Appropriate Methods of River Quality Restoration

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Abstract

The practice of river restoration has grown exponentially over the last several decades. There has been little empirical evaluation of whether restoration projects individually or cumulatively achieve the legally mandated goals of improving the structure and function of rivers. Nutrient reduction through simple methods is the most critical factor. The simplest method, which has minimal financial burden as well as preventing, and reducing the entrance of pollutants into the Chalus River (Mazandaran, in north of Iran), has been selected. The origins of most rivers in Iran start at a high point and move with a steep. Due to low speed and high pollution, rivers that arrive at cities or plain areas usually face problems. Due to this, compared with the rivers in other parts of world, the rivers in Iran carry more sediment, showing a high rate of erosion and inappropriate situation of natural resources such as deforestation and exploitation. As a result, a variety of techniques have been compiled and summarized, such as riparian, wetland, floating island, etc. Therefore, the purpose of this article is to provide a comprehensive overview of the techniques so as to select the best method for the Chalus River.

Keywords: Nutrient, Riverbank Injection, Riparian buffer,

Introduction

The conservation of biological diversity and the sustainability of natural resources is critical. The biological diversity and sustainability of natural resources are affected by the destruction and degradation of natural habitats.

Factors such as anthropogenic activities, along with economic activities, and on top of that city sprawling and land use lead to degradation of land (Sliva and Williams 2001).

Water quality degradation is becoming a wide concern these days. Point source pollutions and nonpoint source pollutions are the two main categories regarding this issue. While the former results from known source the latter originate from diffuse sources. Due to limitations in technology and finances, it has been difficult to carry out NPS pollution control in wide suburban areas. In developing countries, NPS pollution has become one of the biggest source of damage to river ecosystems. Therefore, as local societies seek to implement sustainable development strategies, evaluating the regional water quality and identifying the root cause of pollution is urgently needed (Zhang, Wu et al. 2004).

It is believed that the aquatic ecosystems as well as water supply are in danger due to the PS and NPS surface pollution which comes from surface water deficiency.

Factors including municipal sewage discharge accompanying with industrial wastewater loads lead to PS pollution.

According to (Brown, Pullar et al. 2016), NPS pollution occurs when rainfall, snowmelt water or irrigation water runs over land, carrying and depositing pollutants into rivers, lakes, and coastal waters. NPS pollution from agriculture is regarded as the major cause of the surface water quality degradation and has attracted growing public concern (Darradi, Saur et al. 2012).

According to (Michalet, Pinaud et al. 2005) Rivers are one of the most intensely used environmental resources. However, they are subjected to inputs of treated and untreated wastewater, storm water and combined sewage discharges; flood control channelization, culver ting (a tunnel carrying a stream under a road), shoreline encroachment, erosion and sedimentation (Wu and Chen 2013).

The restoration and creation of wetlands for controlling NPS in agricultural watersheds has been widely investigated. Over twenty years, research in this area has emphasized the need for a watershed-scale design to optimize performance and meet water quality goals. In addition to biological and physical constraints, political, economic, and social factors pose as barriers in the implementation of wetland restoration planning. Within the context of the broader response strategy, wetland restoration must also be considered as a potential method to address agricultural nonpoint source pollution (He, Zhang et al. 2014).

The growth of the human population, and the mismatch between such growth and provision and accessibility of potable water resources, is a huge cause for concern. Even now, it is estimated that 1.8 billion people live under a high degree of water stress (Giller 2005).

In recent years, most studies focused on the water quality and water self-purification of industrial polluted river as well as on the mechanism of water self-purification processes (Wei, Yang et al. 2009).

Watershed management

The first step of any contaminated management strategy is to either control or eliminate the contaminant source (Letson 1992). Control of point source discharges since 1972 has yielded some improvements in the nation's water quality. Industrial and municipal point sources were the worst and most obvious offenders of surface water quality (Royer, David et al. 2006).

Development of strategies for controlling P loss from upland agricultural watersheds requires to identify specific source of P, at field and farm scales, and to predict their resultant effects at the watershed scale (Palmer and Allan 2006).

It should increase understanding of:

- watershed processes and their relation to nature
- The principles watershed management,
- The elements of successful watershed management frames
- The benefits of the watershed management approach (Serveiss 2002).

Iran's Climate

Iran has a hot, dry climate because of the long, hot, dry summers and short, cool winters. January is the coldest month, with average temperatures from 5°C to 10°C. August is the hottest month with a temperature of 20°C to 30°C or more. In the summer it can be both cool and warm. In winter the weather is cold with heavy snowfall during the months of December and January.

In hot climates such as Iran, due to high temperature, there is more evaporation so a smaller amount of rainfall flows in the river but in north of Iran vice versa. In addition, the amount of river's water depends on rainfall intensity, duration of rain and its type.

A river's water flow changes throughout the year and it usually increases in spring because ice melts and the number of rainy days increases. Needless to say, the river's water flow reaches its minimum in hot days of year in north of Iran (figure 1). So Chalous River is a case study which was investigated in terms of cost, efficiency and executive operations.

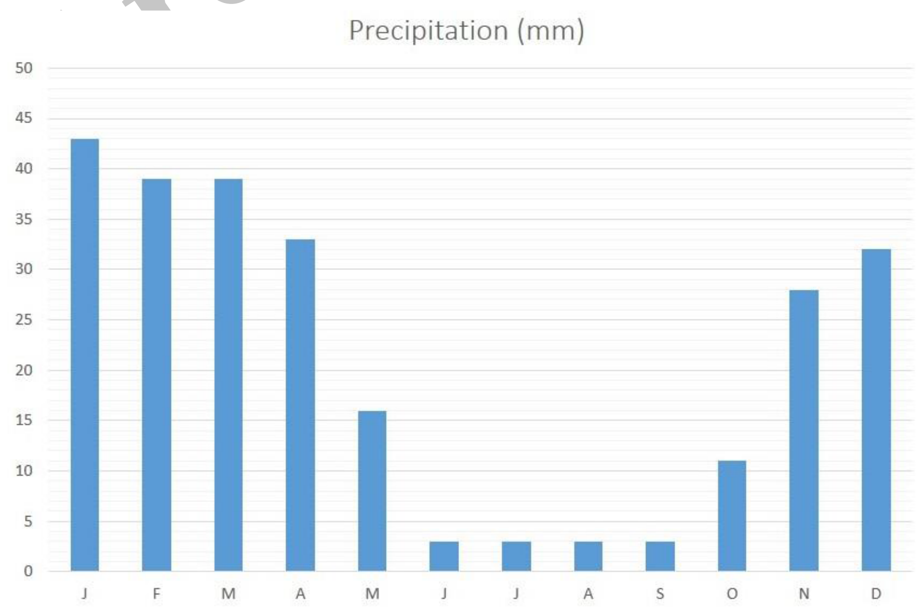

Figure 1. Precipitation of Iran in each season

Another factor affecting the amount of water is the ups and downs of a land. It is clear that water flows faster in steeps than gentle slopes. Also in flat lands slack water will be formed making more evaporation and penetration. Because of this, problems with phosphorous and nitrate is seen more in areas near the sea or areas with low height.

Caspian basin

Most flowing streams in the north of Iran are permanent. During winter and early spring, the rivers in mountainous areas, are filled with water and during summer the rivers have little water or sometimes they are dry. Due to low distance between mountain and the sea, the length of western rivers in this providence is shorter than those originating from east.

Important rivers in the north of Iran, originating from Alborz mountain range (show in Figure 2) include:

Aras (1070 Km), Sefīd-Rūd (800), Chalous River (180), Sardab River (67), Haraz River (185), Larim River (65 Km), Atrek River (715), Kojoor Rive (54 Km), Gorganrud River (350), Astarachay (36 Km). Tajan (192 Km)

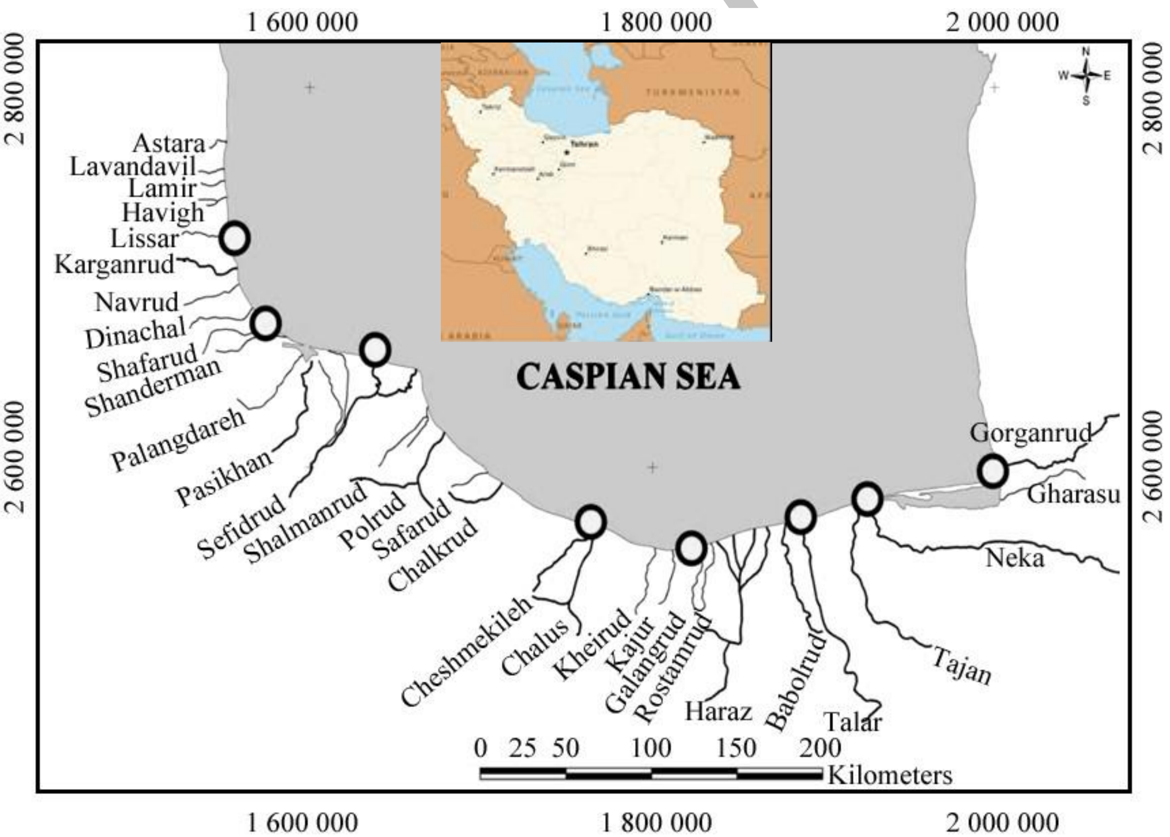

Figure 2. Caspian basin in Iran (Curigliano, Pivot et al. 2013)

Compared with the rivers in other parts of world, the rivers in our country carry more sediment which shows a high rate of erosion and inappropriate situation of natural resources such as deforestation and inappropriate exploitation.

Contaminant resources

- Organic Nitrogen

The main sources of the production of organic nitrogen throughout rivers are urban and rural wastes, agricultural wastes and the remaining aquatic organisms. The amount of organic nitrogen increases by the death of plants and decreases by Hydrolysis and sediment.

- Ammonia nitrogen:

Ammonia nitrogen increases during the process of hydrolysis of organic nitrogen and the respiration of Phytoplankton and decreases by de-nitrification process and plant photosynthesis.

- Nitrate

The amount of nitrate increases by Ammonia nitrification and decreases by de-nitrification and photosynthesis.

- Organic phosphorus

Organic phosphorus increases during the death process of plants and decreases by Hydrolysis and sediment.

- Non organic phosphorus

The amount of non-phosphorous increases in the processes of hydrolysis of organic phosphorus and decreases by phytoplankton`s respiration.

It shows gradual changes on dissolves oxygen throughout the river. In fact the lack of oxygen concentration is called deficit. This is to say that, wherever the entering pollution into river becomes more than normal, the amount of dissolved oxygen drops.
According to graph (figure 3), at first oxygen demanding is low and gradually increases so that it reaches to a critical condition. In other words, oxygenation should be started before critical conditions happen.

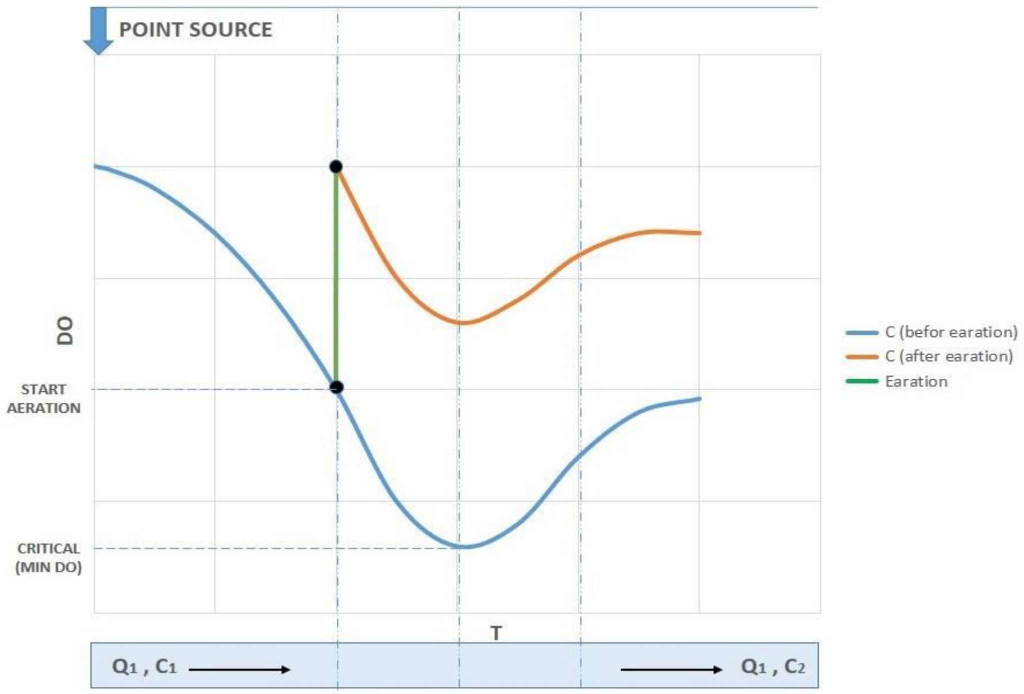

Figure 3. Dissolved oxygen and aeration time

In this way the dissolved oxygen increases and pollution fades out. If too much pollution enters into water, the speed of decreasing the dissolved oxygen increases as well and as a result more speed for aeration is needed. This is a big concern for rivers with very low slope because of nutrient.

Standard in Iran

Discharge of wastes should be done under the standards of department of environment in which standards are based upon the maximum concentration of pollutant.
The standard of arrival of pollutants in surface water, cesspools and agricultural consumption is presented in table 1.

Table 1. The standard departure of contaminant in Iran

Contaminants	Discharge to well mg/l	Discharge to surface water mg/l	agriculture mg/l
NH_4	1	2.5	-
NO_2	10	10	-
NO_3	10	50	-
Phosphate	6	6	-
DO	-	2	2

Metodology

Recommended methods for increase river quality are Riparian buffer and RBI while we can use it in specific situations like Chalous River (with large buffer along the river and high precipitation).

Rivers with low speed In the plains, the best method considering different methods of analysis, which can be employed is the deployment of RBI and Riparian buffer and in places where the entrance of flowing water and or marginal farmland, Riparian vegetation buffer can be significant used in Iran's River as it show in figure 4.

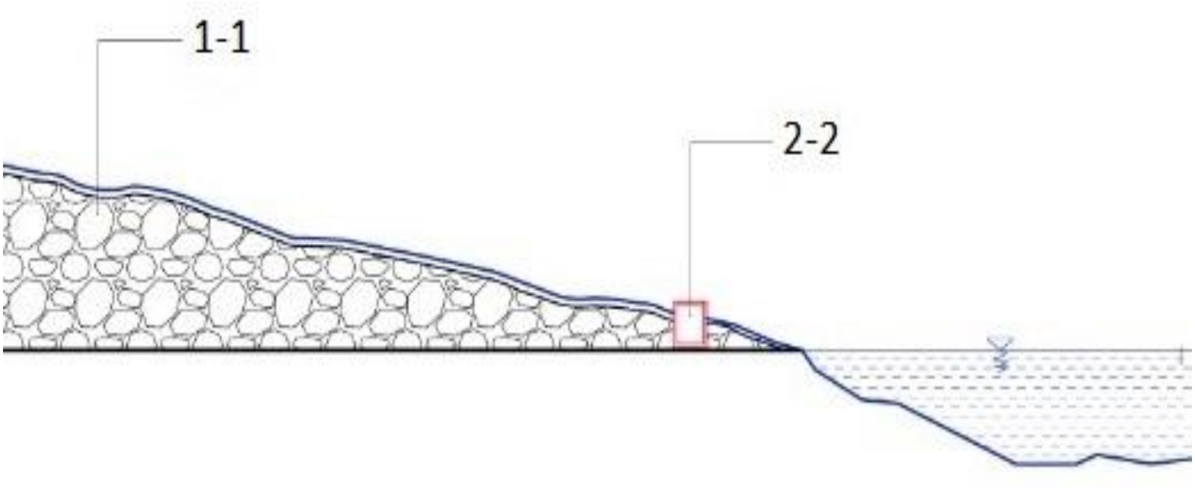

Figure 4. Combined RBI and Riparian buffer section

Riparian buffer strips

Riparian's zones help to protect soil erosion and stabilize the river banks. They provide water storage, runoff control, and water filtration that promotes water quality and protects against flooding. Riparian zones provide habitats for a variety of plants, animals, fish, and aquatic insects

It is an important element of Riparian forest ecosystems, providing many ecological benefits (Valero, Picos et al. 2014);

- Habitat for wildlife
- Hydrologic regulation and water quality;
- Filters for sediments and nutrients;
- To stabilization of stream banks and beds and
- The regulation of water temperature

Runoff or polluted water should pass through grassland. So there is not only soil erosion but also the suspended substances carried by runoff will settle evenly on grassland.

A soil covered with dense vegetation, such as lawn or grass, has the highest resistance against water circulation.

Having said that, for the purpose of more strength, we take a slight change into consideration. Employing nailing method in the solid in a vertical way leads to more resistance in the soil.

Runoff passes the margin of a river through a slope. At this distance, as it is shown in figure 5, an embankment is built to slow down the speed of run off. The surrounding soil will be stabilized by lawn work. The embankment should be longitudinally, per each meter width along river.

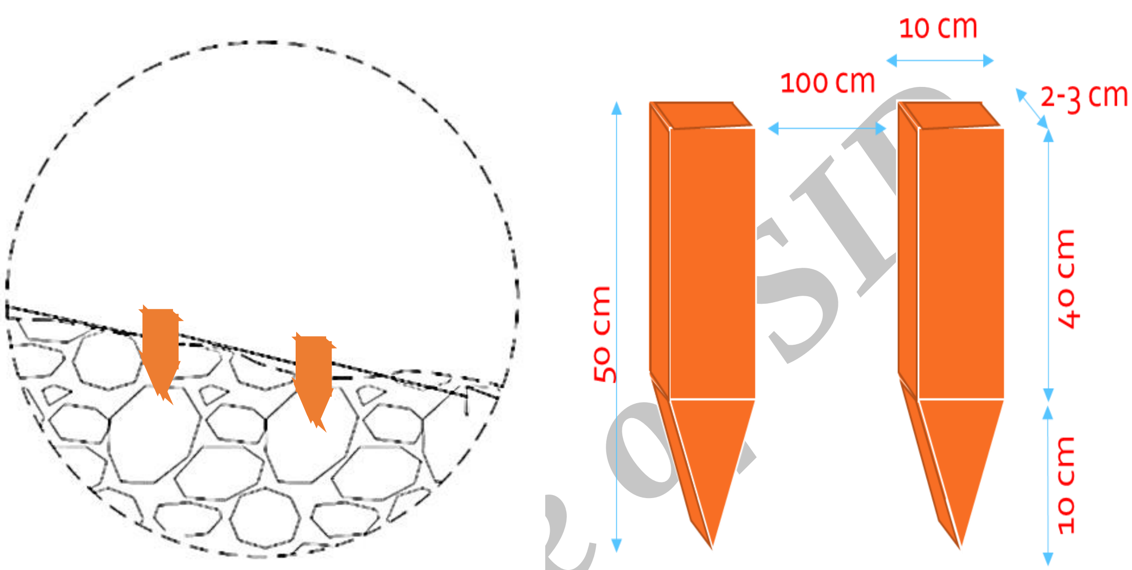

Figure 5. Soil section design 1-1

Sediment plays an important role in pollution which in the method there is a remarkable decrease in its amount and in final run it decreases the amount of phosphorous in water.

In other words, it avoids phosphorous from entering into river. In other words, it avoids soil erosion considering the erosion and or runoff up to 73% in nine-meter buffer stripe (Loucks, Van Beek et al. 2005).
A remarkable affect was observed based on the effectiveness of filtered buffer in passing nutritional substances such as phosphorous in soil about 73%.

Riverbank Injection (RBI)
Riverbank Injection has long been shown its effectiveness as a natural and an inexpensive scheme for water supply in many parts of the world. Travel time of RBI is an important factor controlling the removal efficiency of RBI system. Many studies demonstrate the positive effect of increased travel time on contaminant removal (Smith, Tilman et al. 1999).

After a flood, what must be done to prevent the pollution that comes with a flood from entering into a river?
In a Non-rain season, we build a concrete overflow so that the water flows over it. In lay terms, a blade long the river is built which function as a short dam, flood settles the pond letting clear water flow and enter into water. The mud accumulated behind this construction will be discharged after specific time period. Collecting the mud has two advantages, firstly it can be used for agricultural purposes.

It is believed that such mud contain substances which make a perfect base for growing plants. Secondly, the presence of mud in the river water becomes problematic later on. Neither suspended substances nor phosphate enter river. If phosphate enters river and anaerobic condition take place, the phosphate solves in water, and as a result, algae grow in water which make more problem.
When mud is settled behind such constructions, insoluble phosphate cannot enter swamps and actually can prevent swamp-bed anaerobic ion up to 50%.
In RBI, the depth of digging canals and building overflow should not be dominant over the depth of river show in figure 6.

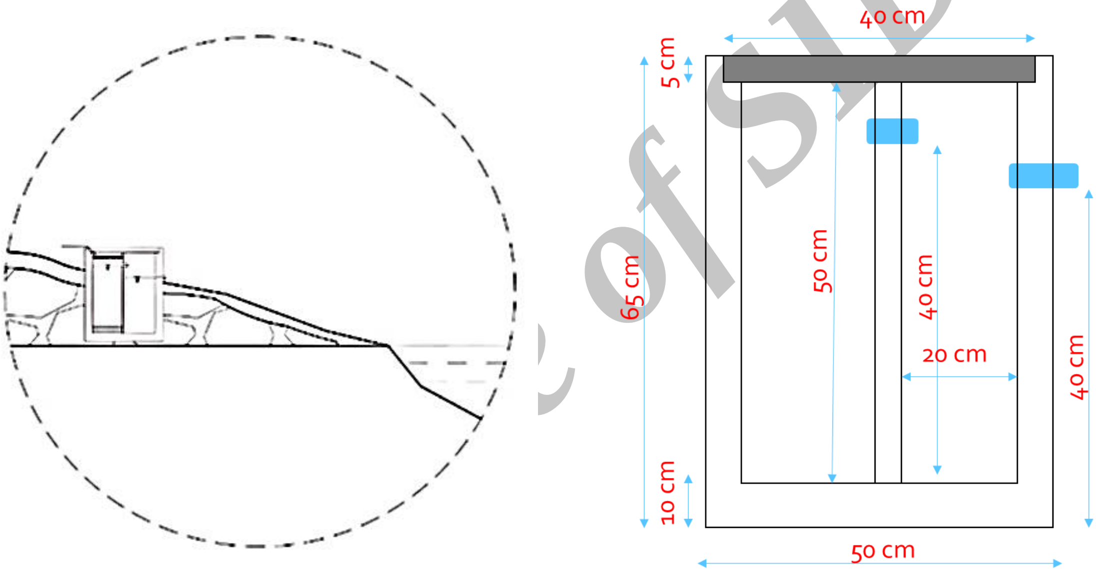

Figure 6. RBI section design

The overflow should be 4 cm higher than the soil level and should be in curved form. In this way, after passing through soil, runoff enters the first area of this block and suspended substances along with phosphate settles, then the clear water enters the second area. The clear water will be guided to river through a concrete canal with the size of 0.2*2 m show in figure 7.

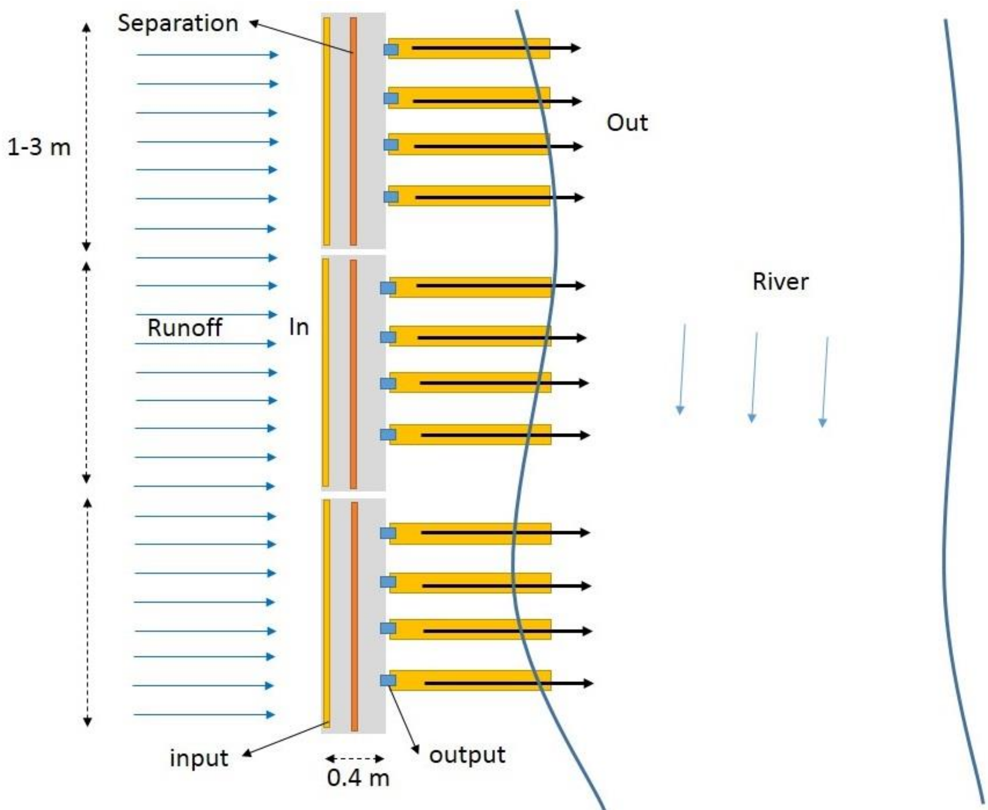

Figure 7. Design plan

These system is the highest absorption of Nitrogen and phosphorous according to result of these review paper and in terms of cost are the lowest. Also, it is easy to keep them with the influence of 80% for phosphate and 73% for nitrate.

Recommended model of nutrient reduction and increase river quality with simple methods are show in figure 8.

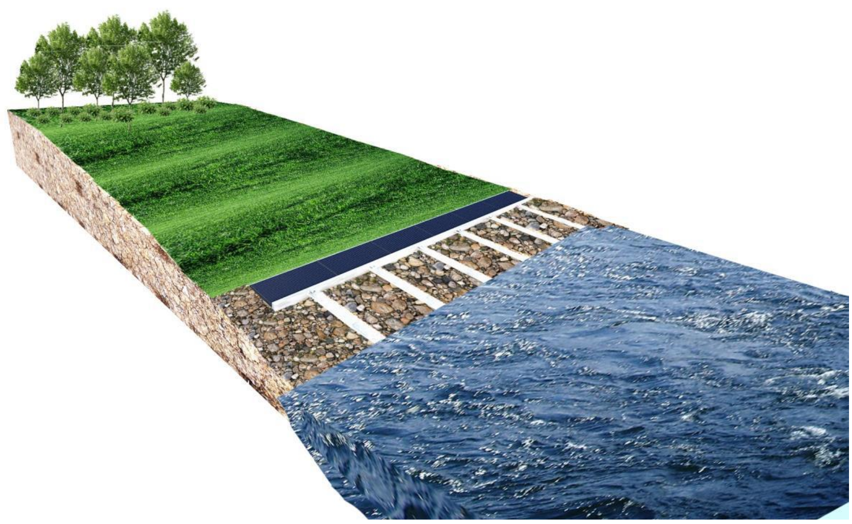

Figure 8. Combined RBI and Riparian buffer

Conclusion

Three stages should be taken to increase the quality of river water which are as show in figure 9. It is important to note that evaluation is done based on the situation of each area and the performance. In fact what type of care should be taken to avoid water pollution?

We have selected the simplest actions which with a little cost a decrease a large amount of pollution entering the river. The simplicity and low cost motivated the companies to employ the same methods.

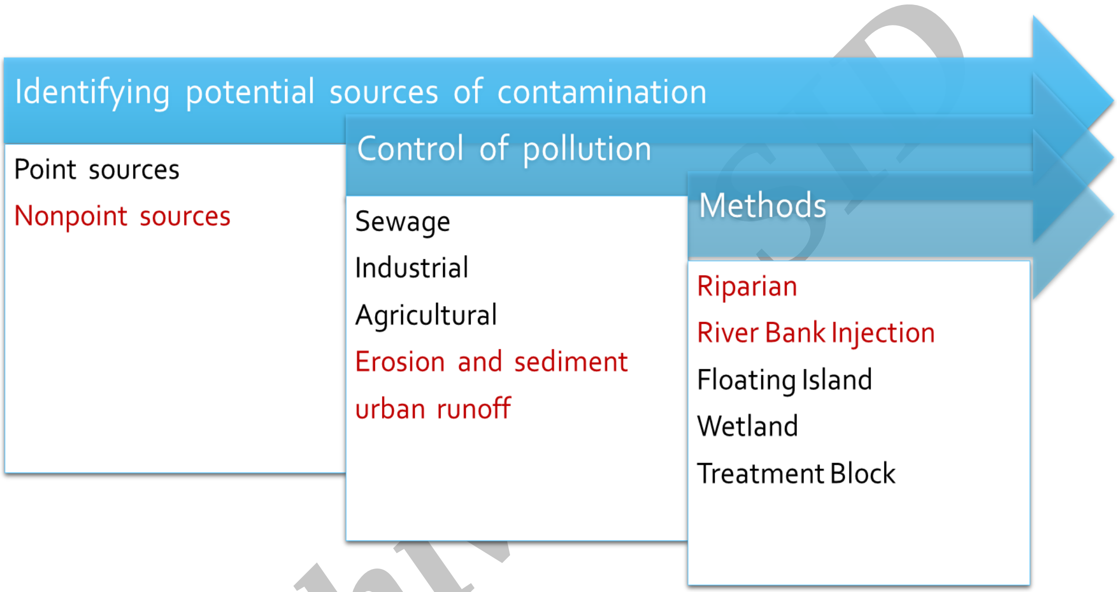

Figure 9. Reduction process

According to table 2, Analysis of existing methods and stating the advantages and disadvantages; so a variety of techniques have been compiled and summarized. In fact therefore, is to provide a comprehensive overview of the techniques and methods available for environmental.

Due to the high cost of water purification and river restoration made us allocate an appropriate and cheap method for each pollutant and type of river.

Table 2. Methods comparative

Methods / properties	Cost	Effect	implementation	Reduction percentage (phosphate)	Reduction percentage (nitrate)
Riparian buffer strips	Low	High	Easy	73	73
wetland	High	High	Difficult	15	40
RBI	Medium	High	Difficult	80	20
Treatment block	High	Low	Difficult	0	15
FI	Medium	High	Normal	5	15
Combine system RBI and Riparian buffer	Medium	High	Normal	80	73

According to the graph (figure 10), one can come up with this conclusion that compared with other methods, RBI and Riparian buffer have the highest percentage of reducing phosphate with 80 percent of phosphorous and 73 percent of nitrogen in water. Furthermore, Riparian buffer method is the best alternative in terms of removing nitrate.
Considering the cost of performing the project in the margin of rivers in the north of Iran, Riparian buffer and RBI are considered to be an appropriate method in most plains in Iran.

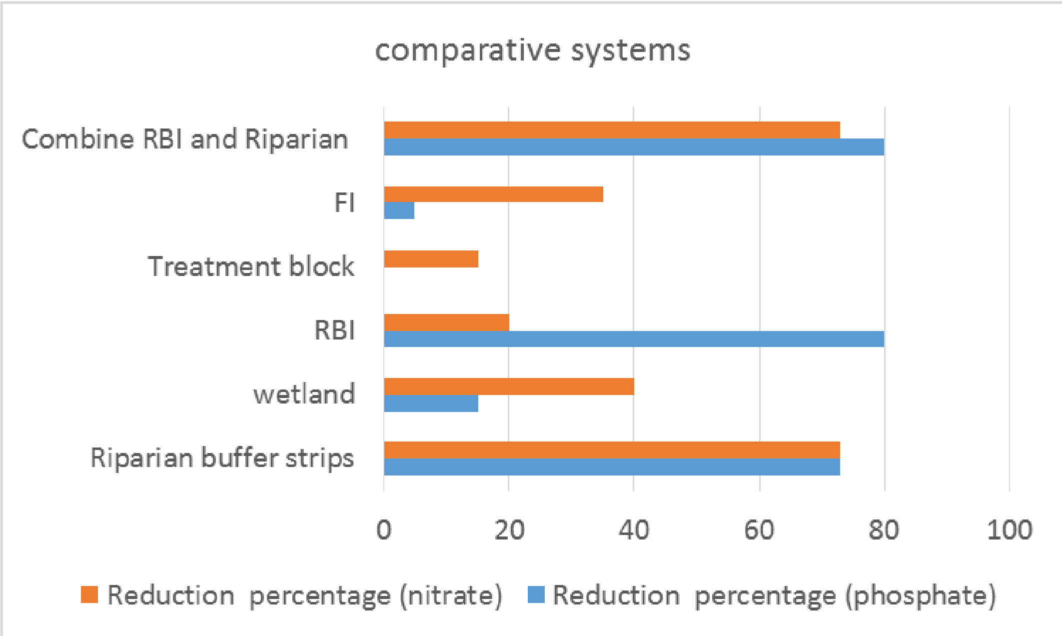

Figure 10. Nutrient reduction systems

These methods have the highest nutrient reduction according to result of these methods and in terms of cost are the lowest. Also, it is easy to keep them with the average influence of 75%.
Chalous river in Mazandaran, Iran with low speed In the plains, the best method considering different methods of analysis, which can be employed is the deployment of RBI and forest riparian and in places where the entrance of flowing water and or marginal farmland, Riparian vegetation buffer can be significant used in Chalous River

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