FRAMEWORK FOR REJUVENATION OF RIVERS

Minor Project Thesis

Submitted by

AMIT

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CERTIFICATE

I hereby certify that the project work entitled **"Framework for rejuvenation of Rivers."** carried out by Mr. Amit, M.Sc. (Climate Science and Policy), TERI University, New Delhi isan authentic record of work carried out by him during May 23, 2015 to July 20, 2015 undermy guidance.

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ABSTRACT

Rivers are the most significant resourceof inland surface water supportingmajority of terrestrial and freshwater ecosystem and natural processes. With advancement and improvement in lives of human beings, the natural environment and specially water system has suffered largely. The effects are seen in quality, quantity, geomorphic, hydrologic, and ecologic aspects. To restore the natural flow and health of river, rejuvenation programs have been promoted. The program has attracted both scientific community and policy makers to initiate the Nobel work. Thepresent research focuses on discussing possible and existing problems and explains the cause and indicators of such problems. Most of the studies are carried out keeping in mind only one or two aspects, while hear, all of them have been compiled to have a holistically view of understanding the real problem. The aim of the study is to develop a framework where each type of problem is addressed and studied so that most suited, logical and natural solution can be suggested if rejuvenation project is to be carried out. The solutions which aresuggested are creating a riparian buffer. It is one the best solution because it improve ecology and geology of rivers and also protect the river from pollution. Streambank Stabilization is important for improvinggeomorphology of streams, artificial structures like- A-jacks are made for protecting rivers from erosion they also provide good habitat to aquatic species. In India most of the rivers are seasonal to maintain the flow of these riversrain and flood water harvesting is also good solution.

1. INTRODUCTION

1.1 General

River is a natural stream of water flowing in a channel to the sea, a lake, or another river. A river begins at a source, it's usually confined to a channel, made up stream bed between banks.It is a part of the hydrological water cycle. The river channel is derived as a single stream of water but some of the rivers flow are interconnecting with streams of water. Waters generally collects the precipitation through drainage basin from surface runoff and river. Likewise other sources such as groundwater recharge, springs and the release of stored water in glacier.River has been classified in many criteria including topography, biotic status, and their relevance to white water rafting or canoeing activities. Rivers carry water and nutrients to the earth surface. It provides excellent habitat and food for many of the earth's organisms.

Rivers play an important role in the lives of the people. They are source of fresh water and provides water for irrigation, transportation, electricity, and the livelihoods for a large number of people. This easily explains why all civilization and cities are located near rivers. Rivers also considered holy and play vital role in Hindu mythology.

Table :1Life Support Services Provided by Rivers and other Freshwater Ecosystems

Ecosystem Services	**Benefits**
Provision of Water supplies	More than 99% of irrigation, industrial, and household water supplies in the world comes from natural freshwater systems.
Provision of food	Fish ,mussels,clams, and other such important food sources for people and wildlife
Water purification/ waste treatment	Wetlands filter and break down pollutants, protecting water quality
Flood mitigation	Healthy watersheds and floodplains absorb rainwater and river flows, reducing flood damage

Drought mitigation	Healthy watersheds and floodplains and wetlands absorb rainwater, slow runoff, and help recharge groundwater
Provision ofhabitat	Rivers, streams, floodplains, and wetlands provides homes and breeding sites for fish, birds, wildlife, and numerous other species
Soil fertility maintenance	Healthy river floodplain systems constantly renew the fertility of surrounding soils
Nutrient delivery	Rivers carry nutrient rich sediment to deltas and estuaries, helping maintain their productivity
Maintenance of coastal salinity zones	Fresh water flows maintain the salinity gradients of deltas and coastal marine environments, a key to their biological richness and productivity
Provision of beauty and life fulfilling values	Natural rivers and waterscapes are sources of inspiration and deep cultural and spiritual values ; their beauty enhances the quality of human life
Recreational opportunities	Swimming , fishing, hunting, boating, wildlife viewing, waterside hiking etc.
Biodiversity conservation	Diverse assemblages of species perform the work of nature upon which societies depend; conserving genetic diversity preserves options for the future

1.2Aims and objective

i. Review and analysis of literature regarding techniques implemented for rejuvenation of riverand proposed new methods for rejuvenation of river.

ii. For each type of problem (quality, quantity, geomorphology and ecology), mention respective manifestation and solution

iii. Develop a framework with best possible solution for rejuvenation of rivers.

1.3Problem Statement

Rivers are blessing for the humankind and source of fresh water which provides water for many purpose like- for drinking, industrial manufacture, irrigation, municipal uses. In India there are 14 major, 55 minor and numerous small rivers and they carry large amount of water. But when we

see the condition of Indian rivers we find that they are in poor condition. In 2015 CPCB monitor 445 rivers of India and finds that 275 are polluted. The condition of rivers are degrading every day. The spiritual reverence for rivers remains intact. But the physical well-being of the rivers show that we have totally failed in keeping our reverence for rivers. With the increase of urbanization, pollution is also increased. Many source of water pollution which work together and reduces the quality of water. Industries and domestic waste pollutes the rivers. The fresh water is habitat of large number of species but urbanization and industrialization have mounted serious environmental pressures on river ecosystem. Aquatic biodiversity has great aesthetic and economic value and it is largely responsible for maintaining and supporting environmental health. Humans are also dependent on aquatic resource like- food, medicines etc. But many human activities causing aquatic species to disappear at high alarming rate. Runoff from urban area and agriculture land, invasion of exotic species and creation of road, bridges, dams and water diversion have been identified as the greatest challenges to rivers environment and because of this rivers start dying and there is a supreme need for rejuvenation of rivers.

1.4Rejuvenation

The term rejuvenation claims to restore or bring back the living entity to its former healthy and lively state from present damaged state.

A river basin is not just about the river but it comprises of all springs, waterfalls and streams which are present in the main river's vicinity and form a vast water network. Therefore, it is must that the impact and action of rejuvenation plan must encompass all these entities. This is the aim of this study, where not only the length of the river is given importance but the whole drainage area is kept into consideration. The reasons for sufferings of riversdoes not just start at its bank but it may be residing hundred kilo-meter away. The objective of the management and restoration studies should be to curb the root cause of problem and not to cling to the easier mitigation methods. Rejuvenation of river has a wider meaning than what is understood by most of us. It means to take care of all influencing factors adversely affecting the health of the river system along with the main river. It is an amazing fact that to regulate the health the supposedly large entities, even the tiniest creatures like bacteria, algae etc plays a very significant role.

Hence, the prior thing to incorporate in our plan is to consider river as an integrated stem and not just an entity.

The best way to bring back the previous health of the river, we need to cut down as much obstruction as we can and allow the river to main its natural course.

2. LITERATURE REVIEW

(Amy B. Filipowicz, July 2006): Restoration of streams in New York's coastal watersheds on basis of ecology. New York is very rich in aquatic resources because it has 52,000 miles of streams. It is used by people for many purposes like navigation, drinking water, irrigation, thermoelectric, manufacturing etc. Agricultural, industrial and urban activities have increased very rapidly and effect can be seen on aquatic ecosystems.

In 2004 The NYS Department of Environmental Conservation (NYSDEC) monitors water chemistry and benthic macro-invertebrates to know streams condition and they found that 6,000 miles of streams have some degree of water quality impairment. Characteristics of the stream corridor and stream ecosystem function were checked andcauses of stream instability and impairment like-Stream aggradation, Stream-bank erosion, Impaired aquatic habitat, Impaired riparian habitat, Decrease in species diversity, Increased peak flood elevation, Lower water table levels, Increase in fine sediment, Impaired water quality were found. For restoration of streams,many techniques were suggested like Riparian re-vegetation, barrier mitigation, habitat construction and enhancement, stream-bank stabilization, grade control, natural channel design.

(Ian Cowx, Natalie Angelopoulos, Richard Noble, Deborah Slawson, Tom Buijse, Christian Wolter, April- November 2013) Agricultural and urban development, hydropower generation, flood protection, waste disposal, water abstraction and transfer activities generate anthropogenic pressures on European rivers and geomorphology, physical characteristic and in-stream habitat impacted. As a result many restoration project started. Authors seen the success of these projects and also review the objectives were achieved or not. They found that there was large economic investments for restoration but many restoration efforts were failed and objectives are not achieved. Main reasons for projects failure

were:- The root cause of habitat degradation was not found, failed to get support from local people and private organizations, poor project design.

They developed a protocol for restoration project planning. Review of current statues of water bodies and identify the issues affecting the water bodies and select appropriate restoration techniques and monitoring the programs.

Prof. BrijGopal (December 2002) Rivers are very important for humankind. All the civilization were developed on the bankof rivers. In India we have venerated rivers. Rapid growth in human population, agriculture, urbanization and industrialization effect quality and quantity of river water. Indian River system is divided in two parts :-The Himalayan and The Peninsular. Ganga, Indus and Brahmaputra are three main rivers and their tributaries come in Himalayan river system. Eleven major rivers and their tributaries come in peninsular river system. Most of Indian rivers are seasonal and they dry during summer. Himalayan rivers are young and highly prone to erosion and they carry large amount of sediments.

Human affect the rivers in two ways : -Storage, abstraction, diversion and channelization of water for many purposes like agriculture, grazing, drinking, hydropower and domestic, industrial wastes are discharged and immersion of idols and religious offerings into rivers.

Riparian zone, physical structure, water quality, water quantity of rivers are effected by human activities. Construction of buildings, temples, ghats, slums near rivers, disposal of solid wastes, intensive agriculture and grazing, mass bathing, river transport, wallowing of cattle are activities which need to be regulated.
Four river regulation zones are created on the basis of these factors :-climate, geomorphology, hydrology, ecological and social-cultural. Solutions were given on the basis of these four zones.

PinakRanade and Y.B. Katapatal Total suspended solids (TSS), Total dissolved solids (TDS), Biochemical oxygen demand (BOD) and Chemical oxygen demand (COD) parameters are taken and find the health of Nag River. On the bases of these parameter wattages were assessed. On the bases of these wattages qualitative analysis of Nag River carried out. GIS based

map is prepared for Nag river urban watershed which shows where the river is Very Highly Suitable and where is unstable.This approach helped out to put water treatment plants.

Prof. Rajiv Sinha, Prof. Pritee Sharma, Vikrant Jain, Dr. Tuhin Ghosh, Prof. David Sear, Prof. Paul Whitehouse, Dr. Patrice Carbonneau, Dr. Patrice Carbonneau, Phil Duddell, Robin Newman (March 2013)

Project aim is to develop a web-powered information portal which give information about river basin and which is interactive and freely accessible. Many meetings were held with Relevant Stakeholders. Climate change models are developed for knowing the effect of climate change. Groundwater modeling, Pollution dispersion modeling and Agricultural modeling is also done. System dynamic model is developed which support in decision making and policy formulation. A risk scenario framework is developed and rule based model is developed which identifies river monitoring requirements for given scenarios.

Bruce Newton, Dr. Catherine Pringle, Ronald Bjorkland (December1998)

Authors made a protocol to assess the health of stream by observing biological and hydrological conditions of streams. Each element which was assessed rated with a value of 1 to 10. In case of channel condition assessment, if channel is natural and no dikes, structures and down-cutting then they valued 10. If channel is actively down-cutting and there is channelization and dikes or levees than it valued 1. Riparian zone, Bank stability, Nutrient enrichment, In-stream fish cover, Invertebrate habitat, Canopy cover, Salinity and macro-invertebrates were also assessed.

JitendarSinha, ManojKumarSinha, UmeshRaoAdapa (August 2013)

In 1996 Aravali region was dry and known for its dead rivers. "Tarun Bharat Sangh" create more than 8000 rain water harvesting structure in Rajasthan for restoration of rivers. They create water harvesting structure after finding the flow of runoff rain water. TBS do water conservation and water management in different part of Rajasthan. In this study they try to find out social, economic, cultural, environmental impacts of their work over the years. For finding the impacts they do group discussions with staffs and local

communities, field visits and analysis primary data. Main impacts which they found are increase in base flow of streams, 5 to 15 feet increase in water level of wells, increase in area under cultivation,start in double cropping, increase in production, better food security and health, reduced migration, less drought and flood, increase in flora and fauna.

K.J Collier, A.B Cooper, R.J Davies-Colley, J.C Rutherford, C.M Smith, R.B Williamson (July 1995) The document is taking about riparian zone for restoration of rivers in New Zealand. It provide information abouthow to manage and improve riparian zone and also provide information how river condition and aquatic ecosystem can beimproved through riparianmanagement. It help to understand the environment problems which are affecting rivers and streams of New Zealand. Destruction of native forest,developing agriculture and grazing land effect the New Zealand streams. In New Zealand Many streams and rivers are in bad condition because of change in land use of their catchment. Riparian zone is very important to maintain microclimate, in-stream habitat, sediment lodes, temperature, food webs and biodiversity. In creation of riparian zone riparian vegetation, watercourse size, riparian zone width and time scale are very important.

3. METHODOLOGY

In this report we will see all the parameters and will developed a framework for rejuvenation of rivers.

3.1 To assess the state of the system

This is the first step. In this we do the baseline survey. We see all conditions of elements and relations of these elements with river. We also see direct and indirect effects of these elements on river. The purpose of baseline survey is to know the situation of all elements and their effects on rivers. The elements are

3.1.1 Climate and Weather

Climate and weather directly affect the flow and discharge of river water. It is very important to know about precipitation because the amount and type of precipitation will affect river's discharge. Rain is the main source of river water. Continuous rain for few days makes ground saturated and further rain will flow as surface runoff. Heavy and continues rainfall or melting of snow increase the flow of rivers. Hot and dry temperature bake the soil, so rain water is not soak in and it will runoff. Increase evaporation rates of water surface and transpiration from plants because of high temperature it reduce river discharge. Extreme cold temperature for long period frozen the ground, so water can't soak in.

3.1.2 Drainage basin

Drainage basin is also known as catchment basin or river basin. It is an area drained by a river and its tributaries where surface water from rainfall, melting snow and glaciers converges to a single point at a lower elevation. Drainage basins are local open systems. River quality and quantity both are effected from drainage basin. Size of river basin effect the flow. Amount of pollution is dependent on water which is carried by tributaries.

3.1.3 Stream Flow

Stream flow is the volume of water that flow in specific channel passing a measuring point in a given time. Measuring unit of stream flow is cubic meters per second. The storm hydrograph shows the stream flow of water. The stream flow is directly related to the amount of water moving into the

stream channel. It tells about the quantity of water.Stream flow is also an important determinant of aquatic habitat and water quality conditions. By low stream flow, low levels of dissolved oxygen and deleterious levels of toxins can be exacerbated.

3.1.4River flood plains

Floodplains are the low flat land adjacent to river usually with areas of higher elevation on both sides. This area of land is prone to flooding. Flood plains are normally seasonal. They are an integral part of a river's ecosystem. They are rich in nutrients and they are fertile agriculture lands. Flood carry sediments and spread that sediment to a wide area. Flood plains are complex physical and biological system. They supports a variety of natural resources and they also control erosion. Flood plain represents a natural filtering system, with water percolating back into the ground and replenishing groundwater.

3.1.5 Fluvial Geomorphology

Fluvial geomorphology is also knows as river morphology. The term fluvial geomorphology is used to describe shape of river channels and how channels are change over time. River channels morphology is function of many processes like- composition of banks and beds, vegetation's, availability of sediment, size and rate of sediment transport through the channel, rate of deposition on the floodplain, bars, banks, and bed. River water is running water and important agent of erosion. These all functions effects the quality, quantity and ecology of rivers.

3.1.6 Ecology

Ecology is study of relationships of organisms and their environment, it includes biology and Earth science. The assessment of river ecology is very important. Riparian habitat, in-stream fish cover, invertebrate habitat and aquatic habitat are good indicators of stream health. The health of riparian habitat is one of the most important element for a health stream ecosystem. If riparian habitat is good, it helps to reduce the pollution which comes from surface runoff, fertilizer and pesticides use in agriculture. It also provides food for aquatic habitat and decrease the erosion. Aquatic habitat acts as bio-indicator of stream health. Fishes are also good indicter of the in-stream health. They have major impact on distribution of other organisms.

3.1.7 Water quality

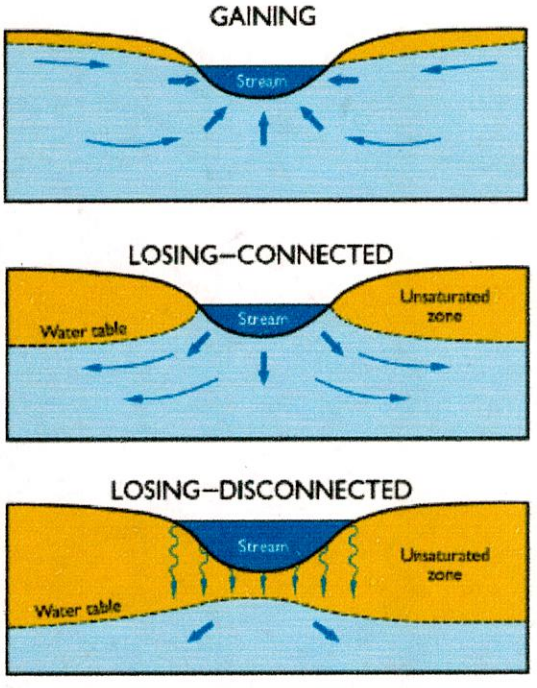
Water quality refers to the physical, biological, chemical and radiological characteristics of water. It is measure of the condition of water related tobiotic species and human needs. In water quality assessment we observe how these factors change over a time. Ph is an important physical characteristics of water. Nitrates, phosphates and salt are important chemical characteristics of water.They are used to measure water quality. Micro invertebrate also tells us about water quality. Different animals have different tolerance capacity in water which helps us to know which type of pollution is present.

3.1.8 Ground water

Ground water is the water which is under the surface or underground in cracks and spaces in soil and rocks. Ground water knowledge is very important because ground water and river water are linked and contribute to each other. The exchange of water is depend on river bed and banks, hydraulic gradient between the river stage, and nearby groundwater levels. There are three process for exchange of water

1. Groundwater level is adjacent to the river and rivers are higher than the river stage and groundwater flows into the river or water is gained from surrounding aquifers.

2. Groundwater levels are lower thanthe river stage and hydraulic gradient is directed away from the river. River water flows into the aquifer and recharge aquifers.



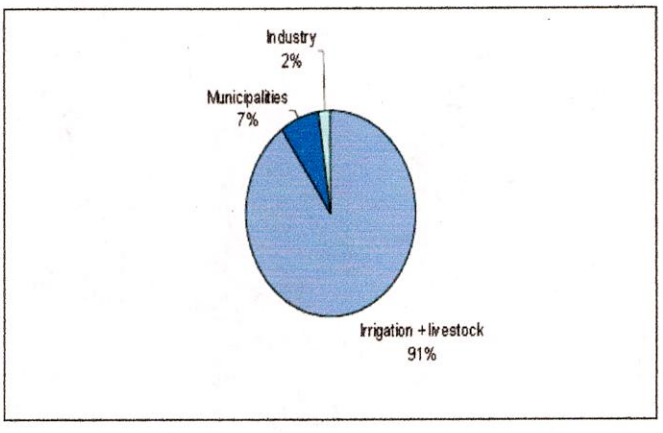
3. The water table is very below the stream bed infiltration of river water is take place through an unsaturated zone and recharge aquifers.

3.1.9 Water withdrawal

Water is one of the basic need and India is a country of large population.That is why the utilization of water is more in India. In 2010 total water

withdrawal in India was 76100 $10^6 m^3$/year. 688000 10^6 m^3/year for irrigation and livestock, 56000 10^6 m^3/year for municipalities, 17000 10^6 m^3/year for industries. In India large amount of water is withdrawal for irrigation (91%), 7% for municipal purposes and 2% for industrial uses. Water withdrawal directly affects the amount and flow of water.

FIGURE 2
Water withdrawal by sector
Total 761 km^3 in 2010



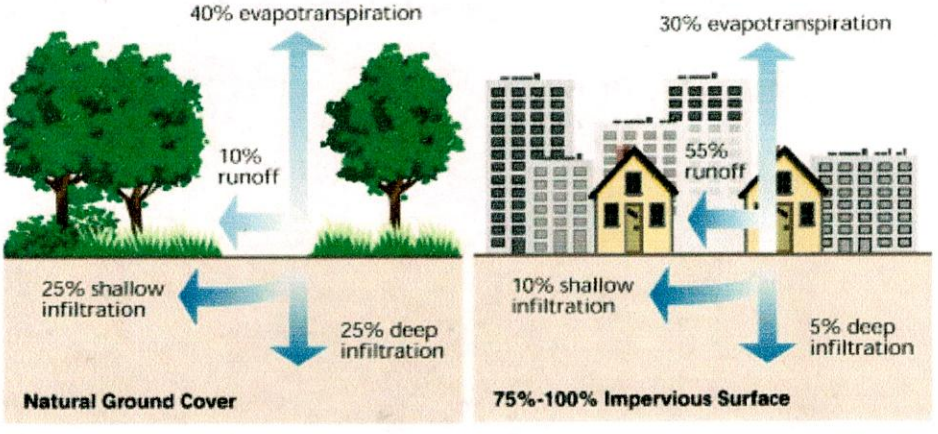
3.1.10 Demography

The study of human population is known as Demography. The baseline survey of demography and support from local people is very important for implication of the plan. Study of human population help us to know that the work which we have done effect how many peoples. Example- if we have put water treatment plant how many people will get benefit from that.

3.1.11 Rock and soil types

Rock and soil type directly effects the river discharge. Water is easily absorbed by permeable rocks and soil like sandy soil, so surface water runoff is less and river discharge becomes high. Impermeable rocks and soil are closely packed, like- clay soil. Infiltration capacity is very less in this soil, so, rain water reaches quickly into the rivers. Porous rock like- chalk have high space between the rock particle and water is easily pass through joints in pervious rocks like- limestone.

3.1.12 Land use



Land useaffects the runoff and infiltration directly and utilization of water is also effected by land use, which effects the quantity of river water. In urban areas roads and buildings are more, means surface is impermeable and large part of rain water waste in runoff. Rural areas is less impermeable that's why rain water easily reaches to the ground. In agriculture area river water is utilized for irrigation. Forest land absorbs more water so runoff is very less and forest land also protect soil erosion.

3.2 To collate information and determine knowledge gaps

3.2.1 Evaporation loss due to increased temperature

In the global water cycle Evaporation is an important process. Water change its state from liquid to gas when radiation of solar hits the surface of water or land and water vapors enters into the atmosphere. Amount of moisture in atmosphere is linked to cloud formation and rainfall. Evaporation acts like an air conditioner because heat is used when water enters into the the atmosphere as moisture, at same time water vapor behave as a greenhouse gas by trapping the radiation in lower atmosphere. As temperature increases so does the process of evaporation. Moisture holding capacity of the

atmosphere is also increases with temperature. 7% increase in moisture holding capacity of the atmosphere for every 10°C increase in global temperature. Change in moisture of atmosphere ultimately leads to changes in rainfall patterns and it effect rivers water. Plants also lose their water through transpiration. Plants leafs are also capture or intercept rain as it falls and water is directly evaporate from leafs before reaching the soil. For all of these reasons rivers are very much effected by evaporation but studies are not consider or talking about evaporation.

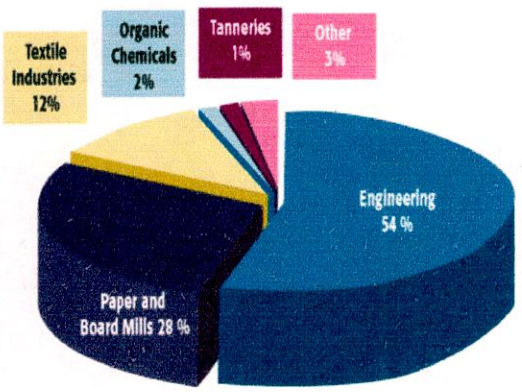
3.2.2 Treatment specific to water type utilization

Water utilization directly affects the flow of rivers but studies are not taking about treatment specific to water type utilization. Water treatment plants are stabilizer for purifying the water which is used by people for many purpose like- drinking, irrigation and other daily uses. Before stabilizing of treatment plants, it is very important to check utilization of water which will be treated by the plants. For example, if water will be used for drinking then tertiary treatment is required, if water will be used for other household purpose then only primary treatment is enough and if water will be used for irrigation then no need to put treatment we can create buffer zones to improve water quality.

3.2.3 No norms for small industries

Pollution is one of the biggest problem in rivers and large amount of waste water is mixed in rivers by industries. In India amount of small scale industries are very big and they pollute rivers. Small scale enterprises in India generate 3900 million liters of waste water per day.

There is no need or requirement of industrial license from the central government to locate a small scale industries in cities with less than one million inhabitants and regulation of these industries is not easy.



Waste water generate by differentsmall-scale enterprises in India

3.3 To obtain better knowledge of problem which require restoration

Understanding and describing the problem help us to determine the causes with the help of this appropriate solution to be derived.In this we see the problem in Indian context. The problems which we are find divide in four parts-

3.3.1 Ecological problems

The main problems which we find in ecology are

a) Aquatic habitat degradation is very big problem in rivers. Rivers, wetlands and lakes contains only 0.01% of the earth's water but these ecosystem support a large part of biodiversity. Freshwater fishes are approximately ¼ of all living vertebrate species and there are 44000 scientifically named species of freshwater biota. But many freshwater species are endangered. World Conservation Union's (IUCN) list endangered species in this list 30% of fishes (mostly freshwater) were considered threatened. Building dams, channelization and agricultural, industrial pollution directly affects aquatic habitat.

Indian Rivers are some of the last global frontiers of rich freshwater diversity, endangered and threatened species. By India's National Biodiversity Action Plan2(p 15), "Nearly 50% of the aquatic plants of the world are recorded from the Indian sub-continent but only a few have been studied in detail." India is a country of rich biodiversity with 650+ freshwater fish species but because of human activities the condition of Indian rivers is deteriorating.

Aquatic animals require different habitats for different stages of their life cycle. Freshwater fish use estuary to breed and then for adult growth they move in upstream. Aquatic insects also need different habitat for their lifecycle. In larval stage many micro-invertebrate drift downstream. Mayfly species live amongst cobbles in fast flowing water as nymphs, spent Adult stage in riparian vegetation and then return to the stream to lay their eggs. Human activities like- urbanization, land use change, channelization, clearance of riparian vegetation, dams construction activities degrade aquatic habitat. Healthy Aquatic habitat is very important for health of rivers

but Aquatic habitat of rivers is not good in present day and the effect of aquatic habitat can be seen on river health.

b) Riparian habitatdegradation

Itis a very big problem in rivers.Riparian habitat is very important for river ecosystem. They are adjacent land and transition zone between upland and water bodies. Riparian area can be comprised of shrubs, forests, grassy meadowsor wetlands. The riparian zone play a significant roles in rivers ecosystem. They provide good stream habitat for fish, provide food resource for aquatic ecosystem, stabilizes the banks, filter sediments and maintain channel. But because of large population in India large amount of food is required on large scale agriculture activities are happening and for the purpose of agriculture riparian zones are destroyed. Because of increase in population, people starts living near rivers and they destroyed riparian habitat. Riparian habitat is degraded by these human activities and impact can be seen on river health.

c) Nutrient enrichment-nutrients, such as nitrogen and phosphorus are required for growth of plants when chemicals are limited plants growth may also limited. Conversely, when water system starts get many nutrients algae and other plants begin to grown a process called eutrophication. Main reason for this problem is that point and nonpoint sources such as sewage treatment works or industrial effluents and fertilizers washed from agriculture. River water is constantly moving that's why nutrient enrichment problem is smaller in rivers then lochs but in dry periods and Lowlands River may be similar to lochs. Nutrient enrichment effects food web, aquatic animal will not get proper light, excess in organic carbon, dissolved oxygen deficits and because of this aquatic habitat becomes unhealthy.

Causes of ecological problem

a)Vegetation clearing

Vegetation clearingis the main cause of ecological problem. Large amount of vegetation is cleared near riparian zone for agriculture and settlement purpose. India is a country of 121cr population large amount of food is required for fulfilling of this requirement large amount of food are produce and riparian zone are cleaned for cultivation. Settlements are also established in riparian zones. That directly affects the aquatic habitat and riparian habitat of rivers. Riparian Vegetation provides food for aquatic

animals and because of clearing on vegetation many aquatic animals dies and river become unhealthy.

b)Channelization

River channelization shows negative impact on aquatic ecosystem. It decreases the diversity of fish, invertebrate and other aquatic animals. Aquatic habitat availability was greater in un-channelized reaches. In channelization large amount of water is withdrawal from rivers and it effects the flow and width of rivers that results into unhealthy aquatic habitat.

c)Pollution

Pollution is main cause of ecological problem. Agriculture waste like-fertilizers and pesticides, industrial waste and municipal waste are main reason of pollution in rivers.

When Agrochemicals, metals, acids type of pollution are high in river they affect the reproductive functionality of fish. **Suspended solids** affects the respiratory processes and secretion of protective mucus making the fish susceptible to infection of various pathogens. Sewage and organic pollutants cause de oxygenation which affects mortality of fishes. Thermal pollution increase ambient temperature and dissolved oxygen because of this some sensitive species were die.

Sufficient level of dissolved oxygen is required for health of stream ecosystem. Fish and aquatic insects require some amount of oxygen in water (typically > 5 mg/L) but because of some pollutions amount of dissolved oxygen is less in water effect seen on health of aquatic habitat. Because of acid rain and industrial effluents acidity is also increase in water which is harmful for aquatic habitat.

d)Sedimentation

Transfer of sediments is primary function of rivers and streams. Because of erosion largeamount of sediments are carried by rivers. The sediments which are carried by rivers are deposit between cobbles and gravels where fish deposit eggs. Because of sedimentation eggs might suffocate.

e)Dams and bridge abutments

Dams, bridge abutments and other water diversion disconnect and siphon off water. Large dams directly impact the biological, physical and chemical properties of river and streams of riparian zone. Dams blocks fish migration and because of this some species separate spawning habitat. Dams also traps the sediments and it affects chemistry and hydrology of water and nutrients are not able to flow downstream.

Indicator of ecological problems

a)Biotic Characteristics

Living organism's composition give information about the chemical and physical condition of the habitat. Biological communities composition is often used as an indicator of ecosystem health. These indicators indicates certain environment conditions.

Macrophytes- macrophytes are aquatic plants. They grow in or near the water. They play important role in balancing ecosystem. These plant have capacity to improve water quality of river by observing nutrients through their roots. These plants are used as an indicators of stream health because they respond to light, nutrients, toxic contaminants, turbidity and water level change. They do not required any laboratory analysis easily sampled through the use of transects.

Periphyton- They are freshwater organisms attached to the plants and above the bottom sediments. Mainly they are aquatic algae. They are good indicator of environmental condition they reacts rapidly on anthropogenic disturbances, contamination by nutrients, habitat degradation, hydrocarbons and acidification. They are used as anindicator because they are naturally high in number , fast respond to change and easy to sample.

Aquatic macroinvertebrates- Macroinvertebrates are aquatic insects, snails, worms and mussels. They live at bottom of streams and other bodies of water. They are integral to the aquatic food web and they are important source of food for many species like fish. Macroinvertebrate community composition is used as an indicator of habitat condition and quality because physical, chemical, and biological conditions of the stream affects them, they are affected by the pollution and show affects of short-and long-term pollution events. We also see the habitat loss impacts on Macroinvertebrate (Viklund, 2011).

Fishes- economically and ecologically fishes are very important. They are also good indicator of streams and rivers condition. For example- water quality of headwater streams is usually excellent when brook trout is present in river. Decrease in brook trout is show that health of an entire stream is at risk(Venture, 2005). Fishes have long historical life and recognized by public that's why they provide a more understandable indicator of environmental degradation.

b)Riparian vegetation and wildlife- Riparian plants and animals are used as an indicator of stream health. Healthy riparian vegetation protect soil erosion and also reduce pollution which is come in form of agriculture fertilizer and pesticide. They also provide food to aquatic animals. Healthy riparian area provide species of resident and migratory reptiles,insects, mammals, amphibians, birds. Riparian vegetation is good indicator and assessment of riparian vegetation is very simple. We can easily meager the vegetation by comparing the site through photos and satellite images. Percentage of large and old trees and density of trees also good indicator to see ability of riparian zone.

3.3.2Geomorphological Problem

a)Fine Sediment:

Sediment is a naturally occurring material which is the result of breaking down processes like weathering and erosion, and is subsequently transported by the wind , water, ice through the force of gravitational force. Fine sediment is a natural component of river system and it plays important role in Hydrological, geomorphological and ecological function of rivers. In most parts, mainly developing countries and countries with low population and urbanization, erosion and sedimentation problem has been associated with deforestation and agriculture of river basin. Around 2200km^2 river basin has been destroyed for overthrusted cretaceous mudstone. Likewise in Minnesota river sediment problem had came from river and its tributaries from suspended solids, largely sediment and transported by metropolitan council ,which is approximately 8620-ton truckloads a day. The sediment problems comes through pollutants also and critical problem of pollutants has been derived from phosphorus. Over Sedimentation can also destroy the spawing grounds and habitat of desirable fish species. Fine sediment can have damaging impacts on all stages of fishes, particularly salmonids. This has been worse for salmonids by a shift in the timing of cultivation,spring to autumn sown cereals, that coincides with their egg's of incubation times.

Salmonid eggs require a well oxygenated environment during the embryonic development stage. But in case of sediment problem it didn't derived because it depletes oxygen from the water due to algae decomposition. So, many problems have been associated with presence of fine sediment of river basin.

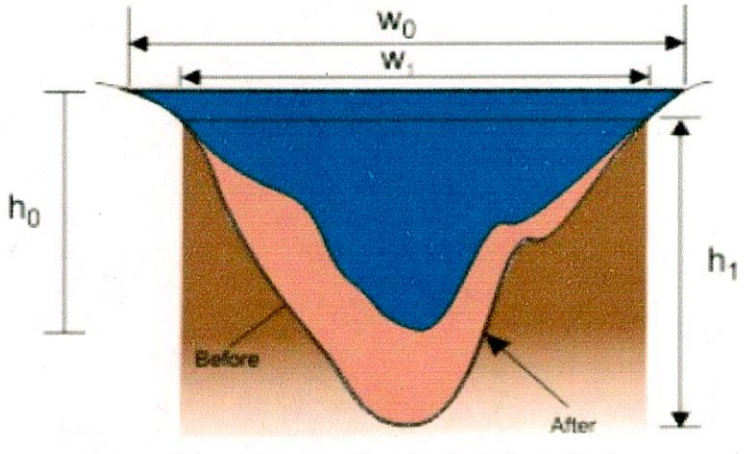
b)Stream bank erosion:

Stream bank erosion is wearing of stream or river physical boundary. It is distinguished from erosion of the bed of the watercourse. The roots of trees growing by the stream are undercut by such erosion. Streambank erosion leads to disproportionate sediment supply, stream channel instability, land loss, habitat loss and other effects. Many landuse activities can affect the erodibility and hydraulic (gravitational) forces that lead to accelerated bank erosion. Indication of streambank erosion is determined by changes in landuse and management that have occurred upstream.

c)Riverbed degradation

Channel degradation refers to the general lowering of the bed elevation that is due to erosion.

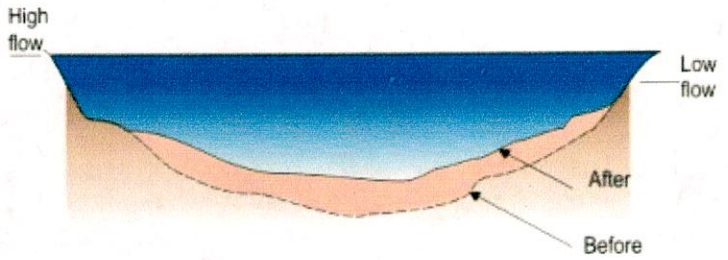
The phenomenon of degradation occurs when the sediment load being transported by a river is less than sediment transporting capacity of the river and the excess sediment needed to satisfy the capacity of the river will be scoured fromerodable riverbed.



River cross section for bed degradation

d) River bed aggradation

When the sediment transporting capacity of a river at a point becomes less than the sediment load being carried, as a result of reduction the velocity due to an increase in cross section or reduction in slope of the river, the excess sediment get deposited on the river bed. As a result the riverbed rises, the phenomenon being termed as aggradation.



River bed aggradation

e)Gully erosion:

Gully erosion is the removal of soil along drainage lines of surface water runoff. It moves from headwater erosion by slumping of the side walls unless steps are taken to stabilize the disturbance.

Gully Type	Modes and condition of Formation	Common advance Mechanism
Base level	Groundwater flow	Slope undermine, slinding and slumping
Scrap	Runoff and slope change	Slope undermine, slinding ,slumping and toppling.
Fracture	Runoff and shrinkage fracture	Collapsing, also block failure
Incidental	Runoff concentration and vulnerable soil exposure by man	Common sliding and slumping.

Causes of geomorphological problem

a)Road construction:

If road cuts and fill slopes are not revegetated during or immediately following road construction, gullies may form on both sides of the road. Inadequate drainage systems for roads. Like , small number of culverts, insufficient capacity of road ditches, etc. This is a major cause of gullying.

Widening operations along roadsides do not often follow road construction but, where widening is practiced, the operation usually causes landslide erosion and then gullying during the first rainy season.

b)Building Dams:

Dams are huge artificial structures storing large amount of river water for generating hydroelectricity, irrigation and other commercial uses. But in long run, dams have overwhelming effects on the course of river in both upstream and downstream. The discussed geomorphological problems are associated with the construction of dams on river channels. Dams degrade the physical channel characteristics, increase the risk of flooding, reduce discharge in downstream areas, affect the ecology of the water, increase sedimentation and erode the upstream banks. Large dam projects are not supported by rivers as they rupture the natural flow of rivers and destroy the lives of inhabitants that regulate the dynamics of streams.

c) Over grazing:

The common attitude of humans is exploitation of the resources without bothering about any future implications or taking the responsibility to restore them, has led to damaging consequences. One of the activity associated with such attitude is over grazing where either we are responsible or not we never care to replant petty grasses and shrubs. Over grazing impacts include soil erosion, disturbing the food web, barren lands, instable biota, and loosening of soil in flooding areas. All these are directly responded by the stream morphology with negative consequences.

Indicators of geomorphological problem

a) Channel condition

Channel condition is the main indicator which tells us about geomorphology of rivers. Active downcutting and excessive lateral cutting are serious impairments to stream function. Both conditions are indicative of an unstable stream channel. Usually, this instability must be addressed before committing time and money toward improving other stream problems. Natural channel, no structures, dikes and no evidence of down-cutting or excessive lateral cutting show condition of river is good. Channel is actively downcutting or widening. More than 50% of the reach with riprap or channelization, dikes or levees prevent access to the flood plain show that condition of river is not good.

3.3.3Hydrological Problems

River hydrology includes studying discharge, channel flow, channel storage, precipitation, infiltration, evaporation, interception, type of vegetation vicinity, runoff, groundwater flow, base flow, flood events and how river interacts with its environment. River hydrological cycle is an umbrella term, which comprises several categories of natural processes such as inputs, outputs, stocks and transfers. That means a number of factors are associated with the river, which affects its existence and survival in a region. However, none of these processes is static but keeps on altering every month, week or every hour. Thus, any unnatural change in these processes and their flows can hamper the health of a river.

The normal state of river is at par when it has sufficient ecology to transport water, energy, and material along its length; it can recharge ground water; provide habitat to aquatic and riparian biota; have natural flooding events; have a sustainable annual base flow and good discharge compared to the cross-sectional area of stream. In numerous studies it has been proved that the there are significant changes and intensification of the hydrological components due to anthropogenic activities and climate change.

a) Frequent flooding

Though flooding is a natural cyclic phenomenon, which is not new to our knowledge but the new thing now is their frequency of occurrence and location of floods. River flood are have positive impact of depositing fertile soils in the flood plain but with increased intensity and occurrence this characteristic is over shadowed. The over shadowing criteria adversely affect natural environment as well as human system. The negative effects can be summarized as channel souring, change in physiological characters, uprooting of riparian vegetation, flood water bring back toxicants and pollutants while retreating and in case of macro-turbulence transport of big boulders may divide the channel, bank erosion and loss of lots of life and property (Baker, 1977 and Kuo, 2015). Thus, an abnormal flood cycle has a potential to create havoc in the system. The effect in river is both physical and chemical.

b) Change in groundwater level

About 50 percent of population is dependent of groundwater for domestic, irrigation, commercial and industrial purposes. Lack of awareness about the consequences of over extraction has resulted in careless usage of water resource. Groundwater contributes to the base flow of many rivers when there is no precipitation or glacier melt (gaining stream). Now the equilibrium has been disturbed as groundwater level has gone down and there is negligible contribution to river. In addition, the flow has reversed causing river water towards ground (losing stream).

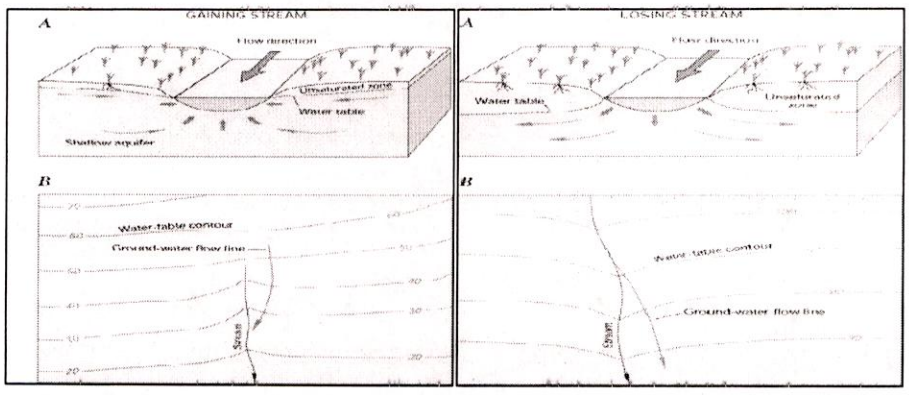


Fig.... Change in groundwater level

Causes of hydrology problem

a)Vegetation clearing-

Plants are vital part of water cycle and ecology. Basic processes of hydrological cycle like infiltration, runoff, evapotranspiration, and ground water recharge are affected by the extent and type of vegetation in the region. The roots of plants direct water to the deeper layer and and water to soil to avoid excess runoff. But the trend has changed and most of the areas are modified to perform agricultural activities which have a temporary existence and instead of conserving water, they are creating a crisis situation. Also, agriculture is a water intensive activity which has resulted in over-exploitation of groundwater. Urbanization and other so called civilized activities are growing and to achieve this natural forests and vegetation are being cleared.

b) Water use pattern-

Disproportionate use of water resource is one of the biggest problem of the society. Water is wasted by using it more than the actual requirement in the regions where water scarcity is not a problem hitherto. Newer water using technologies and lifestyle are efficient in delivering the desired services but

they are not sustainable as they are not in harmony with the nature. Those who can afford have used it as an infinite and free resource which is now costing the unfortunate ones.

c) Climate change

The scientific community believe that he major culprits are climate change and land use pattern change over a few decades. "Alluvial riverbed elevation responds to the balance between sediment supply and transport capacity, which is largely dependent on climate and its translation into fluvial discharge" (Slater, 2013). With climate shifts in stream flow, the sediment flux will be altered and hence changed flood frequency will influence the elevation. This further influences the longitudinal profiles, ecology, river management, and sediment balances. Change in land use patterns has resulted in more settlements and commercial activity in close vicinity of riverbanks. This has created increased land pressure and addition of waste matter in the stream. However, big dams built on river channels also induce the frequent flooding.

Indicator of Hydrological problem:

a) Flood and droughts are more intense and frequent-

We came to know about the climate change and abnormal hydrological cycles when both flood and drought calamities bacame frequent and intense in recent times. The discussed causes came into picture when the effect of these events progressed similarly in many parts of world.

b) Rainfall patterns shift-

A continuous data accumulated over a long period rainfall has shown a deviation from normal trend in various areas over past two decades. It has been observed that the places with normal rain fall are either experiencing an alteration in monsoon arrival, duration and amount of rainfall. In India, the trend is down trading for most of the peninsular regions.

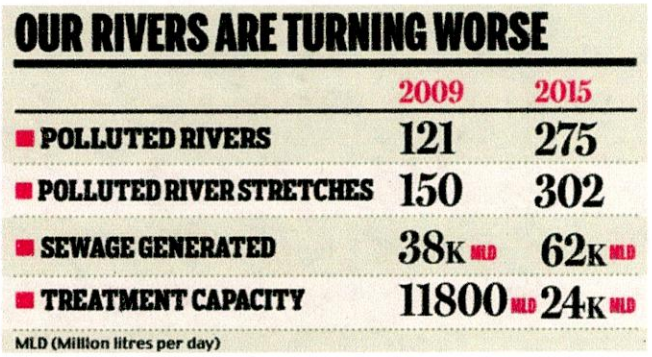
c) Glacier melting-

Scientists all around the globe are concerned about the retreating glaciers and fast glacier melts. Through advancement in remote sensing and geographical information system (GIS) the trends, impacts and caused are predicted to a high level of certainty now a days. This gave a view of what can be the reasons of problems faced river basins and existence of climate change.

3.3.4 Quality problem

a)Decline in water quality (Pollution)

Rivers are main source of fresh water which is utilize for many purposes like- drinking, industrial manufacture, irrigation, municipal uses etc. But many human activities like domestic and industrial sewages and agriculture wastes pollute almost all the Indian rivers. Study shows that most of Indian rivers have turned into sewage carrying drains. In India more than half of the rivers are polluted. Central pollution control board (CPCB) says that the number of polluted rivers in India has more than double in last five years from **121 to 275**. In 2010 the water quality monitoring found that in India most of the rivers have high level of BOD. For example- Markanda (590 mg O/l), Kali (364), Amlakhadi (353), Yamuna canal (247), Betwa (58). CPCB report says that in 2009 polluted river stretches in India are 150 but now they are 302. In 2009, sewage generated was 38000 mld but in 2015 it become 62000 mld. In 2009 treatment capacity was 11800 mld and in 2015, 24000 mld. This shows that water quality of Indian rivers is declining at a rapid rate.



b)High Salinity-

Salinity is the amount of salt dissolved in water. Salt has components which dissolve into the form of ions like- potassium nitrate, sodium bicarbonate, sodium chloride and magnesium sulfate. Salinity is expressed in terms of concentration (mg/L). A new study by Australian and European researchers says that salt level increase in the rivers is a big problem. Salinity poses a measure threat to freshwater river systems because rivers can tolerate only up to a certain level of water salinity. Many factors like irrigation and mining uses salts as de-icing agents for roads that leads to rise in salinity in rivers. Salt interacts with aquatic biota and thus changes the ecological health of

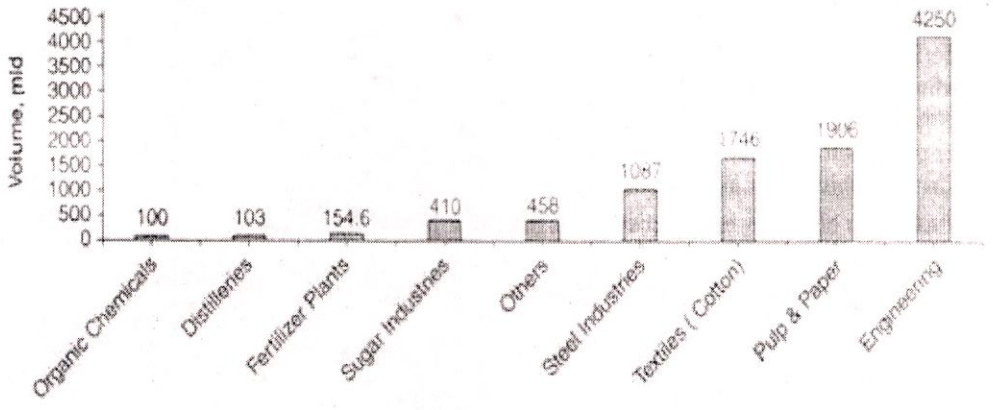
streams. Freshwater invertebrates such as the mayflies, stoneflies and caddisflies are affected by high level of salinity. It also affects the quality of drinking water.

Causes of quality problem

Untreated sewage -A study from year 2007 shows that in India discharge of untreated sewages is the main cause of water pollution. Sewage, garbage and liquid waste of households are discharged into lakes and rivers. These sewage discharge contain harmful chemicals and toxics which make water polluted and destroy aquatic animals and plants. There is a large difference between the waste water generation and treatment of domestic waste. CPCB report says that, in 2009, sewage generates in 650 cities was 38000 Million Litres per Day (MLD) and now it becomes 62000 Million Litres per Day (MLD). Treatment capacity gap becomes broader with 26,200 MLD in 2009 to 38,000 MLD. The problem is not only the requirement of sufficient treatment capacity but also of improper operation of treatment plants.

a) Industrial wastes-

Industrial wastes or effluents pollute most of the Indian rivers. 83,048 Million Litres per Day (MLD) wastewater generated from all major industries. In which 66,700 Million Litres per Day (MLD) is generated from thermal power plants.



Paper mills, steel plants, textiles and sugar industries are main contributors of waste water generation. Both small scale industries

and large scale industries pollute rivers. The increase of heavy metal drains into rivers has resulted in severe river pollution.

b)Agricultural pollution-

Large amount of fertilizers and pesticides are being used in agriculture for high production of food. Running off these pollutants into rivers which are very harmful to the health of rivers as they reduce the dissolve oxygen of rivers and harm aquatic habitat. **Nitrate** is another contaminant from agriculture wastes running off from agricultural fields and emerges as another harmful source of pollution for the rivers.

c) Religious and social practices- Religious and social practices also sometimes co pollute rivers. Animals and cattle carcasses are disposed in rivers. Dead bodies and burnt bodies are flung into rivers. All these activities are done as religious faith. These activities also effect the water quality.

Indicator of quality problems

a) Dissolved oxygen- Dissolved oxygen (DO) is good indicator to measure the quality of river water. DO is amount of oxygen which is dissolved in water. It is measured in milligrams per liter (mg/L) and its expected levels is 4.0 to 12.0 mg/L. Oxygen is necessary for the survival of aquatic plants and animals but less amount of oxygen harms the aquatic plants and animals. Because of the above mentioned activities to the rivers, the amount of dissolved oxygen in water decreases which harm the fish and aquatic organism.

b) pH- pH is acidity or alkalinity measure of water and its hydrogen ion concentration. pH is an important characteristic of water that affects its suitability for aquatic organisms and influences chemical reactions. The ph of water is 7 because water is neutral. Acid rain, agricultural runoff and sewer overflows can change the pH of river water. The limestone soils of Central Texas act to neutralize these acids and often result in a more basic pH. Young fishes and insects are more sensitive to low pH. More acidity or basicity, both condition can be lethal to aquatic organisms. Expected levels of pH in water is **6.5 to 9.0.**

c) Escherichia coli (E. coli)–

It is a type of bacteria which comes from animals and human waste. It is measured to determine whether fresh water is safe for recreation or not. E. coli tells about the presence of disease causing virus, bacteria and protozoa in water. It is measured in number colony forming units of water quality standard by Environmental Protection Agency (EPA). For E. coli bacteria it is 394 colony forming units per 100 mL.

d) Nitrates –

Nitrates are also good indicator for river health. Nutrients are important for the growth of all aquatic animals and plants. Excessive amount of nitrates increases algae and other plants which takes large amount of dissolved oxygen from water and eventually killed fishes and other aquatic life. Source of this nitrates are human and animals waste, industrial pollutants and agricultural wastes. Milligrams per liter (mg/L) is the measurement unit of nitrates. Expected level is less than 1.0 mg/L.

e) Total Dissolved Solids-

Total Dissolved Solids is a measure of the amount of dissolved material in water. It include solutes like magnesium, bicarbonate, calcium, chloride and sodium. Usually TDS level of fresh water is between **0 to 1,000 mg/L**. It depends upon geology, geography, climate and weathering condition of region. TDS is mainly used for study the water quality of streams, rivers and lakes. Primary sources of TDS are agricultural and residential runoff, discharge from industrial or sewage treatment plants and leaching of soil contamination. Harmful element in TDS is pesticides. To analyze movement of TDS within river systems transport models are used.

f)Chemical Oxygen Demand (COD)- The amount of organic compound in water is measured by COD test. COD is a useful measure of water quality. It determine the amount of organic pollution found in surface water. The measuring unit is milligrams per liter (mg/L). It also measured in ppm (parts per million). It indicates mass of oxygen consumed per liter of solution.

g) Biochemical oxygen demand (BOD) - Biological Oxygen Demand (BOD) is very common measure of organic pollutant material in water. It tell us the amount of putrescible organic matter in the water. Good quality water has low BOD, while a high BOD indicates that water is polluted.

Dissolved oxygen is consumed by bacteria when large amounts of organic matter from sewage or other discharges are present in the water. Dissolved oxygen is the amount of oxygen available in the water. If dissolved oxygen drops below a particular level, the aquatic life in that water is not able to live and reproduce at normal rate. The decrease in the dissolved oxygen in the water has bad effect on aquatic life.

4.RESULTS AND DISCUSSION

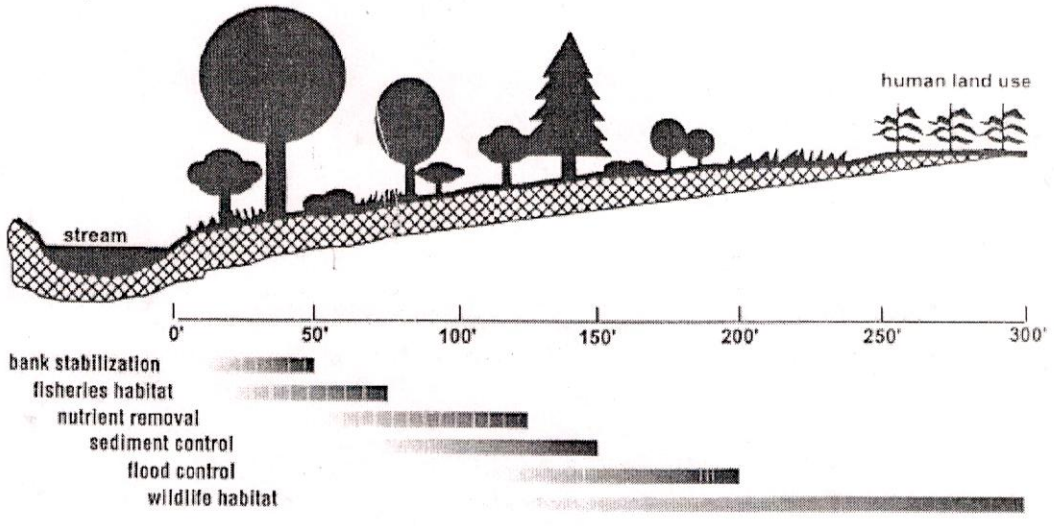
As we know that rivers are the source of life and blessings for the human kind. Rivers play an important role in various application. All the problems were assessed and the cause that affect the rivers life has been identified in the current study. In present day life of river is in critical stage, mass of rivers has been dead. For this concern the framework has been proposed for the rejuvenation the river which are totally dead in condition. In this framework some solution has been suggested.

	Problems	Causes	Indicator	Solution
Ecological	• Aquatic habitat degradation • Riparian habitat degradation • Decrease in species diversity • Nutrient enrichment	• Vegetation clearing • Channelization • Sedimentation • Agricultural and industrial waste disposal • Building dams, bridge abutments • Nuisance plant growth	• Riparian habitat • Aquatic habitat • Presence of exotic species • Micro invertebrates observed • In-stream fish cover	**Buffer zone or Riparian Re-vegetation** **Habitat Construction and Enhancement**
Geomorphological	• Increase in fine sediment • Stream bank erosion • Stream aggradation • Gully formation	• Riparian vegetation clearing • Road building • Bank erosion • Building dams • Overgrazing	• River flow on lower level • Channel conditions • Discharge rate	**Stream bank Stabilization** **Restoration of flood plain areas**
Hydrological	• Floods will more frequent • Change in ground water level • Losing and gaining stream reaches	• Irrigation, agriculture and urbanization • Water uses • Vegetation clearing • Climate change	• Floods and droughts both are more intense • More intense rainfall • Reduction in the mass of glaciers • Rainfall shift	**Rain water harvesting** **Restoration and revival of wetlands** **Design Street drains to collect road runoff**
Quality	• Decline water quality • High salinity	• Agriculture activities, industrial wastages, sewages • Nuisance plant growth • Terrestrial carbon inputs to streams • Contaminant loads	• DissolvedOxygen • Total Suspended Solids (TSS) • Total Dissolved Solids (TDS) • Biochemical Oxygen Demand (BOD) • Chemical Oxygen Demand (COD)	**Sewage treatment plants Bio-remediation**

4.1)Solution For Ecological Problems

a)Buffer zone

"Riparian" means vegetation, habitats, or ecosystem that are associated with water bodies like rivers and lakes. Riparian Buffer is stripes of grass, shrubs or trees along with bank of river or vegetated area near rivers which help streams from adjacent land to use. They are the most effective protection of water resources. Buffer have complex ecosystem that provide habitat and improve the stream condition. Riparian buffers are necessary for rivers, due to their protection of surface and water quality from impacts of human land use. Restoring of riparian buffer is the very important step for water quality, riverbank stability, wildlife and aesthetics of rivers.



Why creating a buffer zone is best solution in Indian context.

It is a soft environment friendly technique. It is also economically benefiter because we only need to create it once, after that it survive automatically. Buffer zone provides lots of services for protection or reduction of ecological, physical and quality problems.

Sediment filter – Riparian buffers serves to both the grass and forest to slow water velocity that helps to catch and filter the sediments and debris which came through surface runoff. Depending upon complexity and width of riparian buffer, 50-100% of sediments are settle out and absorbed by buffer plants.

Pollution filter and sink- Riparian buffers captured and trap large amount of pollution. Nitrogen and phosphorus which came from animal waste and fertilizers, pollutes more if they applied on land than plants because excess amount of phosphorus bond to soil particles. 80-85% of nitrogen and phosphorus is captured by buffer zones. Chemical and biological activities in soil, mainly near riparian forest can capture and transform only some pollutant in less harmful forms. Riparian buffers also act as a sink when excess water and nutrients are taken by roots and store in biomass of trees.

Stream flow regulator - Riparian buffers slow the velocity of runoff water and helps water to infiltrate in soil and improve or recharge the groundwater supply. Ground water reach rivers at much slower rate and over longer time period. Riparian buffers also control flooding and maintain stream flow during dry period of time.

Bank stabilizer - Riparian buffers stabilizes the stream banks and reduces the erosion. Plants roots hold the rocks and soil which help to protect banks by cutting from waves, boat wakes and storm runoff.

Bed stabilizer - Riparian buffers absorbs surface water runoff and slowing surface water velocity which help to reduce the amount of stream bed scour. When plants are removed more surface water reaches to rivers causing water at crest higher during ice melting and storms and scour streambeds effect aquatic life.

Wildlife habitat - Large population of wildlife is sported in riparian buffers because the buffer zone provides many habitat requirements like-water, food, and cover. In riparian buffers different zones of habitat exist vertically including herbs and shrubs, soil-air interface, canopy and intermediate height trees and soil-water interface are insects, spiders, isopods and mites. For reptiles, mice, and birds these organisms are food source.

Aquatic habitat - Riparian buffers are improving aquatic habitat. Type and amount of organic matter which is food source for stream organisms affected by riparian buffer. Buffer zone vegetation affects the amount of sunlight, provide shades and maintain cooler temperature in summers. Cool water hold more oxygen and reduce stress from fishes. Riparian vegetation affects physical structure of the stream like extent of pools and riffles which provide covers for fish and their food supply.

Width of Riparian buffer

Deciding the width of Riparian buffer is very important for reducing pollution and increasing aquatic habitat.

Recommended width of riparian buffer by different authors

Author	Width	Type of buffer	Benefit
Madison et al. (1992)	≥5m	Grass filter strip	Trapped approximately 90% of nitrates and phosphates
Dillaha et al. (1989)	≥7m	Vegetated buffer strip	Removed an average of 84% of suspended solids, 79% of phosphorus, and 72% of nitrogen
Lowrance et al. (1992)	≥7m		Nitrate concentrations almost completely reduced due to microbial de-nitrification and plant uptake
Ghaffarzadeh, Robinson, and Cruse (1992)	>9m	Grass filter strip	Removed 85% of sediment on 7% and 12% slopes
Woodard and Rock (1995)	>15m	Hardwood buffer	The effectiveness of natural buffer strips is highly variable, but in most cases, a 15m natural, undisturbed buffer was effective in reducing phosphorus concentrations adjacent to single family homes
Nichols et al. (1998)	≥18m	Grass filter strip	Reduced estradiol (estrogen hormone responsible for development of the female reproductive tract) concentrations in runoff into surface water by 90%.
Shisler, Jordan, and Wargo (1987)	≥19m	forested riparian buffers	Removed as much as 80% of excess phosphorus and 89% of excess nitrogen
Young et al. (1980)	>25m	Vegetated buffer	25m buffer reduced the suspended sediment in feedlot runoff was reduced by 92%
Lynch, Corbett, and Mussalem (1985)	>30m		30-m buffer between logging activity and wetlands and streams removed an average of 75 to 80% of suspended sediment in storm water; reduced nutrients to acceptable levels; and maintained water temperatures within 1&C of their former mean temperature.
Horner and Mar (1982)	>61m	Grass filter and vegetated buffer strip	Removed 80% of suspended sediment in storm water

Factors influencing buffer width- There are many factors which affects the width of riparian buffers

1. **Slope -** Slope decide the speed of water flow. Therefore, in steeper slope, we need wider buffer because flow of water takes more time to slow down and absorb pollutants and sediments within it.

2. **Soil type-** Type of soil directly affects the water discharge. Water is easily absorbed by sandy soil roots and is not able to effectively trap pollutants.

Soils that are high in clay are less permeable and does not absorb water fast. On a wetter soil, a wider buffer is needed to get the same effect.

3. **Vegetation-** Deciding vegetation type is very important in riparian buffer. In urban and residential areas, trees and shrubs are better for capturing the pollution. In cropland shrubs and grass might be more beneficial. Diverse riparian buffers like mixing of trees, shrubs and grasses and are more effective for capturing of pollutants.

Estimated reduction of nutrient loads from implementation of riparian buffers

Buffer Type	Nitrogen	Phosphorus	Sediment
Forested	48-74%	36-70%	70-90%
Vegetated Filter Strips	4-70%	24-85%	53-97%
Forested and Vegetated Filter Strips	75-95%	73-79%	92-96%

Source: Delaware Department of Natural Resources and Environmental Control

Grass Buffers Removal efficiencies ranges from 61% of the nitrate, 44% of the orthophosphates and 72% of the total phosphorous. Combined grass and Woody Buffers Removal efficiencies are 92% of the nitrate, 85% of the orthophosphates and 93% of the total phosphorous.

Generally, forest buffers are better for nitrate removal from subsurface flows and grass buffers are better for sediments removal.

Plant type vs. removal efficiency

Function	Grass	Shrubs	Trees
Sediment trapping	High	Medium	Low
Filtration of Sediment born Nutrients, Microbe and Pesticides	High	Low	Low
Soluble forms of Nutrients and Pesticides	Medium	Low	Medium
Flood Conveyance	High	Low	Low
Reduce Stream Bank Erosion	Medium	High	High

Source: Jontos 2004 (modified after Fisher and Fischenich 2000)

Table shows that combination of specific amount of grass, shrubs and trees are better for specific problems. Mixing of trees, shrubs and herbaceous plants native to the region is the most effective riparian buffer. Old trees are very valuable for protecting inputs of coarse woody debris. Buffer trees provide an input of leaf and branches that are important for many aquatic

species. Trees have a deeper root system that's why they uptake and trap nutrients from the ground water, stabilize banks and regulate the flow of water. Grasses have shallower and denser root that's why they are more effective in slowing runoff and rapping sediments from the surface flow.

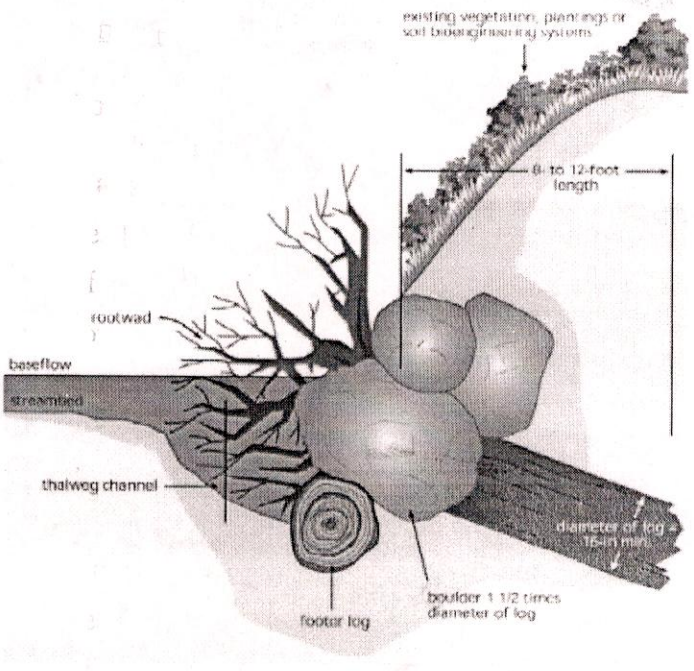
a)Habitat construction and enhancement

Habitat construction and enhancement is very important for aquatic species and it provides better and healthy space for living. Habitat construction and enhancement include the activities to create habitat by directly altering the bed and banks of a stream and also add habitat structures within the stream channel. General caution should be taken before proceeding with habitat construction activity. Materials which are used in construction activities or enhance habitat should be native to the stream. The projects and activities which are designed to be rigid and unchanging over time may interpose with the streams natural recovery process. Anchoring habitat structures prevent them from floating and interacting with the stream channel at different flow levels.

Habitat construction and enhancement activities and projects

Placement of logs, root wads and boulders in rivers

Logs, root wads, and boulders are selectively placed on stream banks. These structure provides good area for resting, overhead cover, shelters for insect and other fish food organisms and provide a surface on which aquatic organism can grows (loyd Reynolds,1991).



Source:Chapter 16 Engineering Handbook, USDA-NRCS 1997

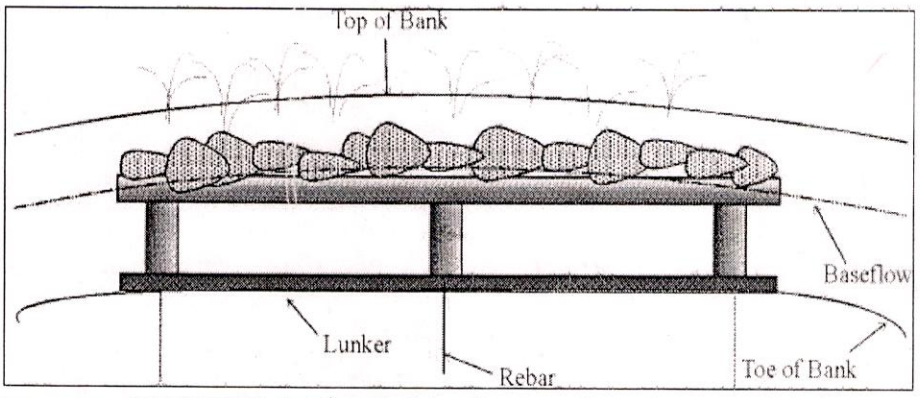
Structure can be made by natural material which is found near site. Take logs of 16" or 406mm diameter that are crooked and irregular shaped, 8-12 ft or 2.4-3.7 m long bole root wads and irregularly shaped boulders which are one and one-half times the log diameter. Put footer log at the base, parallel to the stream bank at the mid-section. For anchor of footer log use boulders. . Excavate trenches into the bank for the root wad boles. The trenches are orient to allow placement of the root mass in a way that faces are slightly towards the direction of flow and brace roots flush with stream bank.

This structure control stream bank erosion in higher velocity streams, Catch the sediments between components, distribute flow velocities, support restoration of slope vegetation, and provide in-stream habitat structure for fishes.

LUNKER

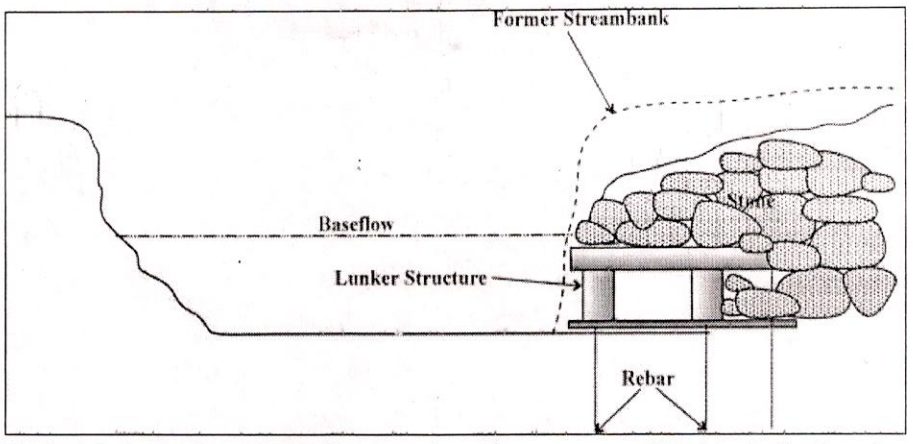
Originally LUNKER was developed in 1982 by Wisconsin Department of Natural Resources. It is a wooden structure which is put along the toe of a stream bank. It provides overhead bank cover and resting area for fishes. LUNKER provides intended benefits if we see something before stabilization like- Stream gradient and flow, Channel substrate and surrounding land elevation, Sinuosity and depth. rough-sawn and untreated woods are used for building LUNKERS. Oak is preferable because of its density and stone is used for providing frame base for LUNKERS.

Section View of Lunker Structure



The structure of LUNKER is installed by first grading the stream bank back and make a trench along the new bank line. This trench are wider and deep so, Lunkers can easily lay flat and covered by water. With the help of rebar lunkers are secured to the stream bottom.

Profile View of Lunker Structure



Once the bunker is placed, rocks are placed on top and behind the bunker and streambank is graded down to meet front edge of lunker.

4.2 Solution for quality problems

a) Sewage treatment plants

When clear water becomes municipal or industrial waste water and travel across to meet large water bodies containing huge quantities of pollutants and toxic substances, such water is called waste water/effluents/sewage water. When such waste water is treated in a treatment plant before being discharged to the natural environment, it becomes biological or ecofriendly .A domestic treatment plant also called as sewage treatment plant basically involves the process of cleaning up the sewage release from industrials commercials and domestic sources.

Sewage treatment plant works similar to a septic tank but technology sound mechanical component provide process to help segregate solid of different size along with breaking down of solid to produce a cleaner, more environmentally and friendly effluent.

Primary sewage treatment tanks are fed with waste water and sewage where solids and liquids separate and the liquor flows into a bio zone chamber and solid into different chamber. In the chamber, pump air it's the waste and bacteria and breakdown organic matter which decomposes as well as purify it up to great extent. Now both the chamber up to humus chamber where effluent is almost 85-95 % clean and is ready to discharge in to local water sources, land , river or canals. That's why sewage treatment plants are very important for protecting the rivers from pollution.

4.3) Solutions for Hydrological problems

a) Rainwater and flood water harvesting- conserving the pure rainwater naturally or artificially to use in the later times or to recharge other natural resources is one the most viable solution to look upon. Harvested water will first reduce the dependence on rivers, lakes and groundwater. Rainwater can be stored in the artificial tanks or natural lakes by collecting the runoff water and directing them to aquifers or rivers. Floods are natural phenomenon which occurs in most of rivers almost every year. The flood water can be slowed down and stored near the rivers by making many small pits on the bank over a few hundred meters of land. In fact, a lake make in depression on bank of river will serve both purposes. Both practices will reduce the surface runoff, enhance percolation of water in ground, provides a good quality water, and decreases problems of soil erosion, siltation and addition of pollutants.

b) Restoration and revival of wetlands- wetlands are ecosystem which have saturated water surface for few months or for the whole year. Their ecosystem services benefit beyond than just improving the quantity of water in streams. The type of floras, faunas and microorganisms develop a dynamic and living system which is far better than a static one. Their prime services include improving surface water quality, trapping the pollutants in surface and subsurface runoff waters, inhabit large number of species of terrestrial, aquatic and aerial birds and animals, restrict flood water to reach the overland areas, provide aesthetic services, and they survive on their own if left undisturbed. Hence, restoring or reviving the wetlands will incur only initial costs while providing a long term positive returns.

c) Design Street drains to collect road runoff- In urban areas infiltration of surface and rain water in ground is very limited and surface runoff are lost by evaporation or other means. However, by improving the road and street infrastructures the surface runoffs can be directed towards the rivers and small streams through specialized drains before they take up pollution loads on its way. This solution can go hand in hand with the developmental scenario of region in a long run.

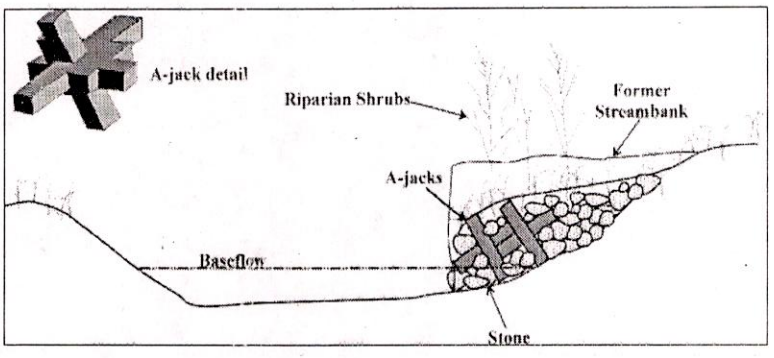
4.4 Solution for Geomorphological problems

a) Streambank Stabilization-

Structures have been placed for hundreds of years at the land-water interface to prevent the erosion and stabilize streambanks. Many materials have been used for stabilization of streambanks like- rocks, concrete, timber, metal sheet piling and tires. For Bank stabilization primarily vegetationor integrate

vegetation with other materials have more effective. Sometimes hard structures like- rock riprap or revetments are necessary for streambank stabilization.

A-jacks



A-jacks are two foot longer cement stakes joined at the middle (six one-foot legs). Commercially they are made concrete product, originally made much larger (10-foot loge) to serve as breakwaters along shore fronts. They serve to add structural stability to the lower stream bank.

A-jacks structure are manufactured by two pipes each weight 45 ilb and assembled onside. The first step in installation is excavating a shallow trench along the toe of the stream bank. A-jacks are assembled and placed in a row(s) near the trench so that each a-jack is interconnected with its neighbor. Rock, geotextile material or coir fiber are placed in the voids between the legs, and the a-jacks are backfilled.

5. CONCLUSION

In this study the framework is prepared through the help of this framework we can rejuvenate the rivers. We see all problems related to rivers and their causes behind this and sagest solution for rejuvenation of rivers. Creating a riparian buffer help to reduce ecological problems of rivers and also control pollution come from non-point sources, Streambank stabilization help to reduce geomorphological problems of river, sewage treatment plants reduce the pollution from rivers and rain water harvesting is very important for maintain river flow. Along this local people sport is also important to do any work on field. There is also need of more laws and policy for controlling rivers from human effects.

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