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Science at the Nano-Scale & Its Implications to India

— Prof T Pradeep

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Science at the nano-scale is one of the major activities of any research institution globally. The effect of this is evident in the number of publications and their citations. The total number of papers published with the word 'nano*' in their titles is over 53,000 in the year 2010, of which a large fraction is related to chemistry and materials. A number of top cited scientists are nanotechnologists. Citations of some of their papers are in thousands. This is certainly an important aspect to assess the impact the subject area has made on larger science.

The impact of this area is especially evident at the interface of disciplines. Materials-biology interface has been growing tremendously in the very recent past. Soft-hard interface of materials as in composites is expanding. Traditional disciplines such as mechanical engineering have been expanding at chemical and biological interfaces using nanomaterials. All of these activities have caused integration of disciplines.

Integration results in the creation of new tools and utilisation of tools of one discipline in other areas. Tools to examine matter at nano-scale have become essential components in every department. Behaviour of materials at the nanometer size has become the central aspect of study in most of the areas. Molecular and chemical effects are probed in much more detail today than some years earlier. Civil engineers, looking at giant structures are concerned with the molecular details of concrete. This integration has made molecular sciences or science of the chemical bond very exciting in recent times.

These activities have also made corresponding impacts on technology. More companies are getting incubated in nano related disciplines. In India, venture funding of nanotechnology companies has started.

What does all of these mean to India and to world at large? Besides integrating science, which the author considers as the largest achievement of nanoscience, what will the current excitement mean to the people on the street? While all science, large or small, has made impact on people at the very bottom of the purchasing capability, some have made greater impact. Examples are advancements in modern medicine, synthetic materials, communication, and a number of others. Due to nanoscience, what would be the next large change that one can expect?

Among the several areas, one of the major ones would be water. Fresh water resources in the world are shrinking drastically and the available ones are increasingly threatened. Increasing development poses greater threats on the available resources. Surface water is being contaminated due to industrial activity, agriculture and urbanisation. For the growing cities, water needs to be found from adjacent countryside where selling water, although possible only for a short time, is more profitable than growing crops. As surface water becomes inadequate, we explore deeper aquifers. The net result of this is increasing salt contamination. Development adds organics and inorganics to water. Urbanisation adds large microbial contamination. Thus newer and newer methods of purification have to be found. Such methods have to be efficient as allowed contamination levels of several species are going down as we understand more and more about their effects on us. For several of the contaminants, the allowed concentration limits are in the parts per billion range and that amounts to having just about 1017 species per glass of water, this amounts to one in ten million parts of the water. Remember that there are 1024 water molecules per glass of water.

How can such low concentrations be removed? It is also important to know what this kind of removal must happen with the lowest possible investment on materials and methods. The act of purification should not cause a large burden on energy. This also should not create a lot of waste water as water itself has become a rare commodity in several areas. Another aspect of importance is that in water purification, the requirement of materials is very large. Thus the materials used must be very cheap and highly affordable. All of these pose a number of restrictions on materials.

What these conditions mean is that we need the materials to do more with less. That becomes possible with nanotechnology and nanomaterials. With minimum material we want maximum removal of toxins, maximum degradation of pollutants and lesser impact on nature. As a result, there is a large emphasis on finding new nanomaterials for water purification.

Most of the water related health issues come about due to microbes. Globally microbial contamination amounts to 80 per cent of all the water problems. How to take care of these problems in the most cost effective fashion? If that is possible, especially at homes, irrespective of whether the water comes from a piped supply or not, microbial contamination induced problems can be eliminated completely. That would lead to large reduction in the human suffering. Availability of such a solution would reduce the expenditure of nations in their social development programmes.

Imagine what it means in terms of materials to implement such solutions. It is expected that we have 244 million homes (expected census 2011 data) in India. Even if a nanomaterials-based solution involves 100 grams of material per purifier, it means 25000 million grams of the material. That is 25 million kilograms or 25000 tons. Materials of this kind may have to be replaced at periodic intervals as and when they are needed by the purifier. Thus nanotechnology solution for water means constant availability of such materials.

Obviously such materials have to be produced with available or common materials so that they are not expensive. Any solution for water will be effective only when the costs are low. How can nanostructured materials be cost effective? For that to happen, such materials have to be made from the most inexpensive sources in the most inexpensive ways. Key to the success of such materials is their nanostructure and not the chemical ingredient.

Drinking water is one side of the water problem which requires urgent attention. There are numerous other problems related to water. Industrial water problems are too numerous to mention. Each one of the industrial wastes such as dyeing, tannery, molasses, paper, paint and many other industry effluents pose tough problems as far as chemical degradation is concerned. They have been serious problems for long which had no effective solutions. New and effective solutions have to be developed for each one of those industries.

In several areas, newer contaminants are surfacing as water from deeper aquifers is being tapped. While problems of such kind are plenty in all societies, very limited efforts are happening in India to find solutions. But this is where most of the solutions are needed as this is where more people face such problems. Thus more number of younger people have to work to find solutions for water.

It is also important to reiterate that our Government has recognised this as an important area to look for scientific breakthroughs. Nano Mission of DST has heavily invested into building resources around the country to pursue nanotechnology activities. Water is one of the prime areas of research in one such laboratory.

Nanotechnology solutions are needed in several of our other problems too. But water is a central aspect which touches upon every other aspect of the society. It is with clean water that one can achieve prosperity and water is essential for all aspects of development. Thus working on water contributes to welfare in a total sense. What better way to work and contribute! ■