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VETIVER SYSTEM APPLICATION IN NATURAL DISASTER REDUCTION AND ENVIRONMENTAL SUSTAINABILITY – A FEASIBILITY STUDY

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Ecosystem-based disaster risk reduction (Eco-DRR) is a relatively new concept in disaster management. This aims to reduce a particular vulnerability by using healthy ecosystems as buffers. The Vetiver System is the use of vetiver plant in hedgerows for environmental conservation and risk minimization activities. The present study looks at case studies about the successful project implementation of vetiver system application in natural disaster reduction (landslides, slope stabilization, seasonal flooding, erosion control) and a phytoremediation study with vetiver plant for polluted river water purification. Detailed field visits were conducted to the two case study locations and data collected from direct observation, focused group discussion with local people and tea estate workers and supervisors, field observation from nearby places which do not having a vetiver system application etc. And for phytoremediation studies vetiver was grown hydroponically for twenty days in the polluted river water taken from a nearby river. A total of 11 water quality parameters were tested. From the study it is observed that vetiver system is very efficient in preventing mud slip, bund attrition, soil erosion, seasonal floods and is very tolerant to harsh environmental conditions. There is a substantial reduction in all the quality parameters such as pH, conductivity, salinity, TDS, turbidity, phosphate, nitrate, COD, BOD, DO and total fecal coliforms found in the phytoremadiation studies. Vetiver system can be effectively used for the purification of contaminated water since it can absorb a good percentage of indicator bacteria within 10 days in a hydroponic condition. Extensive use of vetiver hedges for protecting road embankments and bund erosion as a cost effective method, and using vetiver system for river and canal conservation especially for first order streams are the major recommendations of the current work.

Key words: Vetiver system, Eco-DRR, Case study, Phytoremadiation, Indicator bacteria

Introduction

Due to the diversity of landforms all the natural hazards are present in our country and this affecting people's life and property since ancient times. And to mitigate various natural disasters huge amount of budget allocation needed every year mainly for physical mitigation and post disaster activities (MOHA, 2011). But there are many deficiencies for this kind of natural disaster risk management system and hence the new concept – Ecosystem Based Disaster Risk

Reduction (Eco-DRR) - arises. This is a concept to reduce the risk of being exposed to natural hazards by avoiding development of disaster prone areas as well as by using healthy ecosystems as buffers, to protect people's life and properties (JMOE, 2016). Vegetation has been used as tool for reducing natural disasters from centuries. But they are not very popular. The traditional measures used by our ancestors for natural disaster reduction are not well known to the present society. If the vegetative measures are successful, they are the only low cost, low technology, and environmental friendly method. For river bank erosion, the most popular bio-engineering method is probably the planting of bamboo, while for coastal erosion mangrove, casuarinas, and wild pineapple, nipa palm etc. are also being used (Truong *etal* 2008).

The vetiver system

The Vetiver System (VS) is a system of soil and water conservation whose main component is the use of the vetiver plant in hedgerows. Vetiveria zizanioides (recently reclassified as *Chrysopogon zizanioides*) commonly known as vetiver (derived from the Tamil) is a perennial bunchgrass of the Poaceae family. Vetiver is a fast growing perennial grass with a complex root system that can penetrate in to the deeper layers of the soil. It has the ability to form hedges when planted close together, this property of vetiver makes it suitable for soil erosion that filters out sediment, spreads rainwater, improves the shear strength of soil, and recycles soil nutrients. Many studies all over the world have shown that Vetiver as a hedge is the ideal plant to conserve soil and rehabilitate eroded land (P.Haridas and S.Balasubrhamaian). This grass has been used for soil and water conservation in agricultural lands for many years but its related impact on land stabilization, soil erosion and sediment control only started in the late 1980s following its promotion by the World Bank (Truong 1996*)*.

Objectives of the study

1. To conduct some case studies about the successful project implementation of vetiver system application in natural disaster reduction (Landslides, Slope stabilization, flood and erosion control).

2. To conduct a phytoremadiation study with vetiver plant for polluted river water purification.

3. To study the scope of vetiver system as a low cost mitigation measure for some environmental hazards in connection with ecosystem based disaster risk reduction.

Relevance of the study

In order to enjoy safe and affluent living we must find new ways to live with nature. Ecosystem based regional developmental programmes are emerging worldwide and hence we should develop green technologies and systems for the prevention and mitigation of natural hazards. The application of vetiver system is one among them. The present works investigate in detail about the vetiver system application as a low cause alternative for natural disaster reduction and the findings are valuable to various authorities for implementation purpose. The water quality improvement through adoption of phytoremediation techniques using Vetiver system from post and pre analyses of the samples have showcased the effectiveness of this project. This type of eco-friendly approach has not been implemented anywhere to the best of our knowledge in the state.

Materials and Methods

Data collection

Data collection was done using primary and secondary data sources. The primary data collection was mainly from extensive field visits. The secondary data collection was done by personal interviews with local people and farmers, Telephonic interviews with agricultural officers, Literature review from University and departmental library, the available data published in books, official documents, journals and websites as listed in the reference were reviewed. The review of literature focused on the Disaster Management (Landslides, Floods, Road Batter Failure, River Bank Protection and pollution removal) application of Vetiver. Several authors are discussed about this topic. The current work focused on two case studies of successful project implementation by using vetiver system. First one is the road embankment protection at Punchavayalkattu region at Neendoor Panchayath and the second is the successful implementation of vetiver system at Tyford tea estate. Detailed field visits were conducted to the two study locations and data collected from direct observation, focused group discussion with local people and tea estate workers and supervisors, field observation from nearby places which do not having a vetiver system application etc..

The second objective of the study is to check some phytoremadiation studies of vetiver grass in the polluted river water treatment. A lot of studies already were carried out in the similar field

but removal of microbial pollutants (Total coliform bacteria) is little observed. The vetiver slips grown hydroponically in the polluted river water taken from nearby river (a distributary of Meenachil River).The duration of the experiment was twenty days and the samples were analyzed in five days interval (5, 10, 15 and 20 days respectively) .A total of 11 water quality parameters were tested. The parameters are namely pH, Turbidity, Conductivity, Salinity, Total Dissolved Solids (TDS), Dissolved Oxygen (DO), Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Nitrate, Phosphate and faecal coliform bacteria (TC).

The physical parameters of water such as pH, Conductivity, Total dissolved solids and Salinity of samples were analyzed at the time of sample collection using multi parameter probe. And also Dissolved Oxygen (DO), Biological Oxygen Demand was analyzed by Winkler method, Nitrates, Phosphates were analyzed using Spectrophotometer and Total coliforms were also detected.

Vetiver grass slips was collected from vetiver nursery of the department and J.S farm Neendoor. Four pots of five liter capacity each were selected for the study. The vetiver slips were introduced into the 3 pots with contaminated water and the remaining pot (no vetiver) was considered as control. The vetiver slips have an average 18cm length and 150g weight. These pots were kept in a glass house for 21days. Every 5th day water samples were collected by adding distilled water up to the mark in each pot because the water levels were decreased due to the absorption and evaporation by the plant. Then analysis was carried out and the results were documented.

Fig: 1-Expirimental Setup for phytoremediation work

Results and Discussion

Important observations from the field	
Case study I **Strengthening of road sidewalls in Neendoor area using vetiver system**	**Case Study II** **Application of vetiver system in Tyford tea estate, Elappara, Idukki**
Vetiver system is very efficient for preventing mud slip and soil erosion	About 7 to 8 km Ramacham is planted and also along the sides of first order streams
The vetiver system implemented portions of the Neendoor- Kallara road is well protected from bund erosion	They used the leaves as animal feed and mulch for tea plant.
Other portions of the same road where vetiver system is not implemented severe erosion problem is noticed	Vetiver is very effective for controlling soil erosion during rainy seasons and especially at the time of replanting.
Vetiver system is very tolerant to environmental conditions and in the study area	They used the leaves as animal feed and mulch for tea plant.
The main reason for implement vetiver is its low cost and low maintenance.	Vetiver hedges are not developed as a weed instead it prevents the weed formation.
The project was successful hence the Panchayath decided to extent the project.	Severe soil erosion and land slips observed nearby tea estates without having a vetiver cover.

Table: 1- Important observations from the two case studies.

Fig: 2-Field photos of Case study I

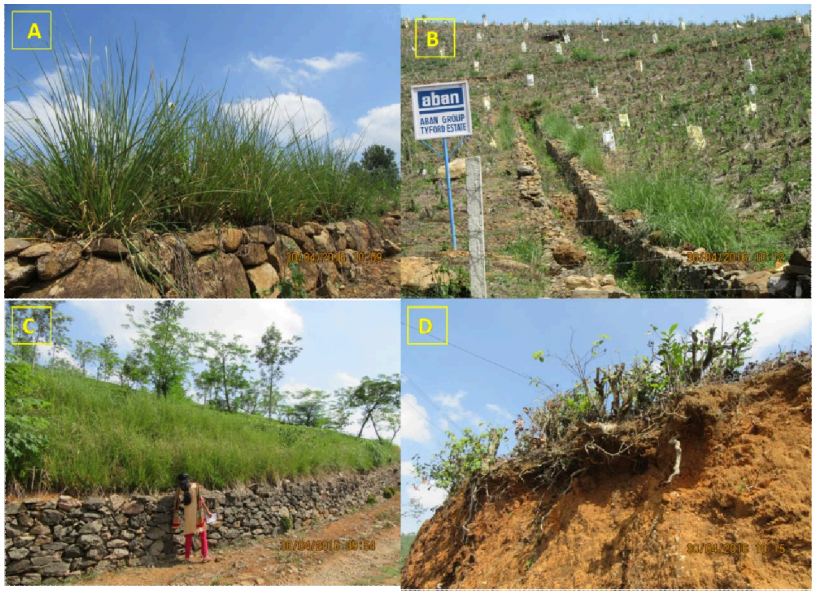

Fig: 3-Field photos of Case study II

Results of Phytoremadiation Studies

The vetiver plant can improve the quality of waste water in a substantial way. All the 11 water quality parameters tested in this study given a considerable improvement. Results of the phytoremadiation studies are given in the table 1.2. D.O and BOD was measured in the alternate days of sampling. As per CPCB guidelines, the Faecal Coliforms count should be equal to or less than 500 Most Probable Number per Hundred milliliter (MPN/100ml). Most of the middle and lower stretches of Indian rivers are high in Total Coliforms. It has been reported that stretches which are high in BOD have high Total Coliforms and Fecal Coliforms also. The samples contain maximum number of Coliforms i.e.,1100CFU/ML. The 20th day of analysis the samples shows an average reduction of 75 CFU/ML. The average percentage reduction in samples is nearby 90 percentages. The samples contain maximum Coliform contamination i.e.,1100CFU/ML.In the fifth day itself ~60% reduction in total fecal coliform were observed in vetiver treated samples while there is no significant reduction in control.

Parameter	0^{th} Day		5^{th} Day		10^{th} Day		15^{th} Day		20^{th} Day	
	Sample Mean	Control	Sample Mean	Control	Sample Mean	Control	Sample Mean	Control	Sample Mean	Control
pH	6.46	6.46	6.62	6.59	7.21	6.71	7.23	6.62	7.07	6.5
Conductivity	311	311	312	316	297	338	259	330	210	294
TDS	219	219	213	221	201	259	201	240	178	201
Salinity	142	142	151	163	125	138	113	140	105	134
Turbidity	3.90	3.910	1.55	7.15	1.41	5.71	1.49	4.46	1.42	3.67
Phosphate	1.5	1.5	.07	1.1	.03	.8	.03	.8	ND	.64
Nitrate	1.3	1.3	.15	.75	.15	.75	ND	.7	ND	.7
COD	16.64	16.64	13.21	16.2	11.77	15.28	10.27	13.1	8.54	12.6
DO	3.8	3.8			5.47	4.1			6.13	4.2
BOD	2.1	2.1			1.77	2.9			1.7	4.2
Fecal coliform	1100	1100	**460**	**1100**	386	460	220	460	75	240

Table: 2- Results of phytoremadiation studies

The Vetiver System is based on the use of vetiver grass (Vetiveria zizanioides L.) for various applications in erosion and sediment control. The potential of VS as low cost bioengineering technique was first addressed by the World Bank for soil and water conservation in India in the 1980s (Truong 2004).Vetiver system to be a very effective in water erosion control in agricultural lands, erosion and sediment control on steep slopes as a bioengineering technique. The plant has a strong and massive root system, which is vertical in nature descending 2-3 meters in the first year, ultimately reaching some five meters under tropical conditions. The depth of root structure provides the plant with great tolerance to drought, permits excellent infiltration of soil moisture and penetrates through compacted soil layers. Above ground, the shoots can grow to two meters and when planted close together it forms a solid vegetative barrier that retards water flow and filters and traps sediment in runoff water. Growth occurs from the crown, which rises relative to soil build-up. It is also highly resistant to pests, diseases, fire and heavy grazing pressure. A review conducted for the World Bank comparing the effectiveness and practicality of different soil and water conservation systems found that constructed measures must be site specific and require detailed and accurate engineering and design. Furthermore, all structured systems require regular maintenance. Most of the evidence also suggests that constructed works reduce soil losses, but do not reduce runoff significantly and in some cases have a negative impact on soil moisture (Grimshaw 1988). The vegetative conservation system, on the other hand, when planted on the contour, forms a protective barrier across the slope, which slows the runoff water causing sediment to be deposited. Since the barriers only filter the runoff and do not convey it, water seeps through the hedge, reaching the bottom of the slope at lower velocity without causing any erosion and without being concentrated in any particular area. This is known as the flow- through system (Greenfield 1989).In Kerala scenario application of vetiver system along with current erosion control practices such as contour bunds, moisture barriers, earthen bunds and contour trenches is very suitable.

Conclusions

In Kerala the use of vetiver system is very limited and the people are not much aware of the vetiver system applications. Vetiver system can be effectively use for the purification of contaminated water since it can absorb a good percentage of indicator bacteria within 10 days in a hydroponic condition. The application of vetiver plant along muddy roadside (case study I) and

in the tea plantation are found to be very effective in order to prevent bund erosion and land slips respectively. The efficiency of existing soil erosion control measures in the highlands of Kerala is limited. Vetiver hedges are used for protecting road embankments and are cost effective, require less maintenance and labor intensive. It is also used in tea plantations to reduce soil erosion during replanting time. The applications of vetiver system can conserves soil moisture in the farmlands and it increases crop yields by preventing the loss of soil humus during rainy seasons. Implementation of vetiver along with current erosion control practices such as contour bunds, moisture barriers, earthen bunds and contour trenches will be very sustainable and cost effective method or we can replace the modern soil conservation techniques with Vetiver system. The use of vetiver system for river and canal conservation especially for first order streams and for reducing bacteriological contamination are the major recommendations of this work.

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