Restoration of Nag River in Nagpur Region

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Abstract— Nagpur is a city in the central part of India in Maharashtra State. Nagpur district is located between 21°45' N to 20°30' N and 78°15' E to 79°45' E. The adjoining districts are Bhandara on the east, Chandrapur on the south, Amravati and Wardha on the west and in the north shares the boundary with Madhya Pradesh. The Nagpur district is located in the Deccan Plateau region of Maharashtra. The city is practically located at the geographical centre of India. In fact the zero milestone of India is in this city. Bakth Buland Shah, the founder of Nagpur city, decided to start the settlement along the river in early 18th century. The expansion took place on both sides of the Nag River. Nag River flows through the city Nagpur which covers 50 km length of city. The name of Nagpur city has been derived from Nag River, which is also known as Orange city for being major trade centre of oranges. Nag River originates from Ambazari Lake which is situated at upstream of Nagpur city. Nag River ecosystem is subjected to human interference and anthropogenic activites like discharge of untreated sewage and industrial effluents of 420 MLD of capacity flows through the river and makes it dark gray in colour and emanates foul smell during non-monsoon period. The length of Nag River around city boundary is 17 kms and this river basin is called as central zone. It is located at west part of city and it flows into Kanhan River and from there it is confluenced with Gosikhurd Project situated at village Gose Tah. Pauni Dist. Bhandara. The untreated sewage is either percolating to ground or routing to natural water bodies. Holistic planning for Sewerage infrastructure requires survey and investigation, population projections, estimated sewage generation, existing infrastructure and obstruction features. The preparation for proposed sewerage infrastructure improvements includes analysis of attributed information to develop optimized designs. This includes selection of suitable materials of construction, techniques for implementation of new components and rehabilitation/augmentation of existing infrastructure along with efficient operation and maintenance. The concerned executing agency of Nagpur, Nagpur Municipal Corporation (NMC) has taken various initiatives including preparation of a Sewerage Master Plan for river. sewerage infrastructure development must include sewerage connectivity to all households, rejuvenation of natural drains, rejuvenation of rivers and alternative source of non-potable water to attain improved hygiene, better standard of living and low mortality rates. Nagpur Municipal Cooperation (MNC) is responsible for providing potable water and sewerage facilities. NMC has taken remarkable initiatives with key approach towards structuring and development of Nagpur's rivers sewerage infrastructure. The purpose of this thesis is to present a Green bridges are an ecotechnical in situ bio remediation system. Their different physical and biological filters work in combination to remove suspended and dissolved impurities of water. Green bridge filters help in reducing the suspended solids by filtration process, reducing Chemical Oxygen Demand (COD)/Biochemical Oxygen Demand (BOD) by aerobic degradation. Green Bridges also help in the restoration of ecological food chain.

Keywords: Restoration of Nag River, Nagpur Region

I. INTRODUCTION

Rivers, integral parts of human civilization. Progress of civilization, growing urbanization and apparent decline in direct dependence of human being on river systems has contributed to changing perspective of use of river resources. Rivers are viewed as source of water and sediment, which are minable economic goods. Interfering within river's domain has a long history, perhaps as old as human civilization itself. Today, many of the world's rivers and catchments are degraded due to intensive human impacts including damming, diversions, storages, clearing of vegetation and other habitat removal, leads to introduction of invasive species and pollution. The damaging effects to aquatic ecosystems through these changes have long been known and demonstrated and it is nowglobally well recognized that the rivers are under stress. Human development has resulted in a significant decline in the health of rivers globally. This is in turn impacting the many benefits that rivers provide to society that is 'ecosystem services'. Population growth, urbanization and climate change, among other factors, are expected to place further pressure on river ecosystems over coming decades. 'River restoration' is now a common response to declining river health and its importance to water resources management can only be expected to grow. River restoration includes any action aimed at improving the health of a river, including improving ecosystem function and any related ecosystem services. River restoration is necessary where river systems have degraded to the point where they can no longer provide the services required of them. Restoration may be triggered by ecological considerations, social and cultural factors, economic drivers, the need to protect infrastructure and assets from water-related risks and, increasingly from the multi-faceted objective of achieving 'water security'. River restoration is an important part of the water resources management system. It can assist with balancing the needs of people for freshwater ecosystem services withanthropogenic pressures on river ecosystems. This requires an understanding of the relationshipbetween the way a river functions and the demands and impacts people have on the river.

A. Challenges for modern river restoration

River managers face significant challenges in restoring river ecosystems. These challenges include:

1) Returning rivers to a natural state is not feasible in most situations.

Traditional approaches to river restoration have relied on the use of natural rivers as a benchmark.The degree of change in river basins around the world means that in many cases returning rivers to a pre-development condition is now physically or economically impractical.

2) Balancing the multiple roles of a river.

River restoration is now often required to achieve multiple objectives, by balancing the natural functions of the river with specific human needs, which can require trade-offs in the planning process.

3) Complexity and scale.

Many restoration projects have failed as a result of tackling issues at the wrong spatial scale, often failing to consider basin-level processes. Operating at a larger scale requires consideration of a greater number of issues, engagement with a wider range of stakeholders and linking to a wider range of planning and management instruments.

City of Nagpur has experienced very fast urbanization during the past 50 years. Exponential and rapid rate of growth has resulted in increased use of water which has increased generation of sewage. Settlement of population has been along the rivers cited above. Resulting wastewater is not being treated adequately thereby resulting in discharge of untreated waste water into these rivers thereby causing

- Deterioration of quality of receiving water and
- Disturbing the eco system.

II. AIM AND OBJECTIVES

- To make a Green Bridge Technology proposal for restoration of Nag river.
- To develop a plan for sustainable restoration of the Nag river.
- To undertake the eco-restoration of the river in such a manner that it can be considered as the pride of the city.
- To improve the aquatic and streamside habitants.
- Planting of shrubs and grass helps in absorption of soluble substance, including heavy metals and helps in regeneration of aquatic life.

III. REVIEW OF LITERATURE

A. Rosgen (1998)

Stated that the width and depth of the bank full channel, flood plain width, meander pattern, and the riffle and pool spacing and slope are based on dimensionless ratios taken from a stable reference reach The goal of this project was to demonstrate the successful use of natural channel design techniques to restore a degraded coastal stream. The objectives are to reduce the rate of erosion by restoring the stream to a natural balance or dynamic equilibrium, and to improve the aquatic and streamside habitats. Rosgen priority 2 was selected for the restoration design, as the historic floodplain area needed for a priority 1 was not available to construct a new channel. The anticipated benefits of this project include a reduction in the amount of sediment and associated nutrient inputs from erosion, improvement in habitat and aesthetics of the stream, and it will serve as a model for possible restoration of other streams in the North Carolina Coastal Plain.

B. Doll et al. (2000)

Mentioned that natural channel design involves rebuilding natural stream characteristics, including a properly sized bank full channel, adequate floodplain width, meanders, riffles, and pools. The area and discharge of the bank full channel are based on the existing condition survey and validated using regional curves.

C. Barbara A. Doll et al. (2001)

Studied about two natural channel design restoration projects on urban streams in North Carolina. Rocky Branch is a highly degraded stream located on the NC (North Carolina) State University campus in Raleigh, N.C. Phase I of this project involves restoring 3000 feet of creek using natural channel design concepts. In addition, the project includes innovative storm water controls to improve water quality, riparian buffer restoration, and construction of a greenway path. Pine Valley is a first-order tributary on a golf course in Wilmington, N.C. This previously ditched channel has been re-meandered through the golf course, increasing stream length by 30%. This project represents the first natural channel design restoration for coastal North Carolina and will serve as a model for further restoration on the golf course. Both designs addressed adjustments to morphologic features, including riffle-pool sequence, bank full channel dimension, floodplain width, meander geometry, sinuosity and slope.

D. Gerald A. Gibbens et al. (2001)

The San Luis Valley Water Conservancy District has implemented the Rio Grande Headwaters Restoration Project in the San Luis Valley of Colorado to develop an overall master plan for restoration of the Rio Grande from South Fork through Alamosa. The project goals include maintenance of channel and overbank capacity, protection of the channel and floodplain from damage by flooding, maintenance of riparian habitat, delivery of interstate compact commitments, and maintenance and improvement of irrigation diversions. In order to evaluate the river's historical, current and potential ability to fulfill these functions, technical evaluations of geomorphology, hydrology, hydraulics, floodplain management, riparian health and aquatic habitat were made. The final overall river plan varies from reach to reach and also contains components outside the study area. Localized alternatives include standard river stabilization structures such as bend way weirs, consolidation of diversion structures to minimize required "hard points" on the river, and modifications to hydraulic structures within the river and floodplain channel. Regional watershed alternatives include erosion control at upstream sediment sources, modified land-use practices along portions of the river corridor, and modification and enforcement of floodplain regulations. Use of the multi criteria decision analysis approach allowed the Technical Advisory Committee to play an integral role in developing a "vision" for river improvements, which led to recommended river improvements to meet varying goals along different reaches of the river.

All of the stakeholders along the Rio Grande Headwaters corridor recognize the importance of the river to the San Luis Valley's economy and livelihood. Although many of the varied river uses are often conflicting, the TAC realized that a healthy river system has many of the same traits, regardless of the specific use being considered, and returning those traits and maintaining them is important to all uses. The multi objective analysis allowed all of the various decision criteria to be thoroughly analyzed and considered in the decision making process with appropriate weighting. The use of GIS provided a spatial means for performing technical evaluations, organizing and displaying data and displaying results. Specific alternatives to address the river problems identified were developed through an analysis that combined a numerical evaluation of the river reach conditions with a non-numerical evaluation of the needs in each sub-reach. Through the joint planning effort, an overall plan for restoration, enhancement and maintenance of the Rio Grande Headwaters corridor for all of its varied uses has been developed. This planning document will serve as a means for obtaining funding for future large projects and as an overall guide for existing and future smaller projects. As restoration of rivers becomes a more widely funded practice, the importance of organizing and prioritizing individual river improvements within an overall watershed framework will become greater.

E. Terence M. Browne et al. (2004)

Observed the Chicago River, like other urban waterways that were once filled with sewage and utilized for only sanitary purposes, is now an invaluable resource allowing commercial ships, tour boats, water taxis and recreational vessels to operate in balance with stretches of river-walks and riverfront cafes. As the historical development of the Chicago River typifies, a single form of waterway utilization may have been prevalent in the past; however, the future brings a demand for multiple forms of waterway utilization. Whether the primary utilization of a waterway in the past was solely for sanitary purposes, commercial shipping, passenger travel hydraulic and mechanical operations, drinking water supply, recreational boating, or waterfront observing, waterway managers and civil engineers must plan and regulate for additional forms of waterway utilization to minimize possible conflicts in the future. It is imperative that municipalities realize the economic and social importance of combined waterways for the future. Commercial shipping is obviously an essential utilization for many downtown communities. Nonetheless, recreational activities and community programs stabilize and unite an urban society. Furthermore, riverfront cafes and commercial tour boat and nighttime cruise vessels attract unique economic opportunities within downtown areas. The combined utilization of a waterway greatly increases the attractiveness of a city to the citizens and tourists, as well as that of industrial, commercial, residential, recreational and transportation related businesses. Increased utilization of a waterway creates immeasurable direct and indirect economic growths for a city. However, utilization conflicts must be resolved with appropriate planning, educating and regulating.

F. Drew C. Baird et al. (2012)

Stated about wide range of methods from which practitioners can select a preferred or preferred combination of applications to accomplish habitat and river restoration objectives. River and riparian zones have wide variability. Thus a geomorphic and ecological process approach is best to determine and evaluate the physical and ecological processes at a reach scale, which are essential for project success. Methods that work best with geomorphologic process can be identified and evaluated. Other applicable methods provide local change to the geomorphic process to meet project goals. Maximizing sustainability and reducing future requirements should be a consideration in all cases. There is a general lack of guidance and criteria to evaluate methods, assessing methods should be done within the broader context of geomorphology, environmental, engineering, and economics (cost). Method characteristics to evaluate include ecological benefits and effects, geomorphic response, advantages, disadvantages, range of applicable river conditions, implement ability and cost. The types of standards to evaluate are cost, environmental effects and benefits, social effects and acceptability, and physical or other constraints.

Channel restoration and stabilization methods are used on rivers for a variety of reasons. An extensive literature review has been conducted to identify a suite of methods. For each method there is a description of the general range of application, method objectives and benefits, features, common modes of failures, common countermeasures if needed, advantages/disadvantages, geomorphic response, ecological benefits and effects, design or implementation requirements, level of reliability, potential construction issues, design criteria, peak flow criteria, durability, and project life. A combination of methods usually provides optimum benefit. The methods evaluated for this compilation are briefly summarized in the following sections.

A compilation of methods is being prepared by Reclamation to provide a summary document for restoration professionals to identify initial alternatives for evaluation and to relatively compare and contrast methods for a particular set of watershed conditions, habitat, river morphology, management objectives and implement ability. Sufficient information will be provided to assist with screening potential alternatives to determine which methods will receive a complete analysis including hydraulic modeling of channel response, and habitat evaluation. The advantages and disadvantages, purpose and benefits, and installation requirements will be documented.

G. Shashank Shekhar et al. (2016)

Mentioned river rejuvenation is an effort aimed at restoring poor health of overexploited and polluted rivers. It requires an understanding of the causes for the poor health and the restoration efforts from source to sink (ICFR 2014). Depending on the level of deterioration, river rejuvenation aims at a new sustainable healthy river ecosystem. This can also be achieved by restoring the river health back to an accepted historical state of the river. A schematic drawing (Fig. 3.1) shows importance of monsoon environmental flow in a non-glacial fed river. During the monsoon season a typical effluent stream (Fig. 3.1A) inundates and deposits sediment load charged with flood waters in the river bank (Bank storage) (Fig. 3.1B). The monsoon season peak flow in the river also inundates adjacent flood plains and recharges groundwater under appropriate condition (Fig. 3.1C). This in the long run maintains the slope of groundwater table towards the river. During the post monsoon seasons the same river initially receives contribution from the bank storage. This continues till the groundwater table elevation in vicinity of the river diminishes to the regional groundwater table slope. Henceforth, the regional groundwater flow charges the river and sustains its flow. In the monsoon, if proper environmental flow in such rivers is not maintained then the river flow contribution from the bank storage may diminish. This will also reduce flood plain inundation and recharge to the aquifers. This in turn will reduce the regional groundwater table slope towards the river, leading to flow variability in the river. It is quite possible that river would lose longitudinal connectivity during the summer season. In case of such deterioration in river health; a proper environmental flow during the monsoon season would lead to the rejuvenation of the river. It is required that measures based on the understanding of river ecosystem coupled with environmental flow should be integrated in the river rejuvenation efforts.

The need of the hour is environmentally sustainable development of river resource. A process- based understanding of the river ecosystem will facilitate sustainable exploitation of this resource. The environmental flow concept helps us in deciding the sustainable limits to river resource development. The planners and policy makers should integrate the concept of environmental flow with water resources development strategy.

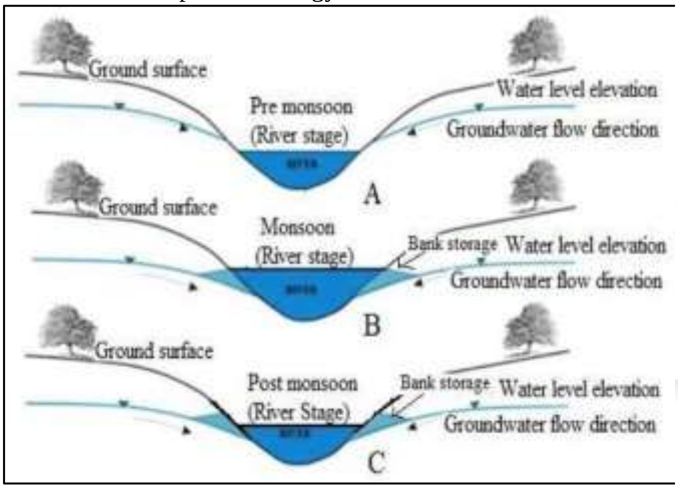


Fig. 3.1: Schematic model showing importance of adequate monsoon environmental flow in a non-glacier linked river

H. Raman Kumar et al. (2017)

Observed Government of India has taken various initiatives with an objective to make the holy rivers pollution free. This requires a systematic and holistic strategic plan involving a large number of stakeholders to accomplish the vision. Technical Assessment study for pollution abatement in the holy rivers from one of the heritage towns has been carried out. The Technical Assessment included analysis of a condition assessment survey (CAS) of affected natural drainage system, sewer network, pumping stations, rising mains and sewage treatment plant along with disposal system. The condition assessment of existing sewerage and affected natural drainage system of the city has been carried out and attributed in GIS platform. Various alternatives were planned and designed considering augmentation, rehabilitation of existing or proposal for new assets in lieu with centralized and de-centralized systems. Government of India is systematically developing a strategic plan involving a large number of stakeholders to achieve the vision of River Ganga Rejuvenation. AECOM carried out Technical Assessment study for pollution abatement in River Yamuna under Ganga Basin from two heritage towns namely Mathura & Vrindavan. Condition Assessment study of existing sewerage system including Sewage Treatment Plant, Sewage Pumping Stations and associated structures along with the cost benefit analysis for various stipulated options. The most economical option from centralized & de- centralized for both Mathura and Vrindavan areas were analysed.

Decentralized solutions are more cost-effective than centralized solutions, even after considering the opportunity cost of land. Interceptor sewer and associate works in the centralized solutions are very costly. The option includes multiple locations of sewage treatment plants at Vrindavan and Mathura. A total of six (6) STPs are proposed for this option which includes two (2) existing sewage treatment plants. All WSP based sewage treatment plants are utilizing large land areas. Approximately 23.4 hectares of land can be release by installation of new sewage treatment plants in place of WSP. The value of this land can be used as an opportunity cost.

I. Vikram Soni et al. (2018)

Mentioned Indian rivers are monsoon rivers which have deep and wide floodplain aquifers that run for thousands of kilometres and serve as an enormous natural storage for water. They get recharged by the river flow and floods, especially during the monsoon period. They feed groundwater aquifers in their environs. Given the increasing scarcity of water, the rivers are likely to be one of few perennial water resources of the future. If not polluted by human intervention, the water in a river is the best water. In the millions of years of flow the river has washed down salinity and other contaminants to give good quality 'mineral water', which makes the river a special and vital survival resource. Priority must rest in the sustainability of all the ecological services the river provides. Care has to be taken to avoid injury to the catchments, floodplains and the basin by overbuilding dams, canals and from the discharge of pollutants into the rivers. For this, environmental flow is required to maintain ecological integrity of a river as a perennial resource.

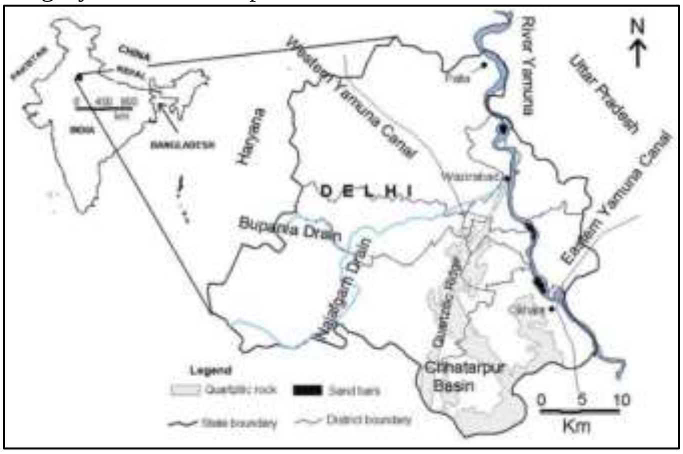


Fig. 3.2: Location map of river Yamuna

Author has attempted a detailed analysis to work out a genuine ecological flow that can maintain the health of a river and all its natural functions. Our finding is that a river needs close to 50–60% of the total flow to be safeguarded as free flow, regardless of the season. Briefly, during the monsoon, 50% of the free flow is needed for efficient soil transport (to avoid silting of the riverbed) and during the non-monsoon period, 60% of the free flow is needed to avoid algal choking. Since rivers in India are Monsoon Rivers, setting a single norm of 50–60% of the total flow as free flow, all year the round, would be appropriate for most rivers.

J. Parikshit P. Mudholkar et al. (2018)

Said sustainable development in a river basin requires the information of the interrelations between urbanization, river basin ecosystem and climate. It also requires the learning of the instruments and systems accessible for better arranging and administration of a river. It is required to frequently screen, oversee and safeguard urban stream bowls to control their corruption. (Satyavati Shukla, Mohan V. Khirea, Shirishkumar S. Gedama 2003). Urbanization is one of the most powerful and visible anthropogenic forces on Earth. With rapid urbanization and economic development, Nagpur has experienced significant change in population and other socioeconomic indicators. Urbanization has also created serious environmental problems in Nagpur, including its climatic and ecological effects and environmental pollution. There is a need for integrated governance, better institutional mechanism in the form of interdepartmental co-ordination and sharing of information and resources for the successful implementation of projects and effective restoration of the quantity, quality and ecology of the river. Through the development takes place with urbanization but it should be in planned manner. Increased population close to river definitely disturb and intervenient the channel. Thus people residing besides the river have bad impact on civil structure as well as on human health and ecosystem. The impact can be seen up to 400mts from the river banks on both sides.

IV. STUDY AREA OF NAG RIVER

City of Nagpur is named after the Nag River. Nag River originates from a lake called Ambazari, which is located to the west of Nagpur City. Please see Figure-4.1 (layout of Nagpur city). Catchment of Ambazari Lake was the present MIDC area and also some area beyond. Hence recharge of the lake was perennial. Overflow of lake constituted the river Nag.

Nagpur city has a Municipal Corporation and is the Sub Capital of the State of Maharashtra. Population of Nagpur city is about 27, 00,000 as per 2001 census.

Water supply to the Nagpur City is about 520 MLD and sewage generation is around 420 MLD. Nagpur Municipal Corporation has inadequate infrastructure to collect and treat the entire sewage generated from the city. Civic bodies have not been in a position to develop adequate environmental infrastructure for protection of environment resulting in increased pressure of environmental degradation primarily due to discharge of untreated / partially treated into the Nag river parts of Nag river basin. This river is grossly polluted and river water is unfit for any use.

Deteriorated water quality of the Nag River can be responsible to affect water quality at Gosikhurd Dam. This dam is constructed on Wainganga River at Gosikhurd, Dist.Bhandara (Maharashtra) Substantial quantity untreated sewage is being released into dam water via the Nag & Kanhan rivers. These have large hydraulic load of the untreated sewage.

Fig. 4.1: Nagpur City Map

V. NECESSITY OF NAG RIVER RESTORATION

Nag River can be divided into three river stretches from their origins. The stretches are from Ambazari Lake to Pardi Village, second from various localities of Nagpur town namely Shivaji Nagar, Ramdaspeth, Dharampeth, Civil Lines, Dhantoli, Indira Nagar, T.B. Ward, Chandan Nagar, Siraspeth, Reshimbagh, Bagadganj, Bhandewadi in the city up to the Pardi village. Pardi to the confluence with Kanhan. Nag River starts from Ambazari Lake's over flow weir at Western End of the City and run through the Middle of the City to the Eastern Part of the City. Nag river acts as the storm water drainage for west (part), south, central & east Nagpur. Total length of Nag River is 17.00 Km up to the city limit. Its width ranges from 12 to 40 m and depth varies from 2 to 4.5 m. Total length of Nag River up to the confluence with Kanhan River at Agargaon is about 68 Km. Growing concern for maintenance of water quality in Gosikhurd storage and for the eco system along Nag river and also for general environmental status of Nagpur city has been discussed at various levels including the legislative assembly of Govt. of Maharashtra. Also the Hon'ble High Court of Mumbai, Nagpur Bench has taken cognizance of this issue of pollution of Gosikhurd dam water due to discharge of untreated sewage through Nag river in particular and other sources is general from within Nagpur city. Therefore, it is the need of the day is to try to restore the status of water in these rivers along with its wholesomeness as per the best designated use.

Fig. 5.1: Present appearances of Nag River

VI. METHODOLOGY

Green Bridge technology uses the filtration power of biologically originated cellulosic/fibrous materials in combination with sand, gravels and the root systems of green plants. It's an innovative approach minimizes the cost of pollution treatment. The cellulosic/fibrous materials, like coconut coir, dried water hyacinth or aquatic grasses are compacted and woven to form a bridge/porous wall-like structure that are strengthened by stones and sand. All of the floating and suspended solids are trapped in this biological bridge and the turbidity of flowing water is reduced substantially. The green plants growing there help absorb soluble substances including heavy metals.

Fig. 6.1: schematic diagram of green bridge technology

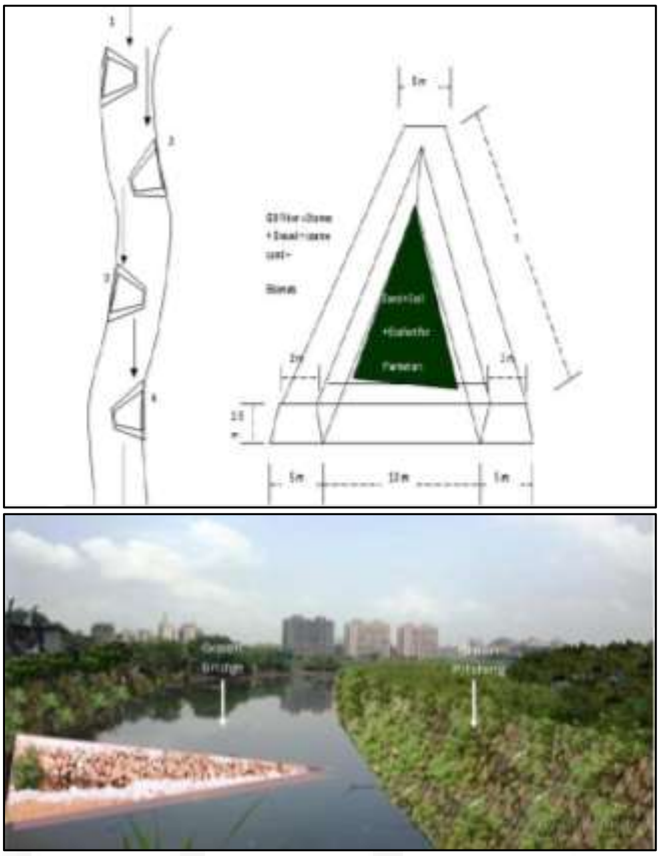
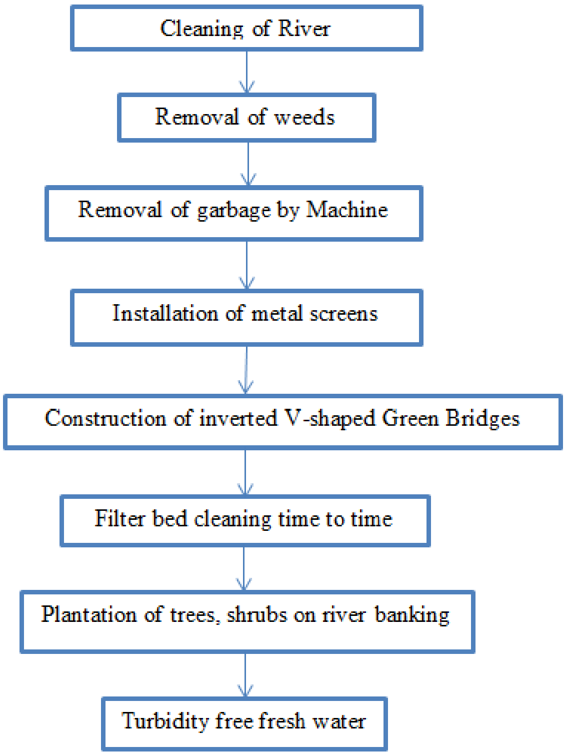


Fig. 6.2: sectional view of green bridges"

This is unlike conventional systems which require power, chemicals and machinery. In this venture energy source is sun, air and they synthesize their own chemicals and assimilate. There is no comparison of expenditure at all. Green bridge technology is a technique of in situ bioremediation the technology used for river restoration.

Green bridges acts as filters. They remove all the floatable and suspended solids are trapped in this biological bridge and the turbidity of flowing water is reduced substantially.



First the river was cleaned. All the weeds were removed. The garbage in river was removed with the help of machines. Two metal screens are installed at upstream of the bridges to prevent the solid waste entering into the system. In this technology a stone wall with gaps is constructed in the polluted river and this wall is covered with natural fibrous material like mat of coconut husk. This wall made from natural materials the technology involves building alternate inverted-V shaped stone structures across the given length. Stone wall with gaps was constructed in the river and this was covered with turf or mat made up of coconut husk which is quite porous. This stone wall and coconut turf act as a filter and prevented the carrying away of polythene and other floating material in river. These filters are cleaned from time to time by removing all trapped floating material. The inverted V is covered with cloth made of coconut husk. A mix of microbes and bio-chemical solution is then poured into it and covered again with coconut husk. The water flowing through these structures carry the solution down the river cleaning up all heavy metals deposit in it. The wastewater passes through the green bridge filter which is a combination of coconut coir mats, sand, gravel and boulders. The floatable and suspended solids are trapped which reduces the turbidity of flowing water substantially. Microbial bioremediation process by Ecofert reduces the organic and inorganic content present in the wastewater. The river banks were strengthened by planting trees and shrubs those are also major component in treatment of waste water. Trees were planted on the bank of the river.

Plantation of local grasses, lemon grass, *Typha* etc. was done to aid the treatment process. The green plants help in absorption of soluble substances, including heavy metals. Cannas are planted on both the banks of the river which acts as natural sponge for sewage and waste.

The river was impregnated with culture and aerobic microorganisms which could act as decomposers or detrivores. The microorganisms digest organic waste and decompose the dead organic waste of aquatic animals and plants. The treatment scheme comprised six green bridges at a stretch of 1.6 km at river. The green bridges varied from 12 to 14 meter, depending on the width of river. The bridges are of varying length depending upon the width of the river at selected site.

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's an innovative approach to minimize the cost of pollution treatment when the cellulosic / fibrous materials like coconut coir or dried water hyacinth or aquatic grass are compacted and woven to form a bridge / porous wall like structure strengthened by stones and sand.

VII. ADVANTAGES:

- Treat Effluent and sewage waste
- Does NOT require electricity, machinery, chemicals, extra landmass, regular dosing and skilled labors.
- Odorless and generate zero hazardous waste
- Less investment, minimal operation and maintenance cost
- Eco-restoration that also promotes local tourism
- 100% control of mosquitos and flies
- Single stage process with tailored made solutions
- Restores aquatic life and surrounding ecosystem

VIII. RESULTS

1) The results started coming within one month of the installation process.
2) The foul smell started disappearing and aerobic conditions began setting up.
3) The quality of water in wells around the river course improved. Even cattle started drinking the flowing water.
4) The physical, chemical, and biological examination of water before and after of green bridges showed great improvement within one month of the installation of green bridge system.
5) The dissolved oxygen increased and biological oxygen demand and chemical oxygen demand reduced. The bridges withstood the onslaught of monsoon and floods. Only the bridges positions had shifted slightly.

- Solids control : 40–80% reduction
- Pollution control : COD/BOD reduction – 40–90%
- Fecal coliforms control : 50–100% reduction
- Eco toxicity : Nil
- Dissolved oxygen : Increased by 150% – 1200%
- Aquatic species :
  - Increase in plants/plankton – 200%
  - Increase in micro-invertebrates – 200%

6) A multifold change in population of avifauna, terrestrial plants along the riverbanks has been noticed.
7) There is an overall odor and mosquito reduction and improvement of river aesthetics.

8) Increase in health status of aquatic life in lentic-lotic system by reduction in Eco toxicity of pollutants.

IX. CONCLUSION

There is an emerging need to restore Nag River in order to conserve the water resources and maintain the ecological balance of the river. The various steps for rejuvenation are as under:

- To capture the entire sewage and convey it to sewage treatment plant, treat it and to discharge safely.
- Closing illegal activities of industries, slaughter house and dhobi Ghats.
- To prevent discharge of untreated industrial effluent and sewage into river water.
- The technology of green bridge is a well suitable for treatment of sewerage generated which is discharged in the river.
- The expected outcomes of this pilot project would be that it would help control odour, provide better aesthetics to the riverfront and also control plastics and other unwanted floatable materials.
- The project would facilitate natural aeration and bio-control of pollutants and filter suspended solids as well as contaminants, which would reduce to about 55-80%.

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