Water - The Elixir of Life : A New Gallery at National Science Centre, New Delhi

N Ramdas Iyer

Abstract

Our Earth is unique because it is the only known place in the universe where water exists as a liquid thus enabling life in all its diversity to thrive here. When the human population was small its effect on the planet and its water bodies was also manageable. But over the past century, it has exploded, thus creating an adverse impact both on quality and quantity of potable water. Human impact has resulted in growth of sprawling cities and towns which pollute our rivers with increasing amounts of waste and threaten our water systems as we squander this precious resource. A new Gallery "Water – The Elixir of Life", conceptualized and opened to the public at the National Science Centre, Delhi is aimed at creating awareness about this scarce and all important source of life among the visitors specially the children.

The exhibits in the Gallery aim to cover the entire gamut of water related issues starting from the science of water, water resources on earth, threat perceptions, conservation methods, importance of water in life and impact of pollution and seemingly innocent cultural practices on our water bodies. It is meant to shock visitors out of their complacency and realize the seriousness of the issue.

Introduction:

Observational records, demographic study and climate projections provide abundant evidence that freshwater resources are vulnerable and have the potential to be strongly impacted by climate change, with wide-ranging consequences for human societies and ecosystems. At this juncture, when there are well-researched speculations of ensuing water stress in India, water education, for the students and people, becomes critical. It is in this background that the National Science Centre has conceived and set up a Gallery called "Water - The elixir of life". In this effort the Centre collaborated with the Delhi Jal Board, the principal government sector water supply and sewerage service in Delhi.

Fig. 1. Water the elixir of life is a gallery in NSC, Delhi that tends to sensitize people on water issues.

In addition to making science accessible, science centres have an added responsibility to educate people on issues relevant to the society and thereby guiding them in taking a stand on such issues. Water issues are one of the most relevant to the continued survival and prosperity of the human race and they need to be portrayed in their entirety so that visitors are made aware of the entire spectrum of the issue.

Water on Earth

As visitors enter the gallery, they become immersed in a watery world. They walk over a virtual surface of a lake, creating ripples. They hear sounds of water trickling, running, crashing, and echoing all around them. Immersive environment created using the Gesturetek Patented Image Processing Technology with white tiling on the floor is employed to create a spectacular introductory theme to the Gallery.

It is an oft repeated statement that the Earth is a blue planet and that more than 70% of the earth is covered by water. While this is mostly true from a layman's point of view, when looked at, seriously, the following figures emerge.

5.1×10^8 Km^2 is the total surface area of Earth and its volume is 1.08321×10^{12} Km^2. Approximately 70.9% of the Earth's surface is covered by water, which means there is 3.61×10^8 Km^2 of water on earth. It has been estimated that 3.79 Kms is the average depth of water on earth. So volume of water on earth works out to 1.36819×10^{10} Km^2. Using the formula of $4\pi r^3$ for the volume of a sphere 1.36819×10^{10} Km^3, we arrive at a diameter of 1377.37 Kms, which is hardly the distance between Delhi and Kolkata. In other words, if all the water on Earth, including those from rivers, lakes, groundwater etc. were to be compressed into a sphere, the sphere will just reach Kolkata from Delhi. This fact is visually and shockingly presented in the introductory exhibit of the gallery[1]. The question we are asking the visitors is "Are we converting the blue planet into a brown planet?"

Propagation
A Journal of Science Communication

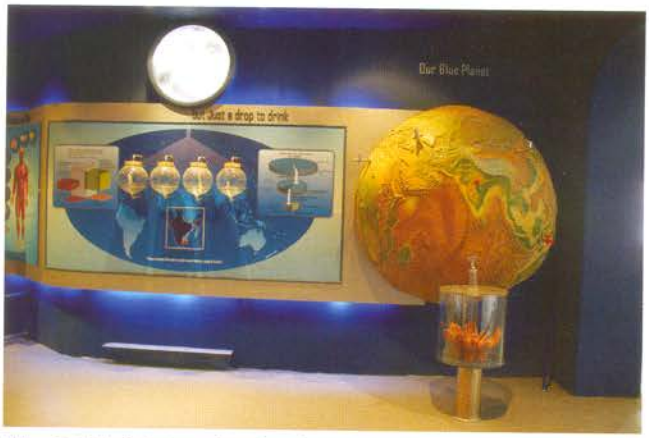

Fig. 2. Exhibit showing the size of a sphere that would contain all of Earth's water in comparison to the size of the Earth. The sphere includes all the water in the oceans, seas, ice caps, lakes and rivers as well as groundwater, atmospheric water, and even the water in us, animals and plants.

Water in our body

Water makes up approximately two-thirds of our body's weight and approximately 75 percent of the brain's weight. Nearly 4 percent of the water in the body is lost through the skin, lungs and through urine and stools each day. This water loss must be replaced continually by water, beverage and food consumption.[2] Water loss resulting in as little as 1 percent decrease in body weight is called dehydration. Dehydration will reduce the body's ability to perform physically and mentally. Infants and children can quickly become dehydrated; therefore, it is critical they consume adequate fluids. Water is so important to well-being that one can only live a few days without it. The Gallery makes use of exhibits which interactively weigh the visitor and gives a detailed reading of the amount of water in her different body organs. This has been a highly popular exhibit and attracts large crowds.

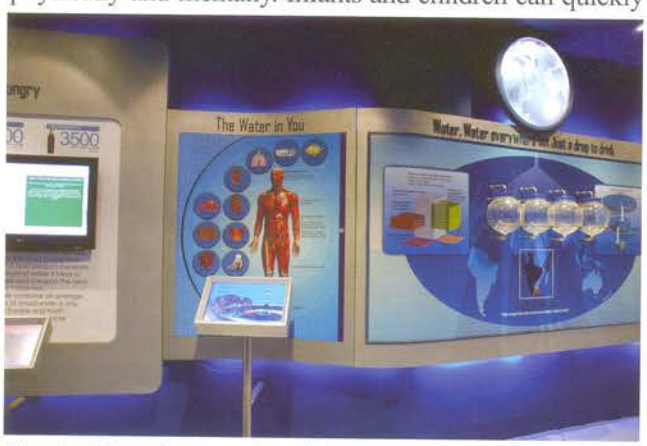

Fig. 3. Water in you - the exhibit which demonstrates that a significant fraction of the human body is water.

Water Properties

Every known form of life on earth, from the largest mammals to the smallest microbes, relies on water. Why? Because water is an extraordinarily versatile molecule - it's the perfect liquid medium in which to dissolve nutrients for ingestion or wastes for excretion and to transport important chemicals. Water has two particular physical properties that are unique among natural molecules: it remains liquid over an extremely broad range of temperatures, and it decreases in density when converted to solid phase (frozen). While this may seem a relatively minor point, its consequences (that ice floats on liquid water) are critical to the evolution of life. If ice were denser than water and the earth cooled slightly, ice formed on the oceans would sink and push the already cold water from the bottom to the surface, where it too would freeze and sink, repeating the cycle until all water on the planet was frozen.

Why does this simple molecule, composed of two hydrogen atoms and one oxygen atom, behave the extraordinary way it does? Many of water's unique properties are largely a result of its chemical structure. The two hydrogen atoms bound to one oxygen atom to form a 'V' shape with the hydrogen atoms at an angle of 105°. When the hydrogen atoms combine with oxygen, they each give away their single electron and form a covalent bond. Excess of electron density on the oxygen atom creates weakly negative regions at the other two corners of an imaginary tetrahedron. This molecular structure makes it the most common, yet, the most unusual liquid. There are several such anomalies in water which make it a crucial component that creates and sustains life. Water is colourless; Water

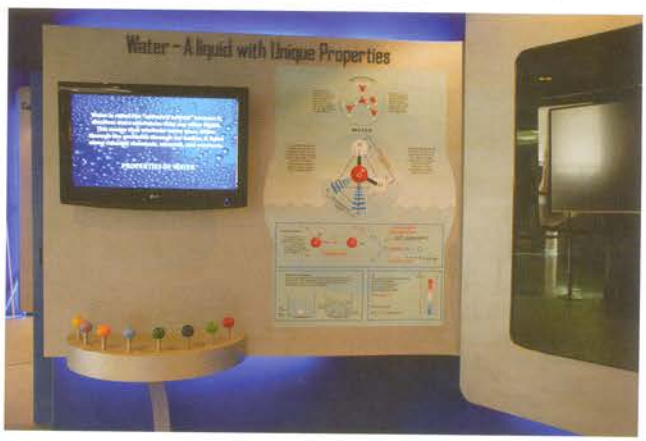

Fig. 4. The simple molecule of water exhibits much uncommon behaviour because of its intra-molecular hydrogen bond. These properties, explained in this exhibit, form the basis of its being the substance of life.

is tasteless; Water is odourless; Water feels wet; Water dissolves a great number of things; Water can absorb a large amount of heat; Water sticks together into beads or drops; Water flows and erodes the surface of the earth; it moves sediments to form lands; It shapes lipid and protein molecules and give them their 3-dimensional form which is critical to their function; It's part of every living organism on the planet.[3] This is demonstrated in an interactive exhibits that showcases some properties of water. It is from water that life on Earth originated. From simple amino acids to single celled organisms to the most sophisticated life forms originated from and depends on water. A film specially procured from Norway shows how water influences the life of humans from life to death.

Water and civilisations

The first great urban developments of the earth were located along rivers that flowed through a virtual desert. Water and waterways sustained those civilizations. The river supplied water; it spread a sheet of alluvial soil that was fertile, the water brought fish with it and later the waterway became an easy means of transport. Major early civilizations like the Mesopotamian or Sumerian civilization, Indus Valley civilization, Egyptian civilization and the ancient Chinese civilization all developed within a thin strip around a river. They were all riparian civilizations. Farming the world over has always relied upon a dependable water supply. For the earliest societies this meant rivers and streams or regular rainfall. The first great civilizations grew up along rivers. Later communities were able to develop by taking advantage of the rainy seasons.

The four places where ancient civilization developed and thrived were riparian. These are Indus Valley in Pakistan and India, Mesopotamian civilization on the banks of rivers Tigris and Euphrates, Egyptian civilization on the banks of the great river Nile and the Chinese civilization on the river banks of Hwangho and Yangtze-kiang. By about 5000 BC, small tribes of farmers in Mesopotamia had made their way to the river valleys. On the floodplains they raised wheat, barley, and peas. They cut through the riverbanks so that water for their crops could flow to lower lying soil. These early irrigation systems were more fully developed by the Sumerians in Mesopotamia, who drained marshes and dug canals, dikes, and ditches. The need for cooperation on these large irrigation projects led to the growth of government and law. Egyptian farmers had settled in the long and narrow valley of the Nile River by 5000 BC. Within 2,000 years they had built massive irrigation works. The primitive farming settlements of Egypt were concerned with the raising of vegetables, grains, and animals. Probably the need to control the Nile floodwaters through dams and canals eventually led to the rise of government in the region.

The valley of the Indus River is considered to be the birthplace of Indian civilization. By 4000 BC primitive farmers were raising vegetables, grains, and animals along the riverbank. By 2700 BC two major cities, Harappa and Mohenjo-Daro, and numerous smaller towns had emerged. They had great public water baths and granaries. These cities had the finest sewage and wastewater systems of the ancient world. These cities even had underground cesspools that were implemented in modern cities of the world only after 1600 AD.[4,5,6]

Societal impacts of water scarcity

Global Freshwater reserves are rapidly depleting and this is expected to significantly impact many densely populated areas of the world. Low to middle income developing regions as well as highly developed countries will face water stress in the future, unless existing water reserves are managed effectively. Although low and middle income developing countries currently have low per capita water consumption, rapid growth in population and inefficient use of water across sectors is expected to lead to a water shortage in the future. By 2025, India, China and select countries in Europe and Africa will face water scarcity if adequate and sustainable water management initiatives are not implemented.[7] By 2025, an estimated 3 billion people will be living below the water stress threshold. Between 1995–2025,

Fig. 5. Imbalances between availability and demand, the degradation of groundwater and surface water quality and intersectoral competition all contribute in water scarcity and its effects are manifest in many societal discomforts. The idea explained in graphics and video.

global population and per capita water consumption are projected to grow at a CAGR (Compound Annual Growth Rate) of 1.16% and 0.67% respectively. Densely populated and developing regions of the world, such as Asia and Africa are expected to face the maximum water stress. There are several exhibits in the Gallery which talk about the ensuing water stress and how we as citizens can do our best in staving it off.

Severe water shortages have already led to a growing number of conflicts across the country. Some 90 percent of India's territory is drained by inter-state rivers. The lack of clear allocation rules, and uncertainty about what water each state has a right to, imposes high economic and environmental costs. There are great variations in current per-capita water availability for each continent. Oceania has over 70,000 cubic meters per person per year (m3/person/year), the average for all of Africa is under 7,000 m3/person/year, while that of Asia is only 3,400 m3/person/year. Even greater disparities are noticeable if one looks at a national or regional basis.[8]

The urban scenario – Delhi: A case study

Delhi is currently the fastest growing metropolis in India. Among the six Indian mega-cities with a population over 5 million people, Delhi is the only one whose population grew at an annual growth rate greater than 4% during the last decade as compared to 2.62% in Mumbai, 1.82% in Kolkata and 3.2% in Bangalore. According to the Census 2001, the population of the national capital territory of Delhi was 13.85 million people, to which can be added the more than 3 million people living in the extensions of the Delhi's urban agglomeration outside the NCT. In 2021, projections of population for the NCT are between 22 and 23 million, and around 10 million inhabitants in the different adjacent cities, making it the second largest urban agglomeration after Tokyo.[11]

Delhi receives most of its water supply from the Yamuna and the remaining from groundwater, the Ganga Canal, the western Yamuna canal, and the Bhakra. Average water consumption in Delhi is estimated at being 240 liters per capita per day (lpcd), the highest in the country. Who brings it to your tap? Through elaborate planning and installation, the Delhi Jal Board has ensured average availability of 50 gallons filtered water per capita per day for the residents of Delhi, through a network of about 9000 kms of water mains/lines. Delhi is experiencing increasing pressure to meet demand for its water resources. Growing urbanization, improvements in living standards, exploding population are just some of the contributing factors. Average water consumption in

Fig. 6. Model of the Sonia Vihar water treatment plant that processes and supplies 140 million gallons of potable water per day.

Delhi is estimated at being 240 liters per capita per day, the highest in the country. Water treatment plants (WTP) and sewage treatment plants (STP) in Delhi ensure that the best possible is done to ensure adequate per capita availability of water to each citizen, but unless the citizens cooperate it is a losing battle. Interactive working models of WTPs and STPs explain how these work in ensuring a clean supply of water.

Delhi has an adequate supply of water. With over 200 litres of water available per capita per day it has more water than many other big cities in the world that provide their residents with 24X7 water supply. Altogether, 80% of the 16 million people living in the National Capital Territory of Delhi (NCTD) has access to piped water and 75% to sewers. But about 15% of the population has no access to sanitation facilities. India faces a turbulent water future. Unless water management practices are changed – and changed soon – India will face a severe water crisis within the next two decades and will have neither the cash to build new infrastructure nor the water needed by its growing economy and rising population. Today, 70 percent of India's irrigation needs and 80 percent of its domestic water supplies come from groundwater. Although this ubiquitous practice has been remarkably successful in helping people to cope in the past, it has led to rapidly declining water tables and critically depleted aquifers, and is no longer sustainable.

Water usage and water footprint

The water footprint of a country is defined as the volume of water needed for the production of the goods and services consumed by the inhabitants of the country. People use lots of water for drinking, cooking and washing, but even more for producing things such

Fig. 7. An interactive exhibit for calculatng an individual's water footprint from his household data and water usage pattern.

as food, paper, cotton clothes, etc. The water footprint is an indicator of water use that looks at both direct and indirect water use of a consumer or producer. The water footprint of an individual, community or business is defined as the total volume of freshwater that is used to produce the goods and services consumed by the individual or community or produced by the business.[9] The exhibit on water footprint of the visitor is made interactive using an electronic-computer-mechanical-pneumatic interface, developed for the first time and depending upon the choices made by the visitor using a computer screen, shows her the amount of water she uses in a day as a rising water column. This also has created a lot of interest.

A very interesting exhibit asks the visitor whether we are thirsty because we are hungry. Very few people realize that the 4-5 litres of water that they drink daily or even the 100-150 litres that they use for personal

Fig. 8. We are thirsty because we are hungry – an exhibit that makes one to think that food production requires a lot of water and that increases our water footprint a lot.

hygiene constitutes the total water consumption by them. This is contrary to the fact. Every product that we use is produced using water. There is an interactive exhibit which talks about which product consume how much water to produce. A kilogram of beef needs over 15,000 litres of water. Non vegetarian food is especially costly in terms of water. Even wheat and rice need upto 1500 litres of water per kilogram for production. Considered this way our indirect water consumption is huge.[10] This exhibit has the very desirable trait of shocking people, and the curator has had many curious visitors asking him if the facts depicted in the exhibit is indeed true, and explanation of the details leaves the visitor wondering. In the press coverages following the inauguration, this was one aspect that was widely reported and discussed. The dignitaries in the inauguration also expressed wonder at this unknown fact.

Threats and opportunities

Bottled water is a recent menace. While Municipal water suppliers supply water of comparable quality at a cheap price (for example, the cost of one litre of water at the tap at our homes as provided by Delhi Jal Board is 17 paise, the same quantity costs Rs.12/- when bought in a bottle. This also comes with the added complication of production and disposal of plastic waste. The energy consumed in production and disposal of bottles in India alone can be used to run 1,00,000 medium sized cars for 365 days. These shocking facts are presented in an attractive graphic. The amount of waste generated on account of the bottled water menace is shown by displaying the amount of bottles used and discarded at the National Science centre in one day.

Water conservation methods, rainwater harvesting, and water efficiency at homes are represented in different exhibits in the Gallery. Simple steps like using a low head shower, cleaning cars using wet rags rather than with a hose pipe, fixing leaking taps etc, can save a lot of water at home. A WTP uses up a lot of money and energy to purify water, but nature does it free of cost in the form of the water cycle. The water cycle is the cycle water goes through on Earth. It makes the rain, clouds, and most of our weather. First, water on the earth is evaporated by the heat from the Sun. Then, water collects as water vapor in the sky. This makes clouds. Next, the water in the clouds gets cold. This makes it liquid again. When it rains, the water then collects into lakes, oceans, or aquifers. From there, it evaporates again and continues the cycle. This is shown as an electromechanical animation. To emphasise the fact that the content of water on earth has remained the same since it was formed, a graphic telling the visitors

that the water we drink today is the same water that the dinosaurs drank millions of years ago is highlighted.

Conclusion

In conformity with the principle of taking a stand on issues, the Gallery raises a question of whether our cultural and religious practices are degrading rivers. While it is a sensitive issue, we cite quotations from scriptures of all major religions which exhort respect to water and water bodies alongside and ask the visitor to refrain from choking rivers with our cultural practices.

Some other interesting formats of presentation involve an interactive virtual book, where the visitor flips pages of a virtual book on a 42" screen by waving his hands to learn about different aspects of water conservation. This virtual book contains text, videos

Fig. 9. The exhibit where one may ask a doctor about a particular water-borne disease.

and pictures. Another is a quad display with a touchscreen interface where the visitor can ask different doctors about different water borne diseases and get live video answers in Hindi or English from them while showing methods of cure, prevention, causes and symptoms of each. Both these exhibits have been well appreciated.

And towards the end there is an unmanned quiz on water issues. The last exhibit is a pledge. The visitor registers a pledge to treat the Yamuna with respect and help prevent its degradation and affirms his pledge with his thumbprint which is recognized and stored along with other relevant details. The next time the visitor uses this exhibit, he is immediately recognized and is asked whether he has kept his pledge. The Honourable Chief Minister of Delhi, who inaugurated the Gallery, was the first to pledge her commitment to the Yamuna.

Fig. 10. People taking digital pledge to keep the Jamuna clean.

The Gallery since its inauguration has seen a huge influx of visitors who come specially to see this Gallery. In fact, people at the NSC, Delhi ticket counters these days often ask for tickets of this gallery only. The appreciation received has been tremendous. Completed in a record time of six moths since it was first mooted, it is also a testimony to the principle of partnering with stakeholders in social issues (in this case, the Delhi Jal Board), to achieve a common objective, thereby saving costs, enhancing quality and at the same time taking to the hundreds of thousand of visitors the social message that the sponsoring agency has a stake in.

Acknowledgement

I acknowledge with gratitude the support of Mr. Manash Bagchi, Curator, National Science Centre, Delhi in the content research for this Article.

Select Bibliography

1. Garrison, Tom S. *Oceanography: An Invitation to Marine Science*. Thomson Brooks/Cole 6th ed.
2. Patricia A. Kreutler, Dorice M. Czajka-Narins *Nutrition in Perspective*, Pearson Education Canada, ISBN 0136276962.
3. Martin Chaplin, *Water Structure and Science,* London South Bank University.
4. Possehl, Gregory. *The Indus Civilisation.* Walnut Creek: Alta Mira Press, 2002.
5. Kenoyer, Jonathan Mark *Ancient cities of the Indus Valley Civilisation*. Oxford University Press, 1998.
6. Michel Danino, *Unravelling Dholavira's geometry,* Paper contributed to Rama Vijayam: History & Archaeological Studies, Festschrift to Prof. K. V. Raman, ed. Dr. P. Chenna Reddy, in press, 2007.

7. Peter Rogers, *Facing the Freshwater Crisis,* Scientific American, August 2008 pp 26-33.
8. Peter H. Gleick et al, *The World's Water, 2006-2007 and 2009-2010: The Biennial Report on Freshwater resources, Island Press 2006 and 2009.*
9. Hoekstra, A.Y., Chapagain, A.K., Aldaya, M.M. and Mekonnen, M.M. (2011) *The water footprint assessment manual: Setting the global standard,* Earthscan, London, UK.
10. http://www.waterfootprint.org
11. Augustin Maria, *Urban water crisis in Delhi. Stakeholders responses and potential scenarios of evolution*, CERNA, École des mines.

N Ramdas Iyer is a Curator at National Science Centre, New Delhi.
nriyer64@gmail.com