Benefit evaluation of pollutants in runoff interception by vegetation filter belt based on hydrological analysis

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Abstract: Vegetation filter interception is one of the most effective management methods to control runoff pollution. In order to avoid unhealthy hazards caused by polluted sites, we need to conduct hydrogeological survey of polluted sites, and then effectively use vegetation filter belt to intercept pollutants in runoff. Taking the polluted sites in a certain area of the city as an example, we have studied the technical requirements, work flow and some matters needing attention in the hydrogeological survey of the polluted sites as a whole. Three vegetation filter belts with different configurations were constructed. The purification effects of vegetation filter belts on several pollutants in surface runoff were tested by experiments, and the influencing factors were analyzed.

1. Introduction

The environmental hydrogeological survey of polluted sites can be divided into two stages, one is the confirmation survey of pollution, the other is the detailed survey stage. The investigation stage of pollution confirmation is mainly through collecting the original and present related materials of the site, checking the relevant information, recording interviews with the staff, knowing as much as possible the ways of pollution in the site, the polluted areas and the types of pollution. Finally, through the identification of pollution in the site, the scope of key investigation is demarcated, and at the same time, the key investigation areas are demarcated. Sampling analysis was carried out in a relatively large range of contamination probability to determine whether there were contaminants in the site. If the results of sampling show that the site is polluted, more detailed and comprehensive investigation and analysis of the site is needed.

2. Main Contents

For the environmental hydrogeological survey of polluted sites, we need to focus on the following key points:

(1) Understanding the hydrogeological conditions of the polluted site environment, including the distribution, burial, dynamic changes and water level of groundwater, as well as the overall flow velocity, flow direction and discharge conditions of groundwater.

(2) Identify the changes in production activities in the polluted sites, and determine the main sources, current situation and ways of pollution in the polluted sites.

(3) Investigate the distribution and quality of groundwater and soil pollution in polluted sites:

(4) After the above investigation, we need to evaluate the environmental risk of the polluted sites, and give some measures and suggestions.

2.1 Workflow

Our hydrogeological survey of polluted sites is mainly based on searching for information and investigating the situation of polluted sites. It also combines the risk assessment of the environment with the calculation and analysis of pollution. Finally, we get the results of risk assessment of the environment and the measures and suggestions for the treatment of pollution. The specific

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workflow is shown in Figure 1.

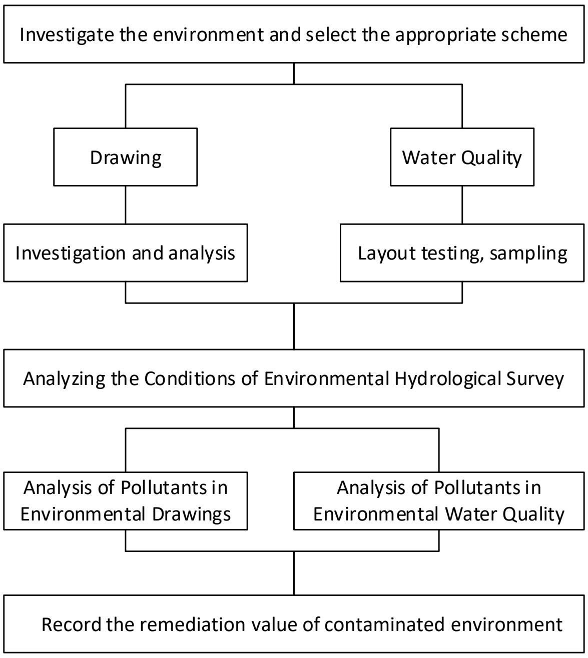

Fig.1 The specific workflow

2.2 Technical Requirements

There are three main technical requirements for hydrogeological survey of polluted sites, namely, the establishment of survey sites, detection requirements, risk assessment of the environment and suggestions for its control. The following four requirements for technology are described in detail:

(1) With regard to the establishment of survey sites, we need to set up survey sites for potential pollution areas, and the number of survey sites needs to be satisfied to be able to distinguish whether the site is polluted or not. In each suspected contaminated area, we need to set up at least three observation points, and at least three detection wells for groundwater near the contaminated site. We need to consider both regional survey sites and groundwater detection wells. In conducting detailed surveys, we need to set up points with a uniform grid. Grid is mainly used in sites with a wide range of pollution. The number of grid points should be determined according to the overall area of the polluted sites evaluated and the number of potential pollution sources.

2.3 Purification of COD by vegetation filter belt

In the process of rainstorm runoff, besides bringing chemical fertilizer and other pollutants into the receiving water, a large amount of natural organic matter in the soil is also brought into the receiving water. In Guanzhong area of Shaanxi Province, the ratio of soil organic matter to soil organic matter is about 1.11%, with Xi'an as the highest, followed by Baoji, Tongchuan, Weinan and Xianyang. Natural organic matter in soil contributes greatly to COD in rainstorm runoff. Therefore, it is necessary to analyze the purification effect of vegetation filter belt on COD. The experimental results are shown in Table 1.

The reduction rate of COD concentration and COD load in filter belt is over 60.48% and 77.97% respectively. The effect of vegetation filter zone on COD reduction is similar to that of PN and PP reduction, because the organic matter in surface runoff is mainly caused by surface soil erosion. Intercepting suspended solids and blocking flow are important ways to reduce COD in surface runoff. In addition, comparing the different concentration test results, the inflow concentration has a greater impact on the purification effect of vegetation filter belt. In the case of large inflow concentration, the reduction rates of COD in surface runoff by 1 # and 3 # vegetation filter belts are higher. The reduction rates of COD in 1 # filter belt are 75.53%, and that in 3 # filter belt are 78.95%.

Table 1 COD removal effects in different VFSs

Test Sequence Number (VFS Number)	Inflow volume /($m^3 \cdot s^{-1}$)	R_w/%	Chemical oxygen demand			
			C_{enter}/(mg·L-1)	$C_{come/}$(mg·L^{-1})	R_C/%	R_L/%
1（3#）	0.0023	81.47	78.0	26.0	66.67	93.82
2（3#）	0.0023	76.32	88.0	25.0	71.59	93.27
5（1#）	0.0023	54.21	85.0	27.0	68.24	85.46
7（2#）	0.0023	48.70	85.5	25.0	70.76	85.00
4（3#）	0.0038	75.08	83.5	27.0	67.67	91.94
8（2#）	0.0038	44.25	83.5	33.0	60.48	77.97
3（3#）	0.0023	79.25	133.0	28.0	78.95	95.63
6（1#）	0.0023	58.40	118.5	29.0	75.53	89.82

2.4 Comparison of Purification Efficiency of Vegetation Filter Belt under Different Bandwidth

By comparing the changes of N, P and COD concentration in the outflow of 3_10 m section and 15 m section in the same discharge process from Fig.1, it is found that the N, P and COD concentration in the runoff of No. 1 and No. 2 discharge tests are not reduced in the 10-15 m section, and the concentrations of N, PP, TN, TP and COD in the 15 m section of No. 3 and No. 4 discharge tests are slightly lower than those in the 10 m section. However, the inflow concentration of No. 3 discharge test is higher and that of No. 4 discharge test is larger, which indicates that when the inflow concentration or inflow flow is larger, a wider bandwidth of filter band is needed to intercept pollutants and reduce runoff velocity. In addition, the concentration of DN and DP changed little in the 10-15 m range, that is, when the balance of nitrogen and phosphorus in surface soil and DN and DP in runoff reached, the concentration would not change significantly.

Table 2 Several pollutants load reduction in different width of the 3# filter strip

Test serial number	bandwidth /m	$R_{W/}$%	Load reduction rate /%						
			TN	PN	DN	TP	PP	DP	COD
1	10	81.5	91.3	97.9	80.6	97.2	97.9	81.0	93.8
	15	96.3	98.3	99.6	96.2	99.4	99.6	96.3	98.8
2	10	76.3	89.8	97.6	75.8	96.6	97.4	71.8	93.3
	15	93.2	97.0	99.3	93.0	99.0	99.3	92.1	98.1
3	10	79.3	93.4	98.3	79.9	97.9	98.4	84.9	95.6
	15	94.3	98.3	99.6	94.5	99.5	99.6	96.1	98.9
4	10	75.1	88.6	96.6	75.1	96.2	96.8	91.2	91.9
	15	92.4	96.6	99.1	92.5	98.9	99.1	97.1	97.6

The results of four drainage tests show that the concentration of nitrogen, phosphorus and COD in the 10m section of the filter belt is basically the same as that in the 15m section, and the concentration reduction rates of the two sections are similar. Therefore, water reduction becomes the main factor affecting the load reduction rate of these pollutants in vegetation filter belts. Obviously, for the same filter zone, with the increase of runoff flow distance, surface runoff will continue to decrease, and the reduction rate of pollutant load in vegetation filter zone at 15 m is higher than that at 10 m, as shown in Table 2.

The concentration reduction of N, P and COD in surface runoff by 10 m wide grassland filter band is more than 98% of that by 15 m wide filter band, and that by 10 m wide grassland filter band is more than 75%, accounting for 81% of that by 15 m wide filter band. The results showed that the reduction of these pollutants mainly occurred in the first 10 m of the 3 # grassland filter belt, and increasing the bandwidth of the filter belt after that could not significantly increase the purification effect of the filter belt. In addition, as mentioned above, the 1# and 2# filter belts are seabuckthorn-herb filter belts with a bandwidth of 10 m. Under similar conditions (2,5,7 test), the reduction rates of TN concentration by 1#, 2# and 3(10 m) filter belts are 55.01%, 56.74%, 56.82%, TP 84.44%, 85.57%, 85.46%, COD 68.24%, 70.76%, 71.59%, PN 88.25%, 87.9%, 89.79%, PP.02%, 88.33%, respectively. See 1 #, 2 # filter belt and 3 # filter belt (10 m) concentration reduction rate is close, which also shows that the concentration reduction of pollutants mainly occurs in the first 10 M segment of the filter belt.

3. Conclusion

The reduction of vegetation filter zone is mainly achieved through physical interception process. The filtering conditions, inflow flow and inflow pollutant concentration are important factors affecting the vegetation purification effect in the zone. Vegetation filter belt can effectively reduce the load of water-soluble nitrogen (DN) and water-soluble phosphorus (DP), but the filter belt has little influence on the concentration change of DN and DP in surface runoff. When the concentration of DN and DP in runoff is high, the concentration of DN and DP can be reduced by the adsorption of surface soil. The purification efficiency of PN, PP, TN, TP and COD in surface runoff by vegetation filter belt decreases with the increase of inflow flow rate, and the change of flow rate has a great influence on the purification efficiency of seabuckthorn-herb filter belt with underdeveloped herbaceous community.

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