. These then need to be scaled up to cater to the requirements of the larger BoP population.

- There is policy gap in terms of monitoring, production and application of nanotechnology based devices. There is no regulation targeted at Nanomaterials presently. Since the health and environmental impacts o the technology are not fully understood there is a need to adopt an approach based on precautionary principle and polluter pays.

Access to clean water is a basic right. This right has been denied to millions of poor people in India and other developing countries for years. These interventions were needed 50 years back and they are still needed today, but we have wasted the last 50 years of their lives. However we do not have a right to use them as guinea pigs to perfect technologies. It is essential that all stakeholders - researchers, industry and government go to the field and see what they really need to be able to meet their needs.

## Annexure

### *i. Agenda*

### *ii. List of Participants*

### *iii. Presentations*

### *iv. Background note*