Eco-Treatment Zone in Open Drain

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ABSTRACT
In India of the 233 class I cities situated in 14 major river basins, only 24% are having proper sewerage systems and class II cities don't have any sewerage system for collection of domestic wastewater. Just collection of the sewage is not enough; further treatment facility to purify the sewage is also a necessity. So, all these city wastewaters are naturally taken to the nearby rivers and lakes by nallas and odhas (streams - natural drains). These natural drains in the cities are serving as sewerage lines. The studies published by CPCB in 2013 reveal the pathetic condition and inadequacy of pollution treatment infrastructure in India. Then Planning Commission has suggested developing "treatment zones" in city drains. It's a very innovative approach acknowledged by Government of India which needs to be strengthened further by very scientific implementations by scientists who have mastered the art of eco-treatment of polluted waters. From the case studies of Udaipur's ecological restoration of Ahar River and Allahabad's ecological treatment Rasoolabad Stream Complex, it can be said that such types of ecotechnological in-situ treatment –Green Bridge– system deliver more than expectations in the form of extended social and ecological capitals. The capital and operational costs of ecological treatment processes are comparatively less than conventional engineering approaches.

***Keyword**:* Eco-treatment, ecotechnology, non-point sources, Green Bridge

I INTRODUCTION

In the developing cities, it is estimated that more than 90 percent of sewage is discharged directly into rivers, lakes, and coastal waters without treatment of any kind (www.nyop.unep.org; www.unep.or.jp). Over two billion people are expected to live in metropolises, mega-cities of developing countries leading to aggravation of problems of river and lake pollution. In most of the developing countries governments are fighting to eliminate fecal contamination from rivers and lakes which are sources of drinking water. In India, cities produce nearly 40,000 million litres of sewage every day and barely 20 percent of it is treated[2].

Central Pollution Control Board (CPCB) carried out study on status of Municipal wastewater generation and treatment capacity in Metropolitan cities, Class I cities and Class II towns of India and published a document. As per the CPCB report, there are 498 Class-I Cities (including Metropolitan cities) having population more than 1 Lac as per 2001 census. Sewage generated in class-I cities is estimated about 35558.12 MLD Total Sewage treatment Capacity of class-I cities is 11553.68 MLD. Out of 11553.68 MLD sewage treatment capacities in Class I Cities, only 8040 MLD exists in 35 Metropolitan cities i.e. 69%. The capacity of sewage treatment in remaining 463 Class-I cities is only 31%. While total sewage generation in class-II towns is 2696.70 MLD, out of which total sewage treatment capacity in Class-II towns is 233.7 MLD which is just 8% of the total sewage generation. Actual sewage treatment, due to inadequacy of the sewage collection system, shall be low compare to capacity. (CPCB 2013)

The 150 years old conventional aerobic and anaerobic treatment systems are yet to be accepted worldwide as they are cost intensive and complicated to maintain. Investment of crores of rupees in the Ganga Action Plan could not give the results due to unavailability of electricity to run the modern facilities of state-of-the-art-treatment systems, technologies and inadequate sewer collection and conveyance facility. Same was the case with Yamuna Action Plan and Dal Lake Pollution Control Plan.

Centralization of sewage treatment facility has many engineering and management difficulties such as –

(a) Disorganized construction of buildings, townships and roads leading to backlog of sewage treatment facilities
(b) Already constructed areas do not have effective sewage collection, conveyance, and treatment systems

Due to lack of proper conveyance/infrastructure facility to collect all sewage generated from already developed/constructed area or remote places in the city, sewage is directly coming into the surface fresh water bodies like lakes and rivers through channelized and un-channelized drains. Consequently all city's storm water or natural drains are converted into the sewage carrying drains. If we are able to treat and reuse this water for non consumptive purposes, our fresh water demand will be reduced and we will be able to save our fresh water resources from pollution which will lead to sustainable development of our cities.

Ex Planning Commission, Government of India's **Report of the Working Group on Urban and Industrial Water Supply and Sanitation for the Twelfth Five-Year-Plan (2012-2017)** spells out explicitly the guidelines and line of action to reduce the pollution of rivers and lakes due to inadequate sewage and effluent treatment facilities in urban and industrial sectors. The studies published by prime pollution authority of India – Central Pollution Control Board (CBPC) in 2013 reveal the pathetic condition and inadequacy of pollution treatment infrastructure in India. May be because of that, Ex Planning Commission have suggested to develop "treatment zones" in city drains. It's a very innovative approach acknowledged by Government of India which needs to be strengthened further by very scientific implementations by scientists who have mastered the art of eco-treatment of polluted waters. The original text of Ex Planning Commission's report is cited here –

(a) Make drains treatment zones

Sanitary engineers-turned-pollution managers have a one-size fits all solution – first build underground sewerage network (however long it takes), then connect households to the system (even if there is resistance or delays) and then once the pipeline has been officially inaugurated, it will transport official waste to the treatment plant (built earlier but not working because of lack of sewage). This will be done and pollution will be controlled.

So, the question is how the waste – generated in households and conveyed through open drains and then into the river can be cleaned? The drains exist – lead to stench, disease and unlivable conditions. Instead of waiting for the end-day when the drain will be transformed into the storm water carrier it was meant to be and the sewage will disappear mysteriously into underground chambers, new solutions can be found. The drain, open and unhygienic, can be used as a treatment zone. The sewage can be treated in the open drain, intercepted in the open drain and then conveyed for after-treatment to the already built sewage plant. This is not to say that this open-air treatment will clean sewage and turn it into drinking water. But it will certainly reduce pollution and also turn the drain, from a stinky and dirty sewer to a planted waterway, which will be part of the city's landscape.

Again, this is not a tired or easy solution. But experiments to clean stretches of drains, using bioremediation technologies have been conducted, with success. The challenge is now to up-scale this approach and to integrate it into the pollution plans of the country. It is also a challenge to compute the costs of this emerging technology and to develop indicators for its performance so that projects do not become new scams, this time in the name of pollution. The bottom line is that the city has to invest in sewage management, but it has to invest to do things differently.(Reference - Report of the Working Group on Urban and Industrial Water Supply and Sanitation for the Twelfth Five-Year-Plan (2012-2017) November 2011)

Environomics - environmental economics of sewage treatment with a changing urban scenario and pressure of clean technologies due to climate change, one is looking for the better option in sewage treatment technologies which are economic, sustainable and eco-friendly. Based on the experience of huge spending in Ganga Action Plan NRCD (National River Conservation Directorate) has strongly recommended using energy less methods to treat sewage. The ecotechnologies are much cheaper than energy intensive conventional mechanistic sewage technologies. It is normally observed that conventional systems cannot deliver as desired, if not properly maintained with designed electric supply and skilled man power. (SERI news, 2009)

As for the existing treatment system the treatment process can be selected as per the output requirements but even with the most sophisticated treatment facility, a recycle and reuse of the treated water is must, as it will not only reduce the fresh water demand but also will reduce the sewage generation. The idea of target specific and tailor made solutions are important for prevention of pollution in local water bodies. Also awareness among people for the proper maintenance of public water bodies is of at most importance and social and cultural differences should not come in its way.

II ECOTECHNOLOGIES

Core of ecotechnological treatment system is based on ecosystem approach. Conventional systems generally exploit elements of nature - a few groups of microbes supported by infrastructure, energy and chemicals for degradation of waste matters while ecotechnological treatment systems rely on ecological interactions and biological improvement in natural web of life.

Natural streams, rivers and lakes have their own in - built purification system which is comprised of biotic – abiotic factors such as winds, natural slopes, stones for biological growth and complex food web help in the purification process. This food web is nothing but utilization of one's waste by another as it's own food. Nature has her own living machinery of detritivorous microbes and other living species to consume wastes. These principles have been harnessed in the treatment of polluted streams using STAC (Saprobic Trophic Absorption and Cycling) system comprised of grafting of

ecotechnological horizontal eco-filtration – green bridges.

Detritus food chain in the nature has capacity to assimilate sewage constituents and transfers them into ecological cycles of nutrients. There is need to bring paradigm shift in design concepts from calculable concentration models and performance criteria to ecosystem approach of using detritus induced complex food chain and nutrient cycles. Use of ecological processes in treating and assimilating nutrients from the sewage reduces capital as well as operational costs substantially. Conventional treatment systems reduce carbonaceous BOD only but remaining COD and non-carbonaceous BOD then lead to permanent undesirable changes in ecosystem of receiving water bodies. This can be evaded by use of ecosystem approach and ecological engineering to treat the sewage to convert into ecologically corrected water. (SERI news, 2012)

There is two types of actions involves in the natural system, one is consumption of pollutants as nutrient source in detritus food chain while other is to use of wastes generated from this process are useful for green plants growth .

The scheme involved application of ecological engineering to remove organic and inorganic pollutants from the water and to utilize them as nutrient in the ecological cycles. Green Bridge is developed using filtration power of cellulose / fibrous material with stones. All the floatable and suspended solids are trapped in this biological bridge and the turbidity of flowing water is reduced. Green plants on the bridges increase the DO level in water, which in turn facilitates the growth of aerobic organisms, which degrade organic pollutants.

Vegetation being significant ecological elements of any landscape, biomass and diversity play key role in ecosystem dynamics and global cycles. Vegetation is a biological sink for atmospheric carbon (CO_2), as 50% of their standing biomass is carbon only.

Applications of ecological engineering principles, environmental chemistry, microbiology, interactions of organisms and succession of biological communities are very useful to consume organic and inorganic pollutants from the wastewaters and bioconvert them into non-toxic form, finally transferring the elements in the ecological cycles. These eco-transformations, eco-conversions and degradation or bio-utilization of pollutants - nutrients are the part of ecological cycles - biogeochemical cycles. In the ecotechnology, attempt has been made to apply natural flora and fauna in well-designed manner to develop technologies like Green Bridge, Green Lake Eco-Systems, Green channel, Biox (biological oxidation) and Stream Eco-Systems.

III ADVANTAGES

(a) Availability of pollution-free water for non-consumptive use
(b) Clean water for agriculture reducing the accumulation of toxic metals into crops and grains, thereby improving the production efficiency, quality and price
(c) Increased biodiversity
(d) Improvement in groundwater quality over a period of time
(e) Control of nuisance insects and odour
(f) Improvement in healthy environmental conditions for the population in the adjacent areas
(g) No failure of system due to breakdowns and non-availability of electricity
(h) Site for the ecological tourism and education

Though ecotechnology is comparatively new option, polluter has got a very cost effective technique to control the pollution and convert it into resources. Ecotechnology harnesses bio-powers to assimilate anthropogenic wastes into ecological cycles without putting demand for man-made electricity. Conventional waste management systems need a lot of electricity which in turn does not become a candidate for carbon credits. But, ecotechnological treatment units having multiple uses like carbon sink, reduction in use of electricity and minimizing release of methane like GHGs are more useful in getting carbon credits at international levels. These techniques are more useful for the developing countries which cannot afford the cost of sophisticated mechanized auto control techniques to manage the waste.

While talking about the various process parameters for studying performance of the treatment system, the significance of Dissolved Oxygen (DO) as indicator of quality of treated water. Maintaining the proper level of DO in the local public water body not only signify the quality of water, but also plays a significant role in sustaining the entire food chain depending on the water body, which will also improve the overall aquatic ecosystem.

Assessment criteria will involve ecological – ecosystem quality indices, health indices and socio-economic parameters. These indices shall be involved in order to cost futuristic trends for reforming action plans, resetting targets and revisiting policy principles.

IV CASE STUDY I

Ecological Restoration of Rasoolabad Stream Complex on the banks of Ganga River, Allahabad (Patil, 2012)

Rasoolabad is cremation Ghat also known as Chandrashekhar Aazad Ghat is situated on banks of holy River Ganga in Allahabad UP. Rasoolabad stream complex was group of 3-5 slender lined-unlined streams. It passes through settlements (Jhondwal, Rasoolabad, and Mehdori Colony) near Rasoolabad Ghat and carries the raw sewage and domestic effluents from the residential complexes and drain into the River Ganga.

Ganga Seva Abhiyan is complete peaceful and non-violence movement under the devotional guidance of Swami Avimukteshwaranand Saraswati ji (disciple and representative of Sri Shankaracharya Swami Swaroopanand Saraswati ji Maharaj). The main object of this Rasoolabad Stream Complex was to prevent the drainage of industrial waste and human pollutants flowing into holy Ganga River along its long flow line. With clear intention of making Ganga River free of pollution, Ganga Seva Abhiyan decided to take up some demonstration projects on five selected nallah treatment using ecotechnology treatment system, so they invited Shrishti Eco-Research Institute, Pune to design and implement the restoration of 5 polluted streams in Rasoolabad Area. It was implemented by Green Infrastructure as per the design given by Shrishti Eco-Research Institute.

Each stream traversing through dense population joined Ganga River, emptying in it a huge quantum of pollution. Each stream/drain became brownish/black coloured and emitting foul odour because of city wastewaters and massive solid waste disposal. At all sites, it is observed that due to lack of oxygen and absence of biodiversity of phytoplankton and zooplankton, anaerobic degradation makes water unsuitable for any type of use. Overall organic load in the Rasoolabad stream complex was about 3 tons per day (50 – 60%% is biodegradable by conventional methods), and load of suspended solids is about 2.16 tons per day.

(a) Ecological treatment system installed under Rasoolabad Stream complex -

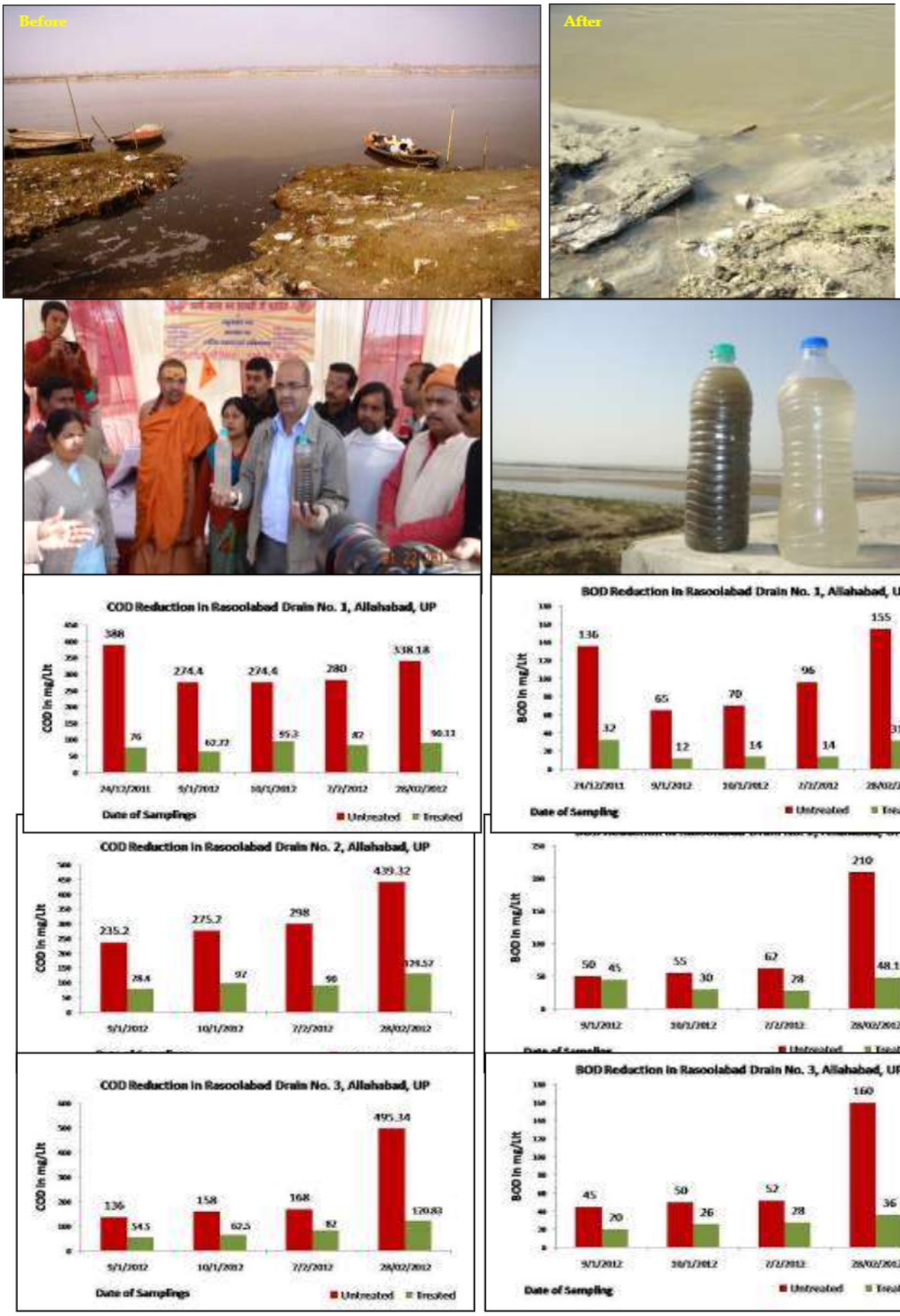
(i) On three line drains – green rolls in different structures were installed to sustain the high velocity of flow and wetland for the streams having flow in the range of 0.5 – 0.8 MLD
(ii) Zero electricity, no skilled maintenance and in-built eco-equilibrium of bio-degradation and bio-absorption processes using green rolls, and wetland systems
(iii) Combination of plants and bacteria for eco-remediation of Rasoolabad stream complex

Eco-restoration project at Rasoolabad stream Complex shows improved water quality of nallahs. Reduction in TSS and Colour improves physical appearance along with Increased DO. Biodiversity status along nallah premises also gets improved. Social engineering helps to create public awareness regarding environment issue and bound locals to project. This is the unique ecorestoration project that shows the effective consortium of saints, technology and localities with mandatory permissions from government. Important point to be noted about ecorestoration by ecotechnology is very low maintenance and low capital cost that it improves water quality by 70-80% without electricity and. which may act as filler that was ignored in Ganga action plan mainly the unavailability of electricity and improper waste management systems.

Some important highlight of the project -

(i) Social engineering of local residents & cooperation from women to reduce the plastic waste in drains
(ii) Support from local administration to provide bins to collect everyday's solid waste
(iii) Control of foul odour & black colour in the drains
(iv) Reduction (50 – 90%) in pollution draining into Ganga River by 5 waste streams (Graphical presentation given below)

The quality of water of drain is clearly visible in photographs of before and after installation of ecological treatment system in below fig.-



V CASE STUDY II

Ecological Restoration of Udaipur's Ahar River (Kodarkar, 2010)

Ahar River is flowing through Udaipur city, Rajasthan (I) and its non-monsoon flow is 150 MLD (Million Litres per Day). Ahar River was highly polluted due to enormous discharge of untreated city's wastewater and industrial wastewater into the river. It affected the ecological

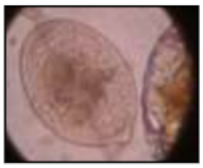
health of river and downstream water reservoir - Udaisagar Lake - a source of livelihood of villagers. The river water was not suitable for any activities also lost its biodiversity and developed bad odour due to anaerobic degradation. There was no suitable water quality for survival of any aquatic organisms as well as river 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 micro invertebrates (2) (Kodarkar and Joshi, 2010)

A Udaipur based non-government organisation - Jheel Sanrakshan Samiti (JSS) initiated ecorestoration project by creating social awareness of the masses to support this river restoration programme with technological support and guidance by experts of Shrishti Eco-Research Institute (SERI) of Pune - a research organisation having experience of 16 years in the ecotechnological systems for point and non-point sources of pollution.. This project was funded by Udaipur Chamber of Commerce and Industries (UCCI).

The treatment site was selected before the confluence with receiving water body i.e. Udaisagar Lake to install ecotechnological based treatment units for water purification and revival of ecological health of river. Ecological restoration activities started with removal of aquatic weed water hyacinth mingled with non-biodegradable plastic material at a selected point 10 km downstream of Udaipur. One screen made up of MS with anti-corrosive painting shall be installed upstream of Kanpur Pulia. The treatment scheme is comprised of Six horizontal in-situ eco-filtration system - Green bridges (2 Near Kanpur Pulia and 4 Before Sukha Naka Bridge) were developed in the course of river in a distance of about 1.6 km. Green bridges were seeded with mixed bacterial cultures helpful in treating organic and inorganic wastes and local green plants were grown to support the activity of microorganisms symbiotically.

The reviving self-purification capacity of the Ahar River was increased by improved level of dissolved oxygen up to 8 ppm in the river previously which was zero. Dissolved oxygen content also increased multifold triggering growth of aerobic organisms. This resulted in exponential increase in phytoplanktons and zooplanktons which attracted the subsequent trophic levels including fish as toxicity of wastes neared to zero. It is a bio-indication of reduction in pollution levels in Ahar River. The entire river stretch got its life again with return of turtles, snakes and increased number of bird species in and around the river.

Change in Ahar River after installation Green Bridge shown in following pictures -



Microscopic Picture of zooplanktons and phytoplanktons

On-site testing of water carried out by CPCB Team, They noted that D.O Level was 8 ppm of treated water while before Green Bridge installation it was zero.

Foam reduction before and after implementation of Green Bridge system

Analysis of Ahar River
Dissolved Oxygen of sample water at various depths and locations
Sample taken between 1.40 pm – 4.30 pm

Sr. No.	Sampling Station	Left Bank			Middle			Right Bank		
		0.1 mtr	0.25 mtr	Bottom	0.1 mtr	0.25 mtr	Bottom	0.1 mtr	0.25 mtr	Bottom
1	Before screen	7.6	7.1	6.3	6.4	5.2	NA	7.3	6.2	NA
2	After screen	10.6	10.2	9.8	10.3	10.2	9.8	10.1	9.7	7.4
3	After Green Bridge 1	10.8	9.7	NA	11.2	10.9	NA	7.9	7.6	NA
4	After Green Bridge 2	10.7	10.1	NA	7.9	6.7	NA	8.6	8.4	NA
5	After Green Bridge 3	11.2	10.9	10.6	7.8	7.6	6.7	10.2	10.1	NA
6	After Green Bridge 4	10.8	10.4	9.4	10.3	10.2	8.9	10.5	10.4	NA

Transparency of river at various locations

Sr. No.	Sampling Station	Unit	Transparency
1	Before screen	cm	12.6
2	After screen	cm	14.9
3	After Green Bridge 1	cm	15.4
4	After Green Bridge 2	cm	17.6
5	After Green Bridge 3	cm	21.5
6	After Green Bridge 4	cm	24.2

Important point to be noted about ecorestoration of any water bodies by ecotechnological treatment systems are very low maintenance and low capital cost that it improves water quality by 70-80% without electricity which may act as filler that was ignored in Ganga Action Plan mainly the unavailability of electricity and improper waste management systems.

VI CONCLUSION

(a) The role of eco treatment is supplementary, complimentary for the existing or upcoming treatment facility; as it will enhance the efficiency as well as it will make the entire treatment process more eco-friendly by reducing land and energy footprint.

(b) Acknowledgement and encouragement of eco-treatment for city drains being zero energy footprint, negligible space footprint, eco-friendly process

We require cost effective and sustainable solutions like ecotechnology that not only corrects water ecologically but also saves energy and improves biodiversity and help water body to regain its self purification capacity along with benefits for people attached with water body. Ecological treatment can give economical and sustainable treatment option to make waste water reusable. This ecologically corrected water will be more beneficial for agriculture, landscaping etc.

REFERENCES

[1] Central Pollution Control Board "Performance Evaluation Of Sewage Treatment Plants In India Funded Under NRCD" (August 2013)

[2] Kodarkar, Mohan and Joshi, Sandeep (2010) ILBM impact story – ecological restoration of highly polluted stretch of Ahar river, Udaipur and ecological improvement of Udaipsagar lake, Rajasthan, India. Presented in Final review meeting and international symposium of a project entitled "Intengrated Lake Basin Management (ILBM), Basin Governance, Challenges and Prospects", Nov. 2- 7, 2010. International Lake Environment Committee (ILEC) Foundation, Headquarters, Kusatsu, Japan.

[3] Joshi, Sandeep (2008) Use of ecotechnology for sustainable management of the lakes. In: Souvenir of ILEC-IAAB Workshop on Integrated Lake Basin Management (ILBM), Hyderabad. India. Pp. 55 – 60.

[4] Joshi, Sandeep, Joshi Sayali paper (2008) Ecotechnological application for the control of lake pollution. In: Proceedings of TAA2007: The 12th Wrold Lake Conference organized by Ministry of Environment and Forests, Government of India and International Lake Environment Committee, Japan. Pp. 864 – 867.

[5] Joshi, Sandeep (2009) Technology Documents submitted to Central Pollution Control Board, Ministry of Environment and Forests and Planning Commission, Government of India.

[6] Joshi, Sandeep & Joshi Sayali (2013) Pollution: Point and Non-Point Source Low Cost Treatment. In Encyclopedia of Environmental Management; S.E. Jorgensen, ed. Taylor & Francis: New York, 2013; Vol. III, 2174 -2189

[7] Patil, Pallavi Agre, Pradnyesh Salaskar Pramod and Joshi Sayali (2012) Water Quality Assessment at Rasoolabad Stream Complex Eco-restoration Project, Allahabad, UP, India paper presented in International Conference Anthropogenic Impact on Environment and Conservation Strategy held at Ranchi, Jharkhand

[8] SERInews Vol. 3 No. 7, March, 2009

[9] SERI news Vol. 6 No.8, April, 2012

[10] www.nyop.unep.org; www.unep.or.jp