ILBM Impact Story

Ecological Restoration of Highly Polluted Stretch of Ahar River, Udaipur & Ecological Improvement of Udaisagar Lake, Rajasthan, India

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Abstract

Ecological restoration of Ahar River in Udaipur and the subsequent improvement of Udaisagar Lake have together become a landmark in the application of ILBM principles to successfully convert an aerobically dead river into a living lotic system. This was initiated in the ILBM meeting organized in August 2009 and then within 63 days the ecotechnological Green Bridge system was developed after getting four of the pillars – policy, institutions, finance and public participation to support knowledge and technology pillars to revitalize a terminal lake – Udaisagar Lake by treating the wastewaters flowing through the Ahar River. The flow of the river (about 100 MLD) mainly consists of domestic and industrial wastewaters. Jheel Sanrakshan Samiti (JSS) of Udaipur took the responsibility of local co-ordination with support from Green Infrastructure (GRIN), Pune. Finances were provided by members of Udaipur Chamber of Commerce and Industries (UCCI). Knowledge and technology was volunteered for by Shrishti Eco-Research Institute (SERI), Pune, which is known for its pioneering work in ecotechnological pollution treatment spanning almost two decades. SERI was requested by the JSS to guide the project. This ecological restoration work has strengthened the faith that appropriate network and timely actions with thorough knowledge of ecology can result in successful revitalization of lentic and lotic systems.

Key words: ILBM Impact, River eco-restoration, green bridges, network, biodiversity

1. Introduction

An international workshop on Udaipur lakes was organized at Udaipur on 12th August 2009 under the auspices of the Integrated Lake Basin Management Programme (ILBM) of the International Lake Environment Committee (ILEC), Japan. It was attended by Chairman of ILEC, SCICOMM, Dr. Masahisa Nakamura and various prominent experts from India and Nepal.

The ILEC team, along with representatives from Jheel Sanrakshan Samiti (JSS) – A Lake Conservation Group, UCCI, MMCF and various Governmental departments, visited Udaisagar and Ahar River and found that the stream carries Udaipur's untreated sewage, along with industrial waste water, and ecologically pollutes the lake Udaisagar. The lake was in a eutrophicated state, and in very poor ecological health. A group of farmers expressed their distress because pollution was not only making their lives miserable but was also affecting the agricultural productivity of the area. It emerged during the visit that there is an urgent need to look into this issue to prevent further deterioration of the lake, as well the environment, health and livelihood of the communities from this rural region.

One of the authors of this paper (Dr. Sandeep Joshi from Pune, Maharashtra), being one of the expert delegates, spoke on the issue of sewage management. He identified sewage as the most important source of pollution leading to environmental degradation of lakes and rivers. He emphasized that sewerage management needed to be given top priority in conservation of water resources. He described latest, cost-effective, advanced ecological, eco-friendly technologies for sewage treatment in the basins of lakes.

Sandeep Joshi, a known expert on sewerage treatment was requested by JSS to help Udaipur in mitigating the problem by applying ecological techniques invented by him for treatment of Ahar river and Udaisagar lake. JSS requested Mr. Arvind Singh ji of MMCF, Mr. Arvind Singhal of Wolkem India Ltd and Mr Virendra Siroya, President UCCI to help in this noble venture. The matter was further discussed with Ms. Aparna Arora, The Divisional Commissioner and Chairman of Jheel Samvardhan and Jheel Vikas Society (JSJVS). Mr. Onar Singh Deora, the Sarpanch of Matun panchayat, consented to help in this project.

Pursuant to this, JSS requested Ms. Aparna Arora, Divisional Commissioner, to convene a meeting under her chairmanship in the office of the Divisional Commissioner on 23rd September, 09. This meeting was attended and actively participated in by representatives of all concerned Governmental Departments, UIT, Municipal Council and representatives from industries, MSMMT, MMCF, various NGOs, scientists and academicians. Outcome of these deliberations that JSS should go ahead with the support from UCCI and government departments would provide necessary consents to undertake such massive pioneering work first time in Rajasthan State.

Sandeep Joshi and Mr. Pravir Sinha gave presentations on GREEN BRIDGE technology for treatment of the stretch of Ahar river at the site where river enters the Udaisagar lake (Kanpur to Sukha Naka). It was unanimously agreed to prepare a project report on the aforesaid technology for implementation. Accordingly, JSS as catalyst and coordinator has prepared the proposal in collaboration with SERI, and GRIN - organizations of Pune.

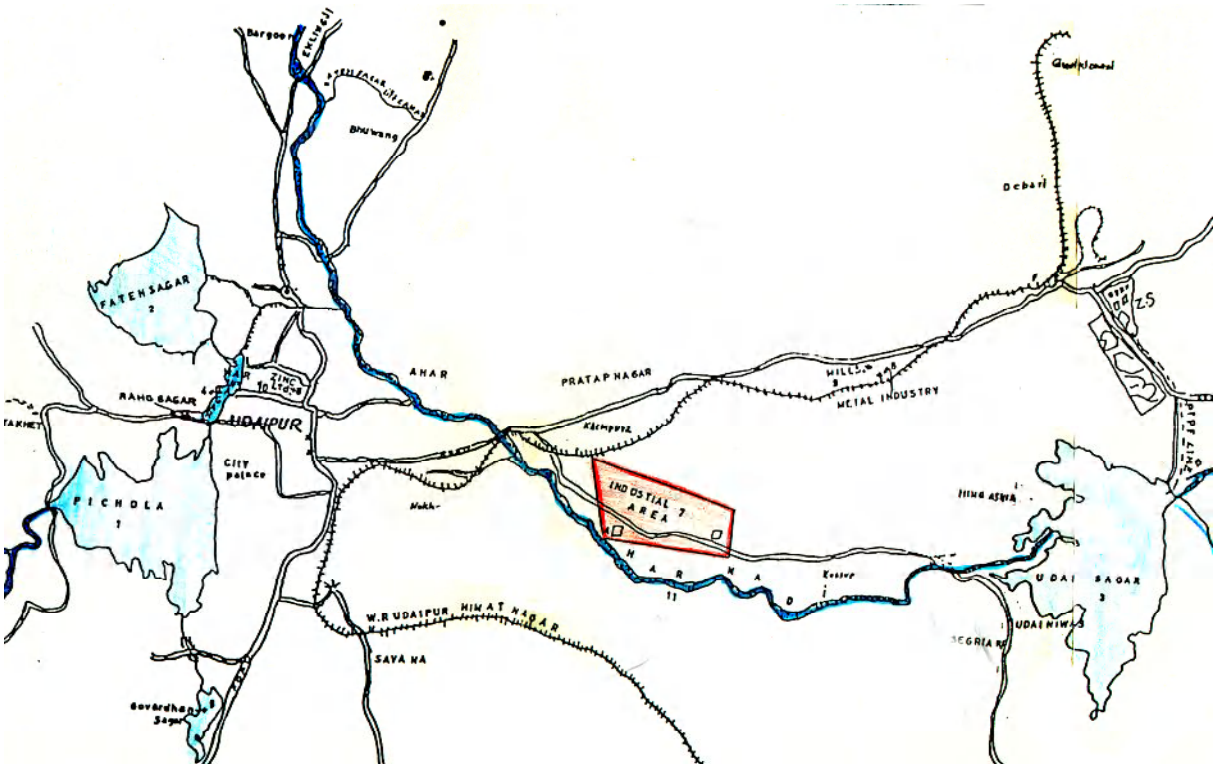
2. Environment Set-Up

2.1. Udaisagar Lake

Lake Udaisagar is situated near the village Bichari at Latitude 24^0 34' 41" N longitude and 73^0 49' 31" E and is about 15 km from the city of Udaipur. The lake is named after Maharana Udai Singh, the founder King of Udaipur city. This lake was developed in the year 1559 A.D. It is the last lake in the chain of Udaipur lake system. The major part of its water is used for irrigation, and industrial needs of M/s. Hindustan Zinc Limited, a unit of the Vedanta group.

The lake was constructed by building a masonry dam on the river Berach. It has a water spread area of 5.20 Sq. km at full tank level (FTL). The gross capacity of the lake is 31.15 million cubic meter (mcm) with the dead and live storage as 3.54 mcm and 27.61 mcm respectively. The length and width of the reservoir are 4.2 km and 2.75 km respectively. The catchment area is spread over the western side

of the lake and the gross catchment is 479.19 Sq. km which includes the catchment of other reservoir in the chain-lake system of Udaipur. Catchment area of only Udaisagar is 196.84 Sq. km. The greatest depth of Udaisagar lake lies at the dam site and is 6.1 m. The reservoir indicates a tendency of shallowness.



2.2. Ahar River

The main source of water for the lake is a tributary of the river Berach, popularly called Ahar, which passes through the city of Udaipur and drains into Udaisagar near Sukha Naka. Ahar River, which is now ephemeral, carries entire domestic and industrial waste water of Udaipur. The waste water enters Udaisagar and is causing severe ecological problems**.**

Table 1. Morphometric Features of Udaisagar, Udaipur, Rajasthan, India.

Name of the lake	**Udai Sagar**	Longitude	73º 49' 31" E
Latitude	24º 34' 41" N	Catchment Area	479.00 Sq. km
Gross Capacity	31.149 mcm	Live Capacity	27.6 mcm
Water Spread	5.60 Sq. km	Depth Above Sill	7.31 m
Depth Below Silt	6.00 m	Gross Command Area (GCA)	5094 ha.
Cultivable Command Area (CCA)	4655 ha.	Intensity of Culture (ICA)	1947 ha.
Maximum Irrigation	2510 ha.(1992-93)		

2.3. Pollution of Udaisagar and Ahar River

Udaisagar is the most polluted lake in the chain-lake system of Udaipur since it receives the entire untreated domestic and industrial wastewaters through Ahar River. Higher concentrations of TDS, COD, and alkalinity indicate the polluted status of Udaisagar reservoir. Eutrophication, which denotes nutrient enrichment and infestation of selective species in the lake, was a serious problem in Udaisagar Lake. The human interferences mainly like deforestation in the catchment area and wastewater inflow have caused serious ecological, biological, socio-economic and human health fabric of Udaipur. Udaisagar is significantly suffering from eutrophication which is evident from the symptoms such as foul odour, mats of algae and macrophytes.

Studies of lake ecosystem processes indicate the deteriorating status of Udaisagar and Ahar River. Dissolved Oxygen (DO) is an important limnological parameter indicating status of water quality and organic production of any lake. Survival of aquatic organisms, especially fishes, depends upon the suitable concentration of dissolved oxygen in water. The DO values once excellent in Udaisagar now have been reduced to alarming level. Low concentration of oxygen in lake water has created anaerobic conditions. Decaying of organic matter releases the free carbon dioxide and it causes depletion of oxygen which usually leads to anaerobicity resulting in foul smell and fish mortality.

Biochemical Oxygen Demand (BOD), Electrical Conductivity, Hardness, Total Phosphates, Nitrates, Chlorides, Sulphates, Silicates and Total Alkalinity have also increased during the last 30 years. Excessive Phytoplankton population indicates the higher organic and bacterial load. The excessive growth of weeds creates many problems such as undesirable odour, taste and colour. The most serious indicators are the presence of faecal coliforms which indicate that the water is not suitable even for bathing purpose.

Udaisagar, like other lakes of Udaipur used to harbor good icthiyo-fauna, consisting of 42 species of fish including Mahaseer and all major carp fishes. But now only 17 species of fish are surviving. Bacteriological concentration is a matter of serious concern as the MPN values are greater than 2400 Nos./100 ml for total and faecal coliforms. Further, occurrence of *Citrobacter* sp., *Streptococcus faecalis*, ova of ascaris, cysts of *E. histolytica*, *Giardia* sp. and *Trichuria trichuria* have been located. All the above parameters indicate an alarming level of contamination.

Table: Water Quality of Udaisagar Lake (Year 2005)

Reservoir	pH	TDS (ppm)	COD (ppm)	Alkalinity (ppm)	Hardness (ppm)	Total Coliform (MPN per 100ml)	Feacal Coliform (MPN per 100ml)
Udai Sagar	8.2	478	24	182	244	6200	2000

Source: CPCB, Regional Office, Bhopal

3. Basis for the Designing of Scheme

3.1. River water characteristics as tested in Sept. 2009

Samples were collected by JSS and tested by the research laboratory of Pesticides India Ltd.

Table: Water Quality of Udaisagar Lake

No.	Characteristic	SAMPLE-1 Sukha Naka - downstream	SAMPLE-2 Kanpur Pulia – 1.6 km upstream	Remark
1	pH	7.23	7.18	Neutral range
2	TDS, mg/l	1446	1224	No significant change
3	TSS, mg/l	28	21	Increased
4	Aluminum, mg/l	0.015	0.004	Increased
5	Cadmium, mg/l	ND	ND	No detection
6	Lead, mg/l	ND	ND	No detection
7	Zinc, mg/l	ND	0.022	No detection
8	Iron, mg/l	0.335	0.745	Decreased
9	COD, mg/l	111	101	Increased

3.2. Site Morphometry of Ahar River

Width (average)	28 meter
Depth of flow	0.3 m non monsoon
Velocity of flow	0.13 m/sec
Normal rain flow over depth	60 cm
High flood flow over depth	3 to 4 meter
Dry weather flow	1.092 cumec

From the Kanpur Pulia to Sukha Naka in a distance of about 1.6 km, it is found the the banks are widened due to excavation and formed as a pond in the river filled with water hyacinth biomass. It was filled with city garbage and plastic trapped in the floating biomass leading to anaerobic conditions. There was obnoxious odour due to these conditions in the river. There was no aerobic life in the river. The restoration scheme was designed after giving due consideration to the ecological status of the river.

4. Ecotechnological Solution (Eco-friendly Technology)

Ecotechnology is an applied knowledge and skill that searches for accomplishing human needs with minimal ecological disruption, by binding and subtly maneuvering natural forces to leverage their beneficial effects. It is the 'ecology of techniques' and the 'techniques of ecology,' requiring a substantial understanding of the structures and processes of ecosystems and societies.

All sustainable engineering that can reduce damage to ecosystems, adopt ecology as a fundamental basis, and ensure an orientation of precaution in the

implementation of the conservation of biodiversity and sustainable development may be considered as forms of ecotechnology. (Wikipedia)

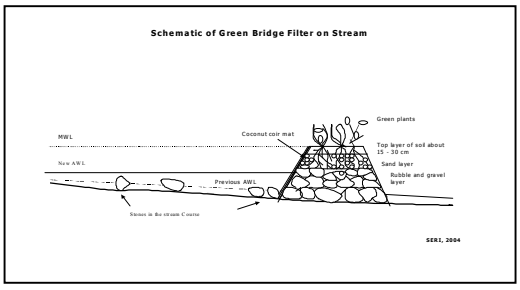
Ecotechnology is essentially the discipline of sustainable development. Ecological engineering practices can facilitate restoration and preservation of the environmental health for the survival, development and economy of society through the integration of engineering and ecological principles. An ecologically sound approach to engineering accounts for the fact that nature responds thoroughly, constantly and cumulatively. Ecotechnology operates within the borders of the ecosystem rather than infringing on or contravening or overcoming it.

Ecotechnology has the essence of the progression of collective intelligence from the beginning of life on the earth 3.5 billion years ago to the present with proven expression of multi-species intelligence. Solutions should be as supple and magnanimous as possible, thus keeping away drastic and irreversible consequences when something wrong or unexpected happens. Hence, it is imperative to obtain knowledge and understanding about the structure and functioning of ecosystems and their particular susceptibilities. Ecological engineering and eco-technologies are dependent on the self-designing abilities of ecosystems and natural forces.

When changes occur in the natural system due to external inputs, biogeochemical cycles and food chains are reorganized and balanced. Certain species are preferred to adapt to the changes. A new dynamic order eventually is emerged suitable to the environmental changes superimposed on it. Thus the ecological engineering and eco-technologies are distinguished from conventional engineering technology owing to focus on, and use of, biological species, communities, and ecosystems.

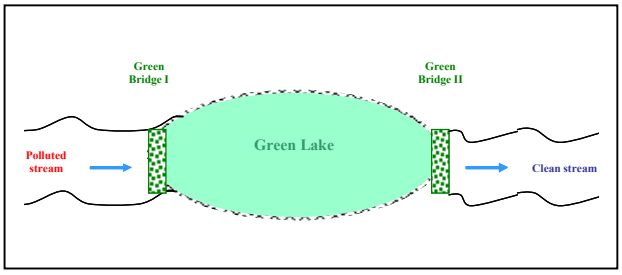
4.1. Green Bridge

Green Bridge technology uses filtration power of biologically originated cellulosic / fibrous material in combination with sand and gravels and root systems of green plants. It is an innovative approach to minimize the cost of pollution treatment wherein the cellulosic / fibrous materials like coconut coir or dried water hyacinth or aquatic grasses are compacted and woven to form a bridge / porous wall like structure strengthened by stones and sand with various consortia of microorganisms specially seeded there for that purpose. All the floatable and suspended solids are trapped in this biological bridge and the turbidity of flowing water is reduced substantially. The green plants growing there help in absorption of soluble substances including heavy metals. (The Patent has been registered in the name of Sandeep Joshi).



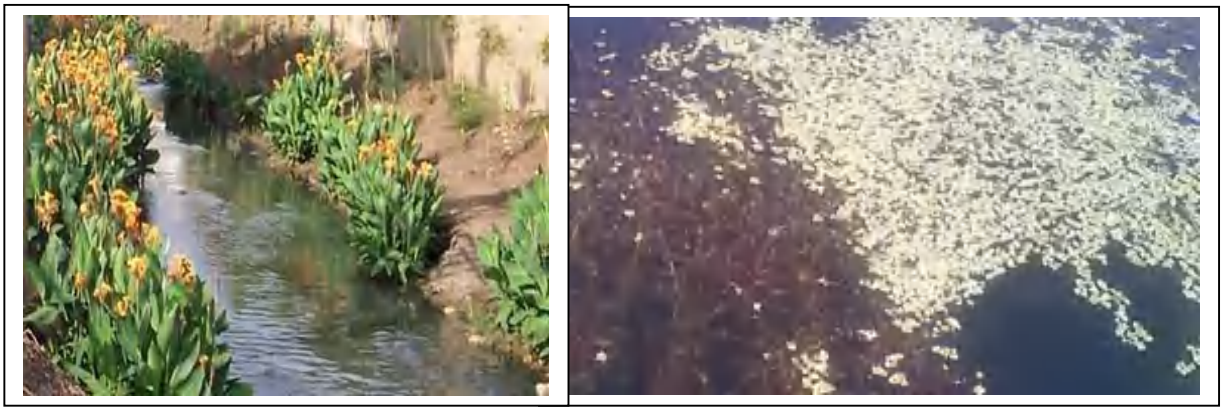
4.2. Green Lake Technology

Green Lake system uses floating, submerged or emergent aquatic plant species. These can be termed as *macrophyte* ponds also. Macrophytes are capable to absorb large amounts of inorganic nutrients such as N and P, and heavy metals such as Cd, Cu, Hg and Zn etc and to engineer the growth microbes to facilitate the degradation of organic matter and toxicants. Green plants detoxify the pollutants and make them suitable for other organisms.



4.3. Stream Ecosystem

It involves the use of the natural slopes of the polluted drains, beds, banks of streams or pond to enhance the aerobic activity in water by generating turbulence and providing shallow depths to allow sun – light to reach the bottom. This is the simulation of the stream flow in the wilderness. It ensures the free-flowing water splashed by stones and cascades. It is observed that the dissolved oxygen in the water increases multifold – in some already installed systems it is observed that this increase is up to 90 – 120 times i. e. (from 0.1 to 8 – 12 ppm).



4.4. Phytofiltration and Biox Process

It involves the use of plant fibers, roots to remove suspended solids from wastewater effectively in a well designed tank. In this techniques normally, the floating plants are used to facilitate the removal of solids by biosorption methods. Biological oxygenation process is defined as the transfer and dissolution of oxygen with the help of certain green plants and algae. It has been observed that in the unpolluted mountain streams the oxygen content in the water rises up to 19 ppm.

Table 2. Comparison of Ecotechnologies with conventional biological treatment technologies.

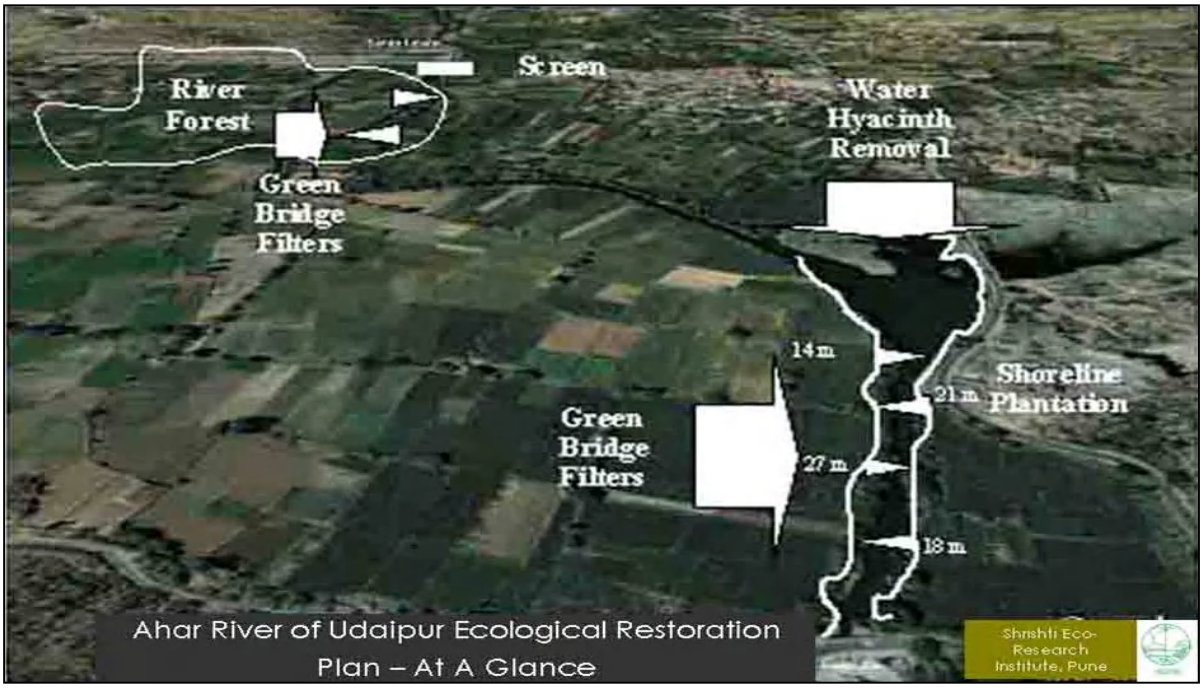
No.	Particulars	Ecotechnologies (considering all techniques)	Conventional Biological Treatment Technologies
1.	Description	Use of ecological principles in combination with phytoremediation & bioremediation	Biodegradation by heterotrophic microbes
2.	Application	Vertical ecofiltration (Soil Scape Filter) suitable For point sources of domestic and industrial wastewaters, containing toxic organic and inorganic pollutants. Horizontal ecofiltration (Green Bridge) suitable for pollution flowing through streams and rivers	For domestic and industrial wastewaters containing non toxic organic matter only.
3.	Wastewater Application	1 – 2 cu m/day per sq. m for vertical ecofiltration 50 – 200 cu m per sq. m for horizontal filtration	0.5 – 2 cu m/day depending on pollution load
4.	Organic loading (COD/BOD)	1--5 kg/m^2.day	ASP - 0.5 kg/m^3.day Anaerobic Process - 0.5-5 kg/m^3.day Lagoons / ponds 0.006 -- 0.0025 kg/m^2.day
5.	COD/BOD reduction range	80 - 99%	ASP – 80- 85% Anaerobic Digester 80 – 95% Lagoons/ponds 50 - 95%
6.	Ancillary units	One unit only for Vertical ecofiltration. The requirement is of neutralization if the pH of wastewater is not in the range of 6.5 - 8.5	5 units Requirement of equalization tank, neutralization, primary settling, secondary settling tanks and sludge drying beds.
7.	Electricity requirement Kw/ cu m of sewage	Nil – Even for Ahar river with flow 94.35 MLD **= Rs. 0.00**	Minimum Electricity requirement 13209 Kw / hr. i.e per day cost approx Rs. 66,045/- @Rs. 5/- per kw for Ahar river flow**. =** **Rs 2.41 crores per year**
8.	Installation Costs	**Rs. 1 lakh per MLD** for Horizontal Ecofiltration	**Rs. 80 – 120 lakhs per MLD**
9.	Operational & Maintenance Costs	Approximately Rs 4.24 per MLD for Horizontal Ecofiltration (Green Bridge **)=** **Rs 1.50 lacks per annum** **+ Rs 3.50 lacks per annum for water quality testing & supervision**	Rs 5000/- per MLD when aeration is provided. **=Rs 172 lakhs per annum**

Where MLD = Million litres per day; $ 1 = approx. Rs. 45/-; Rs. 1 lakh = $22000

* Please note the rates quoted for ecotechnological systems are not applicable to lower volumes of wastewaters. These may vary on case to case basis depending on the pollution load and local site conditions.

5. Treatment Scheme for the stretch of Ahar River & ecological improvement of Udaisagar

The treatment scheme will be comprised of 6 Green Bridges (2 Near Kanpur Pulia and 4 Before Sukha Naka Bridge). Two green bridges of about 12 m in length shall be installed near Kanpur Pulia across the water course and four green bridges of length 22 – 24 m before last bridge. One screen made up of MS with anti-corrosive painting shall be installed upstream of Kanpur Pulia as shown in fig.



The scheme involves total six green bridges of varying length depending on the width of river at particular selected sites.

This screen will be 24 m long and its height will be 1 m. The approach road shall be created to facilitate daily removal of garbage from the screen.

Water hyacinth shall be completely removed from Kanpur Puliya area and downstream of Green Bridge System till the Sukha Naka area, Udaisagar Lake. The river banks shall be strengthened by planting Vetiver, Typha, lemon grass, citronella and local grasses. This will facilitate improved aeration of water and protect the surrounding farms from the flash floods and high floods. Grass plantation will also facilitate the control of bank erosion. Removal of water hyacinth will facilitate the local species to take over the charge of river purification. These plant species help in removal and biodegradation of unwanted man-made chemicals which come into the river from various sources.

General cross section of the Green Bridge for Ahar River (stretch – Sukha Naka) Restoration can be shown as –

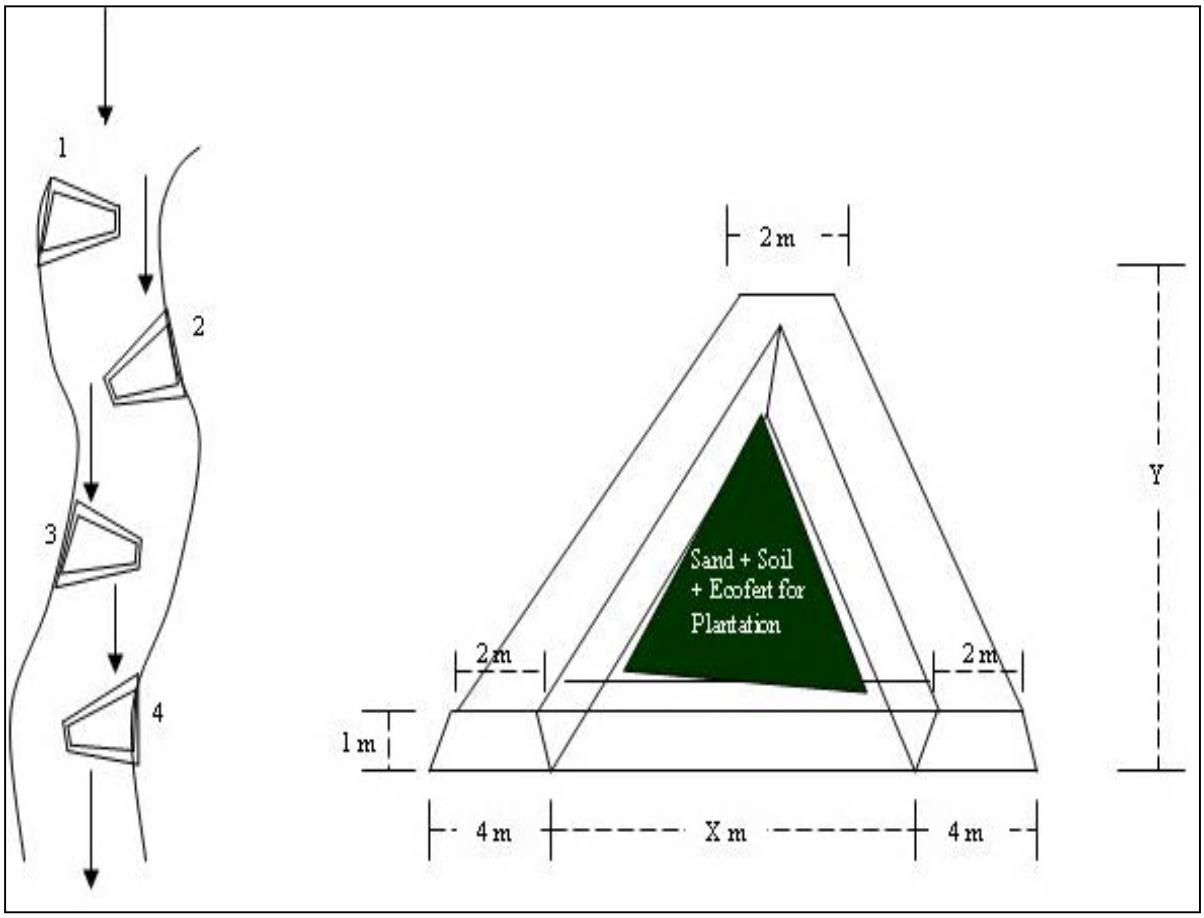


Table . Schedule of ecological restoration activities

No.	Activity/Installation	Expected Performance and Result
1.	Cleaning – Removal of plastics, cloths, dead animals, carcasses etc. near Kanpur	Control of odour, better aesthetics of the riverfront,
2.	Removal of water hyacinth from impounded river downstream of Kanpur before the bridge	Control of odour, mosquitoes and development of multi-species ecosystem
3.	MS screen on the upstream of Bridge near Kanpur	Control of plastics and other unwanted floatable materials from river flow & course
4.	Stream – training downstream of Kanpur Bridge	facilitate natural aeration and bio-control of pollutants
5.	Installation of two Green Bridges near Kanpur Bridge – 12 m in length 3 m wide at bottom and 1.5 m wide at top with 1 m height	Filtering of suspended solids and contaminants – reduction will be 40-80%
6.	Installation of four Green Bridges downstream of Kanpur before Bridge – 20 m in length 12 m wide at river bank, 4 m wide in river course with 1 m height	Filtering of suspended solids and contaminants – reduction will be 40-80%
7.	River forest near Kanpur – 3 – 4 acres	Increment in biodiversity multifold
8.	Plantation near green bridges – local marshland grasses	Control of bank erosion and stability of green bridge structure

5.1. Design Specifications

Treatment Process	Based on horizontal ecofiltration process – Green Bridge Filter (Patent registered by Sandeep Joshi of SERI, Pune) – for the treatment of waste waters and sewage. A very rugged system that can even take abuse in its stride easily.
Flow of Ahar River	Dry Weather Flow – 94.35 MLD Normal Monsoon Flow – 435.46 MLD High Flood Flow - 2909.08 MLD High flood condition may last for 5 – 7 days. But it is not a regular phenomenon.
Pretreatment	Metal screen near Kanpur Pulia
Battery limit of Green Bridge System	Kanpur Pulia to Sukha Naka Bridge Before Udaisagar Lake
Exclusion	Upstream Catchment Treatment

5.2. Expected overall results

Pollution Control

- ✓ Solids control : 40 – 80% reduction
- ✓ Pollution Control : COD/BOD reduction – 40-90%
- ✓ Faecal coliforms control : 50 -100% reduction

Increment

- ✓ Dissolved Oxygen : 150% - 1200%
- ✓ Aquatic species : Plants/Plankton – 200% - multifold
  Micro-invertebrates – 200% - multifold

- Multifold changes in population of avifauna
- Multifold changes in terrestrial plants along the riverbanks
- Overall odour and mosquito reduction and improvement of river aesthetics
- Health improvement of people
- Overall increment of health status of aquatic life in Udaisagar Lake by reduction in ecotoxicity of pollutants
- Ecological control of water hyacinth over the period of time
- Ecological education and demonstration centre for students and tourists

6. Project Implementation and Monitoring Cell (PIMC)

The UCCI shall setup a committee for the implementation and execution of the project. UCCI shall maintain a separate account which will be audited every year and will also open a separate bank account for this project.

6.1. Scope of Work and Project Responsibilities

Scope of work	Organization
All statutory permissions	District Administration
Prior to the start of the project, clearing of water hyacinth, plastics and other non – biodegradables from water body between Kanpur bridge till confluence with Udaisagar lake. With the use of machinery like JCB, bulldozer, dumper tipper and manpower	District Administration
1. To provide design & working drawings of Green Bridge technology, screen etc. & suggestions for the development of eco-forest along the river stretch 2. To provide technical supervision at the time of installation 3. To provide monitoring, supervision of the installed structures till the attainment of satisfactory results 4. To provide training to UCCI team for upkeep, maintenance & performance evaluation of the project	SERI
Supply of biomats at site 1200 sq. mt , bacterial culture 200 kg and Ecofert 24 tons – All inclusive price will be Rs. 16.6 lakhs	GRIN
Providing of manpower and machinery required for construction of Green Bridges, strengthening of banks, laying of biomats, spreading of Ecofert and plantation of plants.	Public- Private Partnership through UCCI
Periodical maintenance of Green Bridge system i. e. changing of biomats, trimming and cropping of overgrown plants on Green Bridges.	Public- Private Partnership through UCCI
Testing quality of water before and after Green bridges	Through UCCI.

7. Lessons Learned and Achievements

1. The Integrated Lake Basin Management (ILBM) Programme of the International Lake Environment Committee, Japan, triggered the concept of ecologically reviving Ahar River which was draining a mix of domestic and industrial wastewaters into Udaisagar Lake. Their participation and support was helpful in obtaining permissions and assistance from local government institutions and agencies. Here the two pillars of ILBM worked – Policy and Institutions.

2. Jheel Sanrakshan Samiti with scientific and technological inputs from Sandeep Joshi, Ecotechnologist of Shrishti Eco-Research Institute (SERI) opened dialogue with funding agencies and city administration after meeting ILEC members in Aug. 2009. Within a period of just three months, the paper work, decision-making and fund raising processes were completed. This is an achievement in itself. The network of professional organisation like Shrishti Eco-Research Institute and Green Infrastructure with the voluntary organisation Jheel Sanrakshan Samiti proved to be fruitful in seeking the participation of affected people in the project. Invoking the spiritual, social and cultural bonding of Indian society was a key approach in obtaining the support from the masses. The third pillar of ILBM - Public Participation - was built strongly by likeminded initiators and groups.

3. The biggest achievement was development of pollution-reduction facility without using a single unit of electricity or a bag of cement, that also within 63 days.

Normally, such wastewater treatment facility development takes at least 12 - 24 months for 100 MLD flow. The fourth pillar of ILBM – Technology – was established with the proven other two pillars - information and knowledge - from the experienced technologist.

4. Thus ILBM was implemented successfully in the ecological restoration of Ahar River.

7.1. Ecological Changes in the River

The first noticeable effect of the attempts of reviving self-purification capacity of the Ahar River was increased level of dissolved oxygen in the river which was confirmed by experts of Vedanta Group in laboratory analysis, field observations by the experts of the limnological institute in Udaipur and Powai Lake Field Research Station, Mumbai.

Moina species was found to be abundantly growing which devoured on planktonic materials as the ecotoxicity was reduced substantially due to introduction of Green Bridges and mixed bacterial cultures. The algal development was also monitored. The result was encouraging as dissolved oxygen content of the water improved to 7 - 8 mg/L during day time from absolute nil in untreated stretch of the Ahar River.

Local villagers first spotted the turtles and snakes in the river again; bird-watchers observed increased number of bird species in and around the river. They also noticed the absence of any stench in the ambient air, improvement in well-water quality and substantial reduction in foam in the river. Their observations were translated by the experts in the language of scientific evaluation of the changes.

Physico-chemical changes in the river water quality due to Green Bridge - horizontal eco-filtration system were the reason for overall positive changes in the ecological health of Ahar River.

The major observations are highlighted as –

1. Higher concentrations of COD and faecal coliforms in the Udaisagar Lake as compared to the standard drinking water standards has affected the livelihood of more than 10,000 poor villagers and farmers who are solely dependent on that water body.

2. Concentration of COD, BOD and TDS is very high as compared to the non-polluted upstream stretch of the river (before the city). This river pollution is a result of the city's discharges and industrial effluents. BOD and COD reduction due to Green Bridges was found to be in the range of 50 – 78%.

3. The river water was infested with water hyacinth in certain stretches leading to elimination of other resident species of the river like turtles, water snakes, fishes and freshwater microinvertebrates.

4. There is frequent shock-loading of industrial effluents. It can be deduced from the observations of research students of local university. They observed the diurnal variation of pH of the incoming effluents from 2 – 10. In the grab sampling, it is not reflected.

5. There are pertinent observations by local villagers and farmers of about complete elimination of odour problem and more than 90% reduction in foam in the river.

6. After completion of Green Bridge installation activity in second week of March 2010, within seven days, residents spotted freshwater turtles which had run away around 10 years ago due to pollution. Farmers along the river started using their well-water which lost stench as a result of revitalization of river.

8. The Way Ahead .....

This is the first phase of the ecological restoration of the part of the Ahar river, which covers the river's most polluted stretch. After attaining satisfactory results and performance from this first phase, more such installations have to be installed at 5 to 6 places in the river, for its proper ecological treatment and for a sustained ecological rejuvenation of Udaisagar lake. The 5 to 6 such installations, as suggested above shall cost as per our estimate about Rs. 3.00 crores.

9. Acknowledgement

One of the authors of this paper (Dr. M. S. Kodarkar) wrote a story of ecological restoration of Ahar River of Udaipur before his demise on 9th Aug. 2010. Sandeep Joshi later on modified it with more inputs, giving due credit to his work. The authors are grateful to all who worked directly or indirectly for the success of the project.

References

Detailed Project Report (DPR) of Ecological Restoration of Ahar River, Udaipur jointly prepared by SERI, Pune and JSS, Udaipur, Sept. 2009.

Personal discussions with villagers, NGOs, GOs and experts who worked together for the project.