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Study of advantages and disadvantages of protecting and training of riversides by vegetation against geomorphologic changes

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ABSTRACT

Hydrologic changes and human interventions gradually change the river course. Geomorphology or study of rivers' behavior seeks to determine the action and the reaction or the behavior of rivers in various conditions. The propensity of rivers to geomorphologic changes, over time, has been clear and ascertained since almost a century. It is very much important to protect and train rivers, coastal regions and to protect lands and valuable reserves on riversides (pumping stations, treatment plants, water-supply wells, prawn-rearing basins etc.). Taking into account vegetation and its use in protecting and training riversides will lessen unnecessary costs and prevent environmental effects and geomorphologic changes of rivers over time. This article is dedicated to investigate advantages and disadvantages of protecting and training of riversides by vegetation against geomorphologic changes.

Keywords: River, River Training, Geomorphology, Vegetation

INTRODUCTION

The flow of waters and rivers is the most important phenomenon in land crust processes, which both contributes in conformation of general landform and determination of human lifestyle on Earth [1]. Rivers have attracted the attention of human societies for a long time: they are crucial in formation of general landform and determination of human lifestyle on the Earth, like emergence of great and ancient civilizations besides rivers [2]. The form of ancient cities and civilizations, such as those people living in Mesopotamia between Tigris and Euphrates in west Asia, Nile valley in Egypt, the valley of Yellow River, or Huang He, in China, owes to rivers and their sides.

Rivers and streams are quite dynamic systems and their morphological position, form and other characteristics continuously change over time. Due to side erosion and displacement of river boundaries, high levels of agricultural lands, residential regions and coastal installations are each year subject to destruction and disappearance [3]. River morphology studies the structure and form of rivers and is considered among river characteristics with a great importance [4]. One of the most critical subjects in river engineering is the geomorphologic study which describes the geometric form, bed form and longitudinal profile of streams, cross sections, changes of form and location of rivers over time [5]. River morphology is influenced by eight important variables of width, depth, speed, flow, slope, bed roughness, sediment load and the type of sediment particles [6]. Any change in one of these variables will lead to unbalance, causing change of other variables and, finally, ending with a change in river course [7]. Apart from the cases mentioned above, human interventions (river course canalization, reforestation, use of river sediments, dam construction) also contribute in changing river courses [8]. Identification and prevision of such changes can be useful in submitting river training plans and river engineering.

MATERIALS AND METHODS

It is critical to protect and train river sidewalls to ensure stability of river ecosystem and frontage, and any instability in this system may have abundant effects and consequences on the environment. To control erosion and destruction, it is appropriate to stabilize and protect riversides and floodplains by planting trees, transplanting and vegetation, a technique which is strictly recommended from an environmental point of view. The aim of this article is to investigate the importance of river training process by emphasizing the role of vegetation against geomorphologic changes. To that effect, the role of vegetation in controlling erosion and sediment, effective elements in settlement of appropriate vegetation in river basins and also different kinds of vegetation used in the plans for river training has been studied. At the end, advantages and disadvantages of using a vegetation to protect and train rivers against geomorphologic changes are described.

RESULTS AND DISCUSSION

Rivers protection and training

The term of 'stabilization and training of river sidewalls' means protecting river sidewalls against side erosion and directing river flow, regulating river bed, and increasing low water depth. In other words, regulation, stabilization and training of rivers consist of directing them into a unique channel so that it follows constantly a stabilized course with a mild curvature. In this case, rivers can flow in a natural course with sections that are able to keep water and sediments. If the stabilized course is adapted to the flow natural course, you have to expect reduction in operating costs. Stabilization of riversides is one of the most principal techniques of river training that is implemented to protect riversides against erosion and sediment load and to prevent bed elongation into outside of the river [9].

Civil engineering centers and water resources directorates are more and more interested in training and beautification of rivers and natural channels. The presence of vegetation in riversides will reduce the flow rate during flood and prevent river erosion [2].

One of the ways to stabilize riversides and river sidewalls is to use bio-engineering technique [10]. In this technique, the use of plants is taken into account, because of their compatibility to any region's climatic conditions. Planting along riversides will reduce in a great extent the development and advance of erosion and morphological changes of the river (figure 1).



Fig 1: Protection of river right side by vegetation

The penetration of plant root inside the soil will act like armature in concrete, arming the soil. This phenomenon increases the shear resistance of the soil and the strength of river sidewalls. External organs of these plants will increase the roughness and decrease the water flow rate and, at last, reduce the energized shear stress. The use of vegetation in order to protect and stabilize riversides and river sidewalls to lessen river morphological changes has always been studied by researchers throughout the world, and all of them have identified it as an economic and environmental choice. This technique has natural ability of renewal and reconstruction, although few studies have been conducted in this regard in Iran.

Goals of regulation, protection and training of riversides and river sidewalls

The goals of regulation, protection and training of rivers are clarified in two primary and secondary categories as follows:

1. Primary goals

- Treatment of river course and section form in order to create an adequate channel to reduce flow level and allow floodwaters to pass with a high and reliable rate.
- Effective transfer of sediment load both suspended and bed loads.
- Prevention and/or reduction of river sidewalls erosion and damages of bridges and public lines across the river.
- Supply of sufficient draft depth for water transportation and creation or improvement of a proper course for ships transit.
- Protection of agricultural lands against any damage endangering people and their products in floodplains.

2. Secondary goals [11]

- Concentration and orientation of the flow in a deep and thin channel in order to reduce evaporation, perspiration and leak in dry and semi-dry regions.
- The non-necessity of periodic sidewalls.

Role of vegetation in protecting and training of rivers against morphological changes

The use of sustainable and long-range river resources requires the application of methods which are adapted to river environment. Under present conditions, the dependence of human societies to rivers has become more and more, and in case of flood and inundation of rivers and erosion of their sides, many economic resources will be endangered [10]. Stabilization and protection of riversides and floodplains by planting trees, transplanting and vegetation is one of the best ways to control erosion and destruction of riversides, which is strictly recommended in an environmental point of view [4]. This method is employed in river training plans in order to protect and control erosion and sedimentation and/or to modify the river course [12]. In addition to this, vegetation is considered as an economic and sustainable choice because of its natural renewal and reconstruction abilities and also its dynamic characteristics [13].

Different studies and researches were conducted on the role and effectiveness of vegetation in river training process. The result of these studies was that vegetation, by stabilization of aggregates and improvement of soil structure under the influence of plant root, will increase the resistance of rivet sidewalls and soil against water erosion force; furthermore, by natural protection of riversides and river course, it will reduce the sediment transported by water flow. Plant aerial organs cause the increase of river sidewalls roughness and the decrease of rate and shear stress of water flow during floods, which in itself contributes in mitigation of the effects of water erosion [11]. In general, the success of using vegetation will depend on river conditions and the destruction level of its walls, triple position of sidewall surface, type of plant, plant diversity and arrangement, plantation technique, biological stability and management of protecting vegetation [2].

Role of vegetation in the control of erosion and sedimentation in order to improve morphological conditions of rivers

The presence of vegetation (natural or planted) will cause the reduction of erosion and sedimentation. The effecting sequence of vegetation is described below:

- Reduction of rate and level and water agitation followed by diminution of water erosive force.
- Increase of the possibility of sedimentation due to reduction of water flow rate, which leads to a better growth of plants.
- Treatment of soil structure of river sidewalls thanks to the increase of resistance of the latter, which is made possible by combination of plant root and soil (biological soil leveling).

Lack of vegetation in riversides is a clear expression of their instability and destruction, because the vegetation is naturally reversible and reconstructable, ensuring a sustainable protection of riversides. Vegetation will exert its effects directly or indirectly on the reduction of wastewater, erosion and sedimentation in three areas of river upstream, riversides and river sidewalls. In return, vegetation is also subject to problems made by wastewaters such as erosion and sedimentation, emerging in form of positive or negative effects. The majority of these mutual effects are explained in table 1.

Table 1. Effecting process of vegetation on erosion and sedimentation of riversides in training plans

Protected areas	Riversides	Riverside lands	Upstream lands (catchment area)
Direct effects	<ul style="list-style-type: none"> - Reduction of flow rate beside walls - Prevention of river sidewalls erosion - More sedimentation in riversides 	<ul style="list-style-type: none"> - Reduction of wastewater in coastal lands - Prevention of surface erosion - Prevention of sediment transfer into the river - Preventing the suffocation of planted seed in the soil 	<ul style="list-style-type: none"> - Reduction of wastewater thanks to raining - Reduction of soil surface erosion
Indirect effects	<ul style="list-style-type: none"> - Provision of better conditions for vegetation settlement 	<ul style="list-style-type: none"> - Prevention of thinness of river sidewalls - Better penetration in the soil and better growth of plants 	<ul style="list-style-type: none"> - Diminution of flood intensity in rivers - Better penetration of water inside aquifers and provision of better conditions for vegetation settlement - Better conditions for vegetation settlement

Effective factors in appropriate vegetation settlement in river basins

Following factors influence on appropriate vegetation settlement in river basins in order to control water destructive effects and reduce environmental displacement of rivers and their morphological changes [14]:

1. Environmental features of the area

Climatic (rain level, rain distribution, temperature oscillation, evaporation, freezing ...) and environmental (topography, gradient, height ...) conditions.

2. River flow regime

As regards the water level (changes of water level in different seasons) and water quality changes (salinity, acidity, suspended materials ...).

3. Soil characteristics

Physical (stability, structure, texture, permeability, and gradient of walls) and chemical (acidity, electrical conduction, salinity and PH levels, materials inhibiting growth) features.

4. Plant characters

Individual and collective characters of plants, resistance to environmental stress (water surface oscillations, force of competitiveness between plants, water chemical changes ...).

5. Protection and conservation

After settlement of vegetation, it is critical to protect and conserve them against important, constant, environmental treats. The technique of doing this depends on environment factors and conditions, necessary time and credits. Gap filling and assisted irrigation, killing insects and couch-grass (in first years of settlement) are among necessary actions to undertake.

Apart from the above instances, amendment of walls slop (if necessary and considering the soil stability of walls) is effective in order to provide appropriate conditions for settling and strengthening vegetation. The use of relevant plant species taking into account the position of walls, water level oscillations and its location is different (figure 2).

Types of vegetation used in river training plans

There are different types of vegetation for use in river training plans regarding their effectiveness and use in each group against morphological changes. Vegetations are split up into three main groups:

1. Grass and herb

Their skein root system and various forms cause a proper binding of soil particles and, creating a felt-form structure and increase of protection surface thereof, will heighten the stability of soil. Coverage of their aerial organs, thanks to their contact with earth surface, provides a considerable protection for soil surface. Aquatic species and their resistance to deep water in this group are mostly used to protect the lower part of coastal walls. Other species that are not susceptible to oscillations of water level are good for coastal walls. Some species that are more drought resistant can be employed to reduce erosion and sedimentation in riverside lands.

2. Bush

Their semi-deep root system is effective in protection and stabilization of the soil. Their leafage and aerial organs create an appropriate contact surface for river sidewalls during contact with water flow and, therefore, damp the energy and erosive effect of water. These are proper species for river sidewalls. By reducing water flow rate and its

hydraulic force, they mitigate the erosive effect of water. In the meantime, bushes increase the relative soil stability and cause its integrity and coherence, controlling the risk of massive fall.

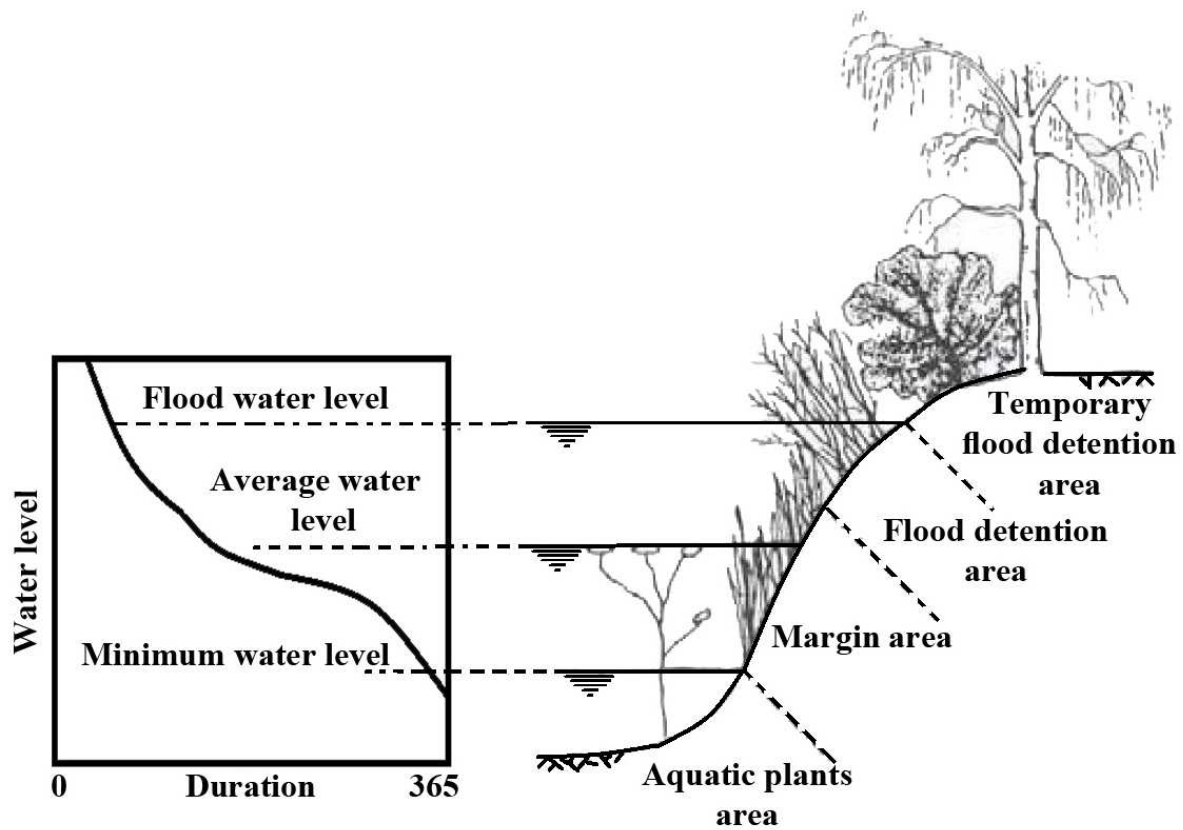


Fig 2: Classification of walls to manage vegetation [13]

3. Shrub and tree

The characteristics of their aerial organs such as leafage and trunk are effective in reducing destructive effects of water. Their deep and semi-deep root system contributes more in maintaining the soil stability in deep waters. They exert their effects normally by their aerial organs (reduction of flow rate) and roots (increase of soil stability). They are appropriate species for protection of coastal lands. Stabilizing the soil of such lands, they are also effective in the formation of armored structure of roots. Some species, especially shrubs that are not susceptible to water oscillations, are used on the surface of river sidewalls.

Advantages and disadvantages of using vegetation to protect rivers against morphological changes

This technique has already attracted the attention of persons charged with rivers thanks to its simplicity of use and economic privilege, and it is one of the most current solutions of protecting riversides against erosion and sedimentation. The fusion between vegetation and other structural techniques physically increase the utility and useful life of such structures. While this technique has its own difficulties and complexities as regards management (production and maintenance), but it is a proper choice to protect rivers against erosion and sedimentation in terms of stability and economic, environmental aspects [14]. Here are some advantages and disadvantages of vegetation used to protect rivers against morphological changes:

1. Advantages of vegetation

- Mechanically, it increases the stability of sidewalls exposed to erosion by stabilizing the soil.
- It heightens hydraulic resistance of sidewalls by roots and aerial organs (especially, organs lying on the soil surface).
- It changes micro-climatic conditions of the soil by roots and plant residues (creeping and fall of organs) to improve the stability of soil structure.
- Environmentally, it has useful and desirable effects.
- Although exerting lower effects in the first years of vegetation, it increases the stability over time and demonstrates more protective effects. It is less costly and needs less facilities compared with other techniques.
- It is reconcilable with other techniques.

- It reduces raining wastewater due to the slow action of plants in creating runoffs, which is very effective in stabilizing vegetation near rivers.
- It controls floods by penetrating water into soil and preventing the increase of runoff level to stabilize vegetation settled down in riversides.

2. Disadvantages of vegetation

- The activity of vegetations depends on environment conditions and stresses.
- The settlement of vegetations is limited to specific times.
- The change of effectiveness of vegetations is inevitable in different seasons (at least in winter due to diminution of aerial organs and at the most in summer and plant's optimized growth time).
- It is costly and needs more attention in the first years.
- The development of vegetations into riversides increases the riverbed roughness and the risk of flood detention.
- Floods can uproot trees and shrubs in the river course and transport them and, in consequence, cause damages to downstream and mainly to existent structures.

CONCLUSION

Rivers are quite dynamic systems and their position, form and other morphological features change continuously over time. Due to side erosion and displacement of river boundaries and also human interventions, a great extent of agricultural lands, residential areas and coastal installations are each year exposed to destruction and disappearance. Such changes will be stepped-up by constructing parallel and transverse structures in the river course. The study of the above factors plays a considerable role in river training plans in order to take the best measures for protecting and training riversides against morphological changes. There are different techniques to protect and train riversides such as stabilization and protection of riversides against plain floodwaters by planting trees, transplanting and vegetation, which is also effective to control erosion and sedimentation in rivers and to prevent their morphological changes. This technique is strictly recommended in an environmental point of view. The use of vegetation has its own advantages and disadvantages, and it is necessary to investigate effective factors such as flow regime (permanent or seasonal), water level oscillations, biological characters of the area, features of bed and riverside soils, climatic specifications, physical form of rivers and characters of plant species. It is therefore required to use the best plant species in order to protect and train rivers against morphological changes. What's more, the correction of the slop of river sidewalls (if necessary and considering the level of stability of sidewalls soil) to provide appropriate conditions of plant settlement is among the most effective actions to stabilize the vegetation.

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