ParyAvaraN ShikshA Evam Jal PhasalIkaraN
i.e.,
Environmental Education And Water Harvesting

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A:- HOLISTIC ENVIRONMENTAL EDUCATION THROUGH SUSTAINABLE HABITATS

A1. ABSTRACT: Environmental education is the process of transforming individuals into eco-friendly citizens. It can be called 'Holistic Environmental Education' only when nine important aspects of human development (each representing a letter in the word 'education') -such as Evolution, Distinction, Unison, Capability, Agility, Time, Innovation, Objectivity and Normalcy (i.e., overall peace) are promoted. It is quite comprehensive as compared to a formal education, imparted in every school of learning. To transform a formal education into a holistic environmental education, we need to transcend beyond the boundaries of regular schools into 'Sustainable Habitats'. These sustainable habitats are essentially shelters imparting environmental education by virtue of their capability to cause minimum ecological footprint, which is a measure of the load imposed by a habitat on nature. Theoretically sustainable habitats should have a fully self-dependent physical infrastructure. In practice any shelters self-dependent at least in terms of their water and power requirement can be considered as sustainable habitats. Here salient features of recent sustainable habitats in Australia and India. Considering the global emphasis on ecological issues, they can eventually become role models -creating environmental awareness and inspiring everyone to replicate them.

A2. INTRODUCTION

The objective of this paper is to briefly describe some of the vital components of three trend-setting sustainable habitats constructed within the past decade. It is said that a positive idea is a great communicator, capable of effectively propagating the basic principles of holistic environmental education that aims at preparing a society that is aware of and is concerned about the total environment and its associated problems [CSE, 2000]. It will be holistic when the earlier mentioned nine aspects of education are grouped into three domains of input, process and output. These domains bring about a transformation as shown in Figure 1A.

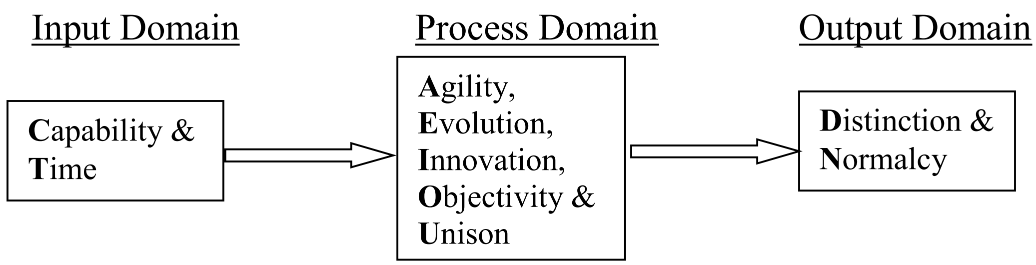


FIGURE 1A. Illustration of the Process of Transformation in Holistic Education

A3. CASE STUDIES OF RECENT TRENDSETTING SUSTAINABLE HABITATS

The invention of electricity and the commissioning of centralized water supply / wastewater treatment systems -around 1850 AD, has significantly influenced the human development and thus are treated as two important parameters constituting human development index (HDI). On the other hand and in the long run, they have resulted in the loss of ecologically sustainability as well as economically viability in a large number of nations, especially in the developing world. Thus sustainable habitats with a reasonably satisfactory economic viability are becoming the global trendsetters among the newly constructed habitats. The following pages describe the salient features of three of the modern sustainable habitats viz. the 'Sustainable House' in Australia as well as 'RETREAT' and 'Green Business Centre' in India. They are the potential role models in imparting holistic environmental education in future.

A4. 'SUSTAINABLE HOUSE' IN SYDNEY, AUSTRALIA.

A 'Sustainable House' has been defined as a house almost entirely self sufficient in electricity, water and waste disposal. It conserves its own potable water, recycles / reuses all its wastewater (either sewage or storm water) and generates / meets its own power requirement through appropriate renewable energy sources [Mobbs, 1998].

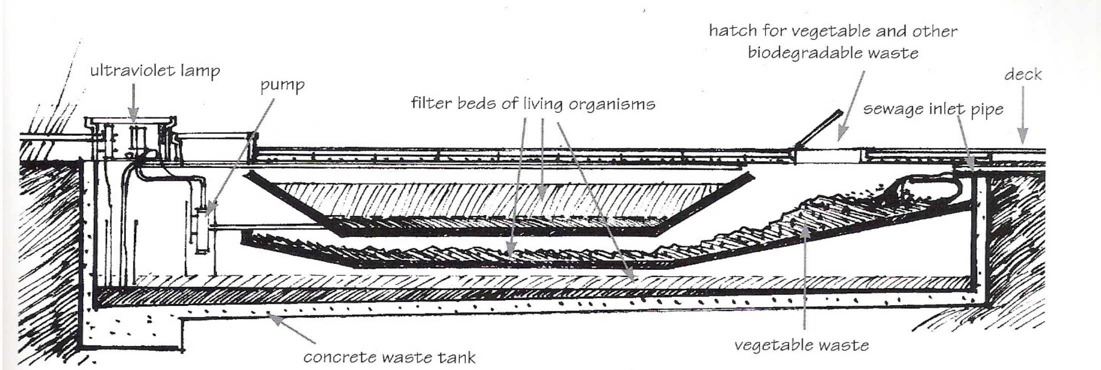
In 1996, an environmentally conscious lawyer couple from Sydney, Australia set out to renovate their 100-year old terrace house in the inner-city suburb of Chippendale. With a bit of vision, some common sense, and a lot of tenacity, they built what most of us would think impossible -a house in the middle of Australia's biggest city that can produce its own power and water, and can reuse its sewage on site. These might seem hopelessly optimistic objectives for a house on a 35 m X 5 m plot area, but what began as a private experiment a few years ago is today an example of how a little ingenuity and perseverance can change a house from a waste-generating house into a sustainable habitat, without huge sacrifices in lifestyle, routine or comfort.

The three salient features of this sustainable habitat are:

- A drinking water system consisting of an underground tank of 10 m^3 capacity used for storing potable water obtained from rooftop rainwater harvesting (RWH);

- A wastewater treatment system consisting of a concrete wastewater tank with three biolytic filter beds [Refer to Figure 2] containing specially selected soil-like medium consisting of sand and peat. The filter beds are full of micro-organisms / macro-organisms / worms. There is an ultraviolet (UV) lamp at the downstream end and a recycling unit at the bottom. The treated wastewater can be used for flushing toilets, washing clothes and watering the garden.

- A solar power system having 18 numbers of 120 W solar panels on the rooftop. During the daytime, extra power generated is fed into the grid. A solar water heater is also there.



A cross-section of the waste-water tank showing the three filter beds of the biolytic filter.

FIGURE 2A. Tank with Filters and Ultraviolet Lamp Used for Wastewater Treatment in the 'Sustainable House' in Australia [Source: Mobbs (1998)].

Tests carried out on the treated wastewater by the University of Technology Sydney, are reported to have demonstrated consistently low turbidity and fecal coliform counts. Also, the highest level of lead ever measured in the tank water was 0.03 mg/L - below the safety threshold of 0.05 mg/L recommended by the National Health and Medical Research Council of Australia in 1991.

Any residual nasty bacteria or viruses get killed as the water leaves the wastewater tank with a UV radiation, powered by a small solar panel. The water looks clear with no foul smell, and its turbidity is quite comparable to the potable water. Few initial breakdowns unusually long, narrow tank specifically designed for the small yard, but eventually it started functioning quite satisfactorily, requiring no maintenance and producing no offensive smells.

The water exiting the other end of the wastewater tank is found to be clean enough to be reused in the house as gray water to and any excess overflows into a dry reed bed. Figure 3 shows a typical reed bed profile. Beneficial microorganisms provide most of the wastewater treatment in a reed bed. Aerobic organisms breathe oxygen supplied by reed plants which pump oxygen to their roots, surrounding them with a thin layer of air to stop them drowning. Aerobic organisms live here and capture passing pollutants.

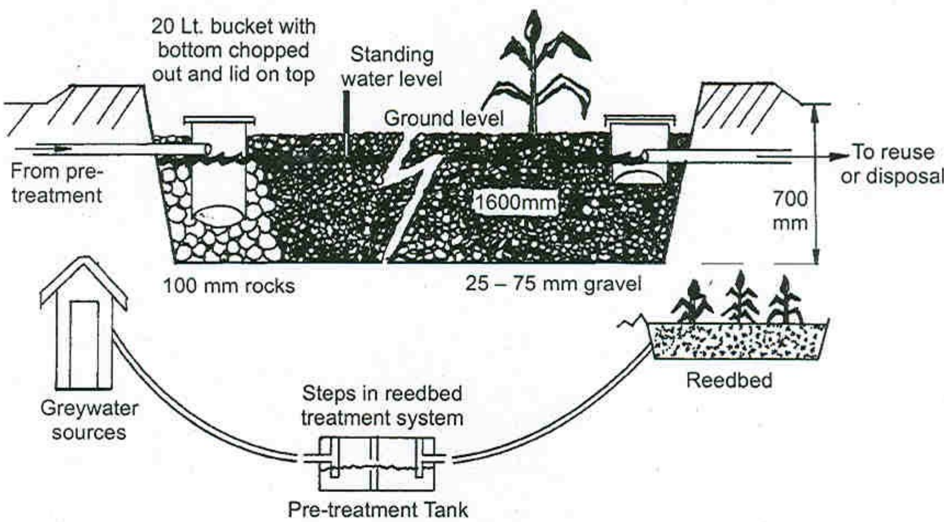


FIGURE 3A. Profile of a Reed Bed for Domestic Wastewater Treatment Locally [Source: Ghosh and Desai, 2006]

A5. RESOURCE EFFICIENT THE ENERGY AND RESOURCES INSTITUTE (TERI) RETREAT FOR ENVIRONMENTAL AWARENESS AND TRAINING (RETREAT) IN GUAL PAHARI, HARYANA [NEAR NEW DELHI], INDIA.

Resource Efficient TERI Retreat for Environmental Awareness and Training (RETREAT) –an institutional building, was commissioned in July 2000 by the Tata Energy Research Institute (TERI), New Delhi, India to demonstrate a sustainable habitat fully self-sufficient in its power requirement. It is located in Gual Pahari in the northern state of Haryana at about 35 km on the outskirts of New Delhi and it does not have any external power supply.

Both traditional techniques and modern means of utilizing renewable energy sources are intelligently blended to offer all modern amenities like lighting, air conditioning, cooking, laundry etc. The total energy requirement is reported to be around 25% of the requirement of other comparable buildings, on account of a high value of energy efficiency. RETREAT can accommodate 36 persons and can provide indoor conference facilities to 100 participants. It consists of two semicircular blocks, which are arranged one behind the other. The living quarters forming the south block comprise of 24 single occupancy rooms, 6 suites while the north block comprises of public utilities such as a conference canter with a large hall, a dining room, a library, a lounge etc. It has a covered area of 3000 m^2 and the project cost at 2000 AD rates [in millions of ₹] was reported as follows: Civil works – 23.60; Electrical works – 2.50 and various technologies – 18.54 [TERI, 2001]. The total cost was estimated as ₹ 44.64 millions. Following are the key techno-economic features of RETREAT under nine headings as follows:

Orientation, insulation, and design of the building and the system: Building oriented to face south for winter gains; summer gains offset using deciduous trees and shading. Wall insulation with 40-mm thick expanded polystyrene and roof insulation using vermiculite concrete (vermiculite is a porous material, was mixed with concrete to form a homogenous mix) topped with china mosaic for heat reflection. South side was partially sunk into the ground to reduce heat gains and losses. East and west walls devoid of openings and are shaded. Cost of the building at 2000 AD rates in Indian Rupees (INRs) was 14,880 /m^2. The total cost was 19,000 INRs/m^2. This included site development, access roads, culverts, furniture, interiors, fixtures and fittings.

50kW Gasifier to be run during daytime: 1 unit of electricity (i.e., 1 kWH) produced by gasifier needs 1 kg biomass and 90 ml of diesel. Gasifier generates producer gas containing methane, which can run a diesel generating set with 70% diesel replacement.

Earth air tunnel (EAT) for the south block: 4 tunnels of 70 m length and 70 cm diameter each were laid at a depth of 4 m below the ground to supply conditioned air to the rooms. In the EATs at a depth of 4 m below ground, the annual temperature variation would be restricted to 26 ± 4 ° C in Delhi Area as compared to the normal surface temperature fluctuations of 26 ± 20 ° C in Delhi Area. 4 fans of 2 hp each force the air in and solar chimneys force the air out of rooms. Air conditioning load of the south block without the tunnels would have been 35 TR (tonne of refrigeration). Assisted cooling by air washer in dry summer and a 10 TR dehumidifier in monsoon. Costs of earth air tunnels and dehumidifier (in million INRs at 2000 prices) were 1.7 and 0.8 respectively.

Ammonia absorption chillers for the north block: Gas-based system with minimal electrical requirement of within 9 kW was commissioned. Chlorofluorocarbon (CFC)-free refrigerant (i.e., ammonia) is being used. The ammonia absorption chiller was proposed to run on producer gas from gasifier in future to replace liquefied petroleum gas (LPG).

10 kW solar photo voltaic (PV) cells store energy (55kWH/day in summer) in batteries during daytime: Electricity loads during night hours were planned to be met by 900 amp-hr batteries at 240V. 36kVA bi-directional inverter is being used. There is a load manager to control and manage the electrical loads. Area of a 50-watt peak module PV panel used is 1 m X 0.5 m. Cost of PV system with battery and inverter was 7.4 million INRs at 2000 prices (inclusive of the cost of the monitoring equipment also). Expected Life of PV panels and batteries were estimated as 25-30 years and 10 years respectively.

2000 liters per day (Lpd) solar hot water system: 24 solar water-heating panels (inclined at 70° instead of 45° to reduce the effectiveness by less than 10%) integrated with parapet wall and an insulated tank is being used. Back-up by producer gas from the gasifier on cloudy winter days. Cost of solar water heating system was 250,000 INRs at 2000 level prices.

Lighting: A reduced lighting load of 9 kW is required as compared to a minimum of 28 kW in a conventional building. Lighting is being provided by compact fluorescent lamps (CFLs), high efficiency fluorescent tubes with electronic chokes. There are lighting controls to reduce consumption (timers, key-tag systems). Innovative daytime lighting by means of skylights is being adopted.

Wastewater management system by root zone treatment system by reed plants: There is a provision to clarify wastewater (5 m^3/day) from toilets, kitchen, etc. A bed of reed plants (i.e., Phragmytes) treats the wastewater and the output is used for irrigation. The plants take up nutrients from the wastewater and thrive on them and thereby cleaning the wastewater. A reed bed is already described earlier in Figure 3.

Building management system (BMS): There is a Building management system (BMS) to monitor building parameters such as temperature, humidity, power consumption, etc. BMS also monitors electricity generated from each source. The load sharing and load shedding to optimize energy usage is also being decided by the BMS which records at regular intervals. Data is being collected and analyzed by the BMS for future research and dissemination.

A6. 'GREEN BUSINESS CENTRE' (GBC) IN HYDERABAD, TELANGANA, INDIA.

The third and the last case study of trend-setting sustainable habitats discussed in this paper is an institutional building of the Confederation of Indian Industries (CII) in Hyderabad, India known as the 'CII- Sohrabji Godrej Green Business Centre' (GBC). It is a perfect example the highest quality of human excellence resulting due to the best possible coordination between a provincial government, a national level organization for commerce & industry and an international agency for development. When the Leadership in Energy and Environmental Design (LEED) Green Building Rating System was developed, it was not expected to be an international standard. On the other hand, it was meant for the U.S. commercial market. However, experience has shown it is gradually becoming an international standard for all building types in all the countries, under the banner of U.S. Green Building Council (USGBC).

By virtue of being a founding member of the World Green Business Council (WGBC), India is in fact a trendsetter to LEED. In 2001, the USGBC signed a Memorandum of Understanding (MoU) with the for the purpose of exchanging information of green buildings, technologies and systems, particularly in regard to energy efficiencies. LEED workshops have been successfully conducted in India and two delegations have attended LEED workshops in the U.S. The India Green Building Council (IGBC) set a goal in 2003 of having 10 LEED accredited professionals in India by the end of the year.   By the recommendation of the LEED's design certification team (which awarded 57 out of 69 points) in November 2003, India also led the way with the first LEED 2.0 Platinum rating for the GBC. See Figure 7 for a typical exterior view of the GBC in Hyderabad, India. Construction began in August 2002 and the building now serves as home for the Indian Green Building Council (IGBC), a green business incubator, and a conference center.

The world body known as the World Green Business Council (WGBC) is based in Sydney, Australia.   It has seven countries as the founding members, as under:

1. Australia - Green Building Council of Australia (GBCA); 2. Canada - Canadian Green Building Council (CGBC); 3. India - Indian Green Building Council, (IGBC); 4. Japan - Japan Green Building Council (JGBC); 5. Mexico - Mexico Green Building Council (MGBC); 6. Spain - Spain Green Building Council, (SGBC) and 7. United States - U.S. Green Building Council (USGBC).

Out of these seven founding members, only the USGBC has initiated a rating system in the form of the LEED rating system for sustainable habitats through out the world. In fact, LEED had to upgrade its standards to LEED 2.0 Platinum version, so as to be able to rate the GBC at Hyderabad, India. By the end of 2004, the following list of sustainable habitats through out the different parts of the world were awarded with different LEED ratings:

LEED 2.0 Platinum - CII Sohrabji Godrej Green Business Centre, Hyderabad, Andhra Pradesh, India;
LEED 2.0 Gold - Green Operations Building, City of White Rock, British Columbia (BC), Canada;
LEED 2.0 Gold - Vancouver Island Technology Park, Victoria, BC, Canada;
LEED 2.0 Silver - Semiahmoo Library and Community Policing Station, City of Surrey, BC, Canada; LEED 1.0 Bronze - Kandalama Hotel, Damulla, Sri Lanka.

The other salient features of the GBC, Hyderabad, India can be summarized as follows:
Due to 100% wastewater recycling, GBC has zero wastewater discharge. There is a 55% reduction in energy consumption as compared to similar buildings because of 100% Day lighting and eco-friendly air conditioning (AC) plant. 20% of the power is generated through solar photovoltaic (PV) cells. There is a roof garden covering 60% of the roof area wherein 60% of the wastewater is recycled. No toxic paint or sealant has been used. Carpets with low volatile organic compound (VOC) have been used. There is a wind tower to supply naturally conditioned air from an optimum depth below the ground.

A7. CONCLUDING REMARKS

Green buildings are feasible & economically viable. An ancient nation like India or a modern nation like Australia can reach and are quite capable of setting new global environmental standards, by virtue of it being a powerhouse traditional knowledge, ecological balance and scientific from times immemorial. It is relevant to recollect here that in most of the temples of Lord Shiva -the Hindu god of potential and destruction, the deity is located at some depth below the ground.

This is possibly to derive the advantage of minimum annual variations in temperature at that depth. Indian construction industry can reach global standards, deriving necessary inspiration from sustainable habitats like RETREAT and GBC. Promotion of sustainable technologies and practices through the construction of buildings (designed for either individual families like the 'Sustainable House' or the institutions like TERI and CII), can very well indicate our commitment for sustainable habitats and thereby ensure holistic environmental education. When such sustainable habitats gain a general acceptability among the public, they become more typical rather than being simply prototypical and eventually lead towards holistic education.

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B:- <u>SCIENTIFIC PROMOTION OF WATER HARVESTING THROUGH RAINWATER QUALITY ANALYSIS</u>

B1. ABSTRACT: Climate change is causing an increase in the precipitation intensity and a decrease in the number of annual rainy days as well as the average storm duration. Even though this established fact is sufficient to promote water security through water harvesting schemes, current pace of implementation of water harvesting schemes in India is highly inadequate. Although most of the traditions of the world in general and the Indian *Ayurvedic* tradition in particular have promoted rainwater usage for all purposes due its purity, there is a need to scientifically re-establish this fact through rainwater quality analysis in terms of the modern potable water quality parameters as adopted by the Bureau of Indian Standards (BIS) and the World Health Organization (WHO). The present study reports collection and quality analysis of rainwater in terms of 18 parameters over a 6-week period.

B2. KEYWORDS: Water harvesting; rainwater quality analysis; potable water quality parameters.

B3. INTRODUCTION

Water is one of the most important necessities for all living organisms in general and human beings in particular. Depending upon the water availability, mankind has developed a preference for rainwater over river water and for river water over groundwater. In an ideal situation, all these three forms of water -that are generally available for human usage, are expected to have the same acceptable level of water quality standards. Such water can be used as potable water (i.e., for drinking and cooking) which requires the best water quality as established by the World Health Organization [WHO (2008)].

The daily per capita quantitative requirement of potable water is very little (i.e., 10 liters) and it can be easily met by adopting water harvesting at the individual house level [CSE (2000)]. Still many cities / towns / villages -in many parts of the developing world in general and in India in particular, face severe problem of potable water scarcity. This problem has also resulted in many other serious adverse socio-economic consequences like excessive number of school drop-out children, severe health related issues among women / children, significant reduction in the family income due inadequate working hours etc.

Unfortunately, these problems are continuing in India even in 2018 in spite of the following facts:

1. There are many documentary evidences in old Indian Sanskrit texts on *Ayurveda* and other Indian traditional systems mentioning the purity of properly collected / stored / harvested rainwater.
2. India has a strong tradition of ecological region-specific water harvesting which is at least as old as the Indus Valley Civilization [Agarwal and Narain (Ed.) (1997].
3. The normal annual precipitation of 1150 mm in India is higher than the corresponding values for all the continents except South America where it is 1596 mm [CSE (1987)] as well as the global average value of 857 mm [Chow (Ed.) (1964)].

This study aims at compiling the rainwater / water quality related documentations obtained from various ancient Indian texts in Sanskrit Language as well as from the modern literature in support of water harvesting while simultaneously presenting the results of a collection / quality analysis of rainwater sample after about 6 weeks of its collection undertaken by the author's team in 2001. It is sincerely believed that this study would positively contribute in scientifically promoting the water harvesting in its own miniscule manner among various communities in India and the rest of the world.

B4. MATERIALS AND METHODS

The ancient Indian medical tradition and system of *Ayurveda* recommends rainwater which is devoid of impurities, microbes as pure potable water. This is called *"GangAmbu"*. It is the water which is not harmful to health and has all the qualities to serve as drinking water. This potable rainwater must be free from heavy metals, suspended particles and pathogenic bacteria. Such potable rainwater is healthy, refreshing, cools body, increases alertness and satiates taste buds. All the above mentioned properties of pure *GangAmbu* or potable rainwater are narrated as follows in a Sanskrit shlOka:

"JIvanam tarpaNam hridyam hlAdih buddhih prabOdhanam |
tanvavyakta rasam mrushTam shItam laghu amrutOpamam||"

Its English meaning is as follows:

Potable rainwater can satisfy living organisms by touching their heart, providing them with buoyant energy and awakening their intellect. This is because the syrup provided by the potable rainwater is sweet, pleasantly cool and is like a small immortal nectar.

In the present scenario, the polluted skies, dusty winds, chemicals spewed from industries getting dissolved subsequently into the rainwater causes acid rains. It is not advisable to drink such rainwater. Even in *Ayurveda*, it has been mentioned that rainwater has to be used only after analyzing its purity.

The water contaminated with mud, weeds, algae and microbes is referred to as "*dushTajala*" in *Ayurveda*. *dushTajala* or contaminated water should not be used for any purpose as it is harmful to the living organisms [Suri (2008)].

Yajur vEda –one of the four Vedas, describes the benevolent nature of water as follows:

"ApO hi shThA mayO bhuvah …." -which means that, pure water can positively transform this universe into a comfort zone. Incidentally, this is also in the logo of the National Institute of Hydrology (NIH), Roorkee, Uttarakhand, India.

Similarly in one of its *shlOkas* given below, the *Athrva vEda* describes an ideal situation of in which it is wished that let the rivers carry the pristine rainwater and let there be abundance of vegetation which can provide food as well as medicine:

"Yantu nadayO varshantu parjanyAh supippalA OshadhayO bhavantu……"
.

Likewise there is a custom of smelling the pure water by holding it on hand followed by the offering of at least three morsels of pure water to the Sun God along with the simultaneous chanting of *GAyatrI Mantra* in *SandhyA vandan* –a Hindu daily ritual of saluting the Sun as well as the female deity existing at the morning / noon / evening time. Similarly there is another custom of maintaining general hygiene in an area where some form of worship is planned by sprinkling clean water along with the chanting of the Mantra '*SarvE sthaLAni shuchinO bhavantu*' which means that let all the locations be clean enough for ensuring the worship-worthiness of the place. These customs are some examples denoting the importance attached to water quality and general cleanliness in the Indian heritage.

This tradition of maintaining the purity of water in the form of either rainwater or river water or groundwater in India led to the establishment of rich and time-tested water harvesting traditions and practices which are specific to each of the ecological regions of India shown below:

As the human communities moved from individual / decentralized municipal water resources planning towards centralized municipal water resources planning involving long distance transport of water through pipelines / canals sometime in the 19th Century, these millennium old water harvesting traditions became the first casualties. While on one hand these centralized municipal water supply systems ensured an easy availability of water globally as well as in India, many villages and communities were left with inadequate backup plan in case of failure of the centralized systems.

These centralized municipal water supply systems have resulted in the shifting of the responsibility of providing a sustainable freshwater from the individuals at the village or community level to the water supply departments of local self-governments. As a result of this, most of the people have taken for granted the availability of freshwater and have become detached from their responsibility or have developed a general tendency to use more water than their requirement leading to wastage of municipal water supplied. Added to this, the adoption of centralized wastewater system -generally associated with an uncontrolled release of untreated / partially treated wastewater into rivers / other water bodies, in many villages / towns / cities in India / elsewhere in most of the developing world has severely affected the water quality rendering it unfit for drinking.

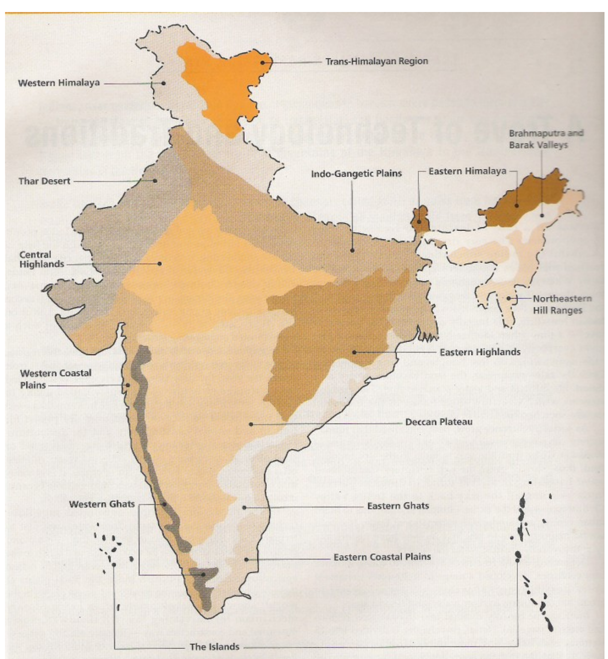

Figure 1B. Ecological regions of India [Source: Agarwal and Narain (Ed.) (1997)]

Villages and communities, who have judiciously stored the rainwater and / or have substantially prevented water quality degradation in nearby rivers / water bodies, have ensured a sustainable freshwater supply through rainwater and / or river / lake water. On the other hand, many other villages and communities have adopted some other unsustainable means such as the overexploitation of groundwater. This has led to many problems like arsenic or fluoride and their associated health problems as shown in Figure 2B and Figure 3B [Jamwal and Manisha (2003)].

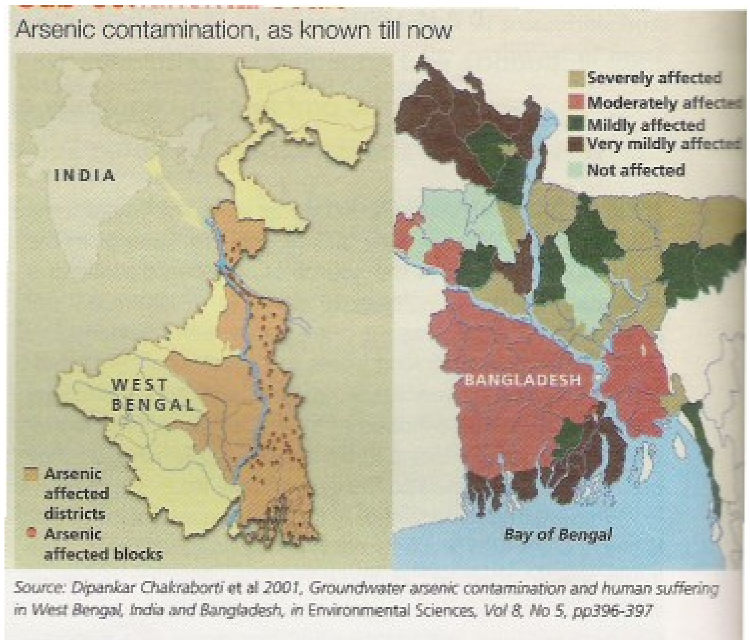

Figure 2B. Arsenic affected areas in West Bengal, India and Bangladesh in 2001.

The problems of arsenic and fluoride are over and above the general problem of hardness associated with the tastelessness in the groundwater when it is pumped out from the confined aquifers which generally do not get adequate recharge of freshwater as rainwater / river water regularly on an annual basis.

All these problems are occurring in various parts of India in spite of the fact that the normal annual rainfall value of 1150 mm is significantly higher than the corresponding values of 456 mm for Australia, 630 mm for Asia, 725 mm for Africa, 769 mm for Europe and 808 mm for North America [CSE (1987)]. On the other hand, there are at least two instances of best management practices (BMPs) adopted in parts of desert areas of Western Rajasthan in India with an annual rainfall of 100 mm using the traditional technology and in the Negev Desert of Israel with an annual rainfall of 105 mm using the modern technology [Agarwal et al (2001); Schwarz et al (2000)]. Such BMPs have ensured a sustainable freshwater supply in spite of the highly deficient rainfall.

All these facts need to be utilized to further promote the water harvesting activities on an accelerated pace globally and also in India. To achieve this on a scientific basis, the author personally collected rainwater from the roof top of his rented accommodation in Noida, Uttar Pradesh, India once during the monsoon months in 2001. After filtration through two layers of thick cotton clothes, the rainwater was collected in a stainless steel container and it was treated with alum which resulted in the settlement of suspended particulate matter at the bottom portion of the container.

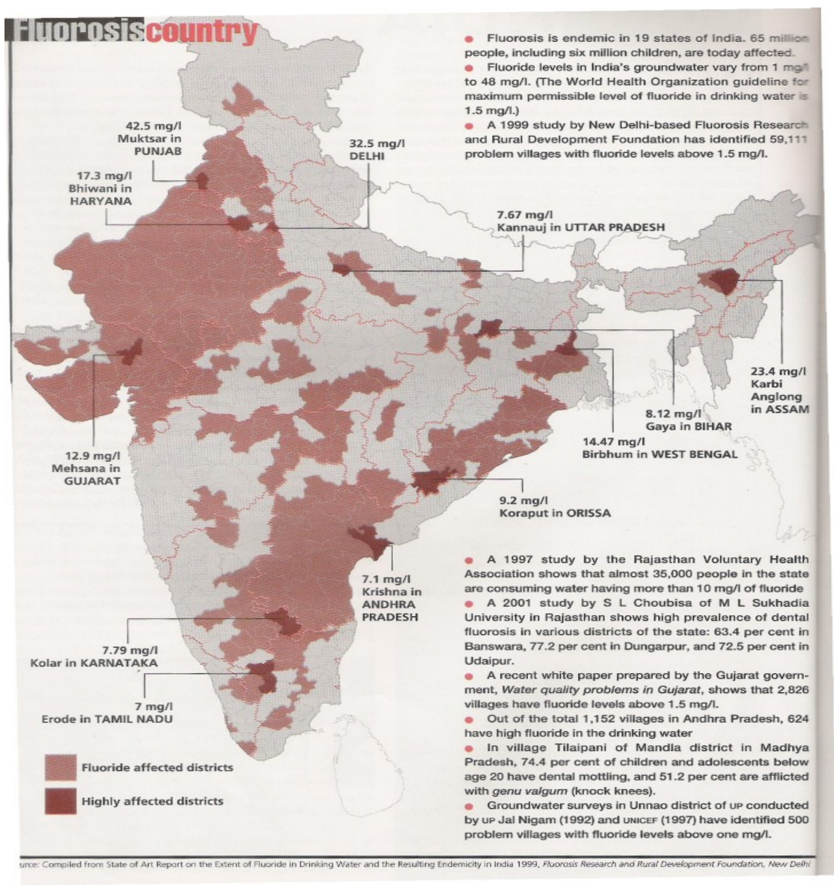

Figure 3B. Fluoride affected areas in India in 1999.

The relatively clear portion of rainwater sample was taken in 2 to 3 numbers of 1-liter mineral water plastic bottles and its quality analysis was carried out in the Environmental Engineering Laboratory of Civil Engineering Department in the Indian Institute of Technology (IIT), Delhi -after approximately six weeks of its collection. The following paragraphs describe the results of this analysis.

B5. RESULTS AND DISCUSSIONS

Rainwater collection: on June 30, 2001 by Dr. V.R.Desai, presently Professor of Civil Engineering, IIT Kharagpur (on lien at RM Software India Ltd., Noida, Uttar Pradesh, India during 2001-'02).

Rainwater sample analysis: during the 3rd week of August 2001 in Environmental Engineering Laboratory of IIT, Delhi by Dr. BJ Alappat, presently Professor of Civil Engineering, IIT, Delhi.

The results of the rainwater quality analysis are presented in Table No. 1 below. These results are very much in agreement with the findings of Gould (1999). We need to propagate rainwater harvesting through television commercials similar to the 'Pulse Polio Programme' propagation [Padre (2004)].

Table 1B. Rainwater Quality Analysis Results

Sl.No.	Parameter	Results (mg/l)	Indian Standards (IS) Limit Desirable (mg/l)	IS Limits Permissible (mg/l)
1.	pH	***7.16***	6.5-8.5	No relaxation
2.	Colour	***Colourless***	5 Hazen Units	25 H.Units
3.	Taste	***Agreeable***	Agreeable	-
4.	Odour	***Absent***	Unobjectionable	-
5.	Turbidity	***0.5 NTU***	5 NTU	10 NTU
6.	TDS	***417***	500	2000
7.	Total Hardness	***210***	300	600
8.	Chlorides	***110***	250	1000
9.	Residual Free Chlorine	***Absent***	0.2	-
10.	Sulphate	***47***	200	400
11.	Alkalinity	***52***	200	600
12.	Oil & grease	***Absent***	0.01	0.03
13.	Calcium	-	75	200
14.	Iron	-	0.3	1.0
15.	Nitrate	***3.0***	45	100
16.	Fluoride	-	1.0	1.5
17.	Cyanide	***Absent***	0.05	No relaxation
18.	M.P.N.	***Negative***	10	No relaxation
19.	B.Coli	***Negative***	0	0

B6. CONCLUDING REMARKS

India is blessed with a rich knowledge base on water harvesting techniques. Combining this with the modern best management practices related to water, there is an urgent need to scientifically promote rainwater harvesting. This can also provide lasting solutions to quantity as well as quality related water problems in remote communities, towns as well as busy metropolitan cities in India and many developing countries. Rainwater harvesting is becoming more relevant now with the manifestation of water resources related impacts of climate change which have led to an increase in the rainfall intensity leading to an increased frequency of floods and droughts. Proper storage of even small quantities of flood waters can overcome the drinking water problems both during the floods as well as droughts.

B7. ACKNOWLEDGEMENT

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