EFFECT OF VEGETATION GROWTH IN DRAINAGE CANALS ON WATER MANAGEMENT

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Abstract. In 2002 a new regulation was adopted in the Netherlands to protect flora and fauna. As a consequence mowing of drainage canals will be restricted during the growing season leading to vegetated canals that may hamper the discharge of water. In the summer of 2006 a field experiment has been executed in combination with a model study to investigate the effects of vegetation growth in the Fliert, a drainage canal located in the central part of the Netherlands. The field experiments showed extensive vegetation growth in absence of mowing. For the model study SOBEK Rural was used to evaluate different rainfall and vegetation (mowing) scenarios. From the model study it could be concluded that vegetation growth in combination with high rainfall can lead to water management problems. This means that if mowing is not allowed alternative measures are necessary. Unfortunately, model results could not be validated due to a relative dry summer.

1. Introduction

To comply with European legislation the Netherlands adopted the Flora and Fauna Law in April 2002 to protect plant and animal species. One of the activities that became restricted under this law is mowing and clearing of drainage canals during part of the growing season. So far water boards have been able to obtain exemptions to clear the drainage canals because of the uncertainties in the effects of vegetation growth on the drainage of low lying polders. However, it is expected that these exemptions will be more difficult to obtain in the future. It is therefore important to

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investigate the possible effects of vegetation in drainage canals and its impact on water management in the Dutch polders.

2. Research Approach

To investigate the vegetation growth that occurs when maintenance is omitted a field experiment was conducted in 2006 in the Fliert, a drainage canal in the district of water board Veluwe in the central part of the Netherlands. The Fliert flows from Lake Bussloo and drains 9.5 km north in another drainage canal. Surrounding land use is mainly agricultural. Over a stretch of approximately 100 m no mowing and clearing was performed until July 15. Plant species and abundance were monitored every three weeks. Water levels and related discharge were recorded every fifteen minutes.

Besides field observations a model study was performed to evaluate the possible effects of vegetation on polder drainage. For this purpose SOBEK Rural [1] was used to calculate discharges and water levels in the Fliert for various rainfall and vegetation scenarios. SOBEK Rural consists of a rainfall-runoff module, based on water balance calculations for separate elements, and a 1D channel flow module, based on the Saint Venant equations.

3. Model study

3.1. Rainfall scenarios

To evaluate the effect of different rainfall intensities and distributions, six rainfall scenarios were used: a constant rainfall of 2 mm/day, statistical 8-day rainfall events with a recurrence time of 1, 10, 25 and 100 years (T = 1, 10, 25 or 100), and a rainfall distribution based on an extreme event measured in November 2005 near the location of the study area. The T=1-100 rainfall events were obtained from [2]. The cumulative rainfall of these statistical events follows a power law with the highest rainfall intensity after one hour reducing to less than 1 mm/hour within the first day followed by a gradual decrease in the next 7 days. Total rainfall for these events is 71, 103, 115 and 133 mm, respectively. The extreme rainfall event is characterized by high rainfall on the first three consecutive days, with an extreme rainfall of 68 mm on the second day and a total rainfall of 125 mm. For comparison, the annual rainfall in the Netherlands amounts 750 mm.
3.2. Vegetation scenarios

Vegetation roughness can be described by different methods in SOBEK Rural. For this study was chosen for the De Bos and Bijkerk method [3] which is based on Manning’s equation where the Manning coefficient is defined as a function of water depth \( h \) to account for the additional resistance of vegetation with increasing water depth compared to bed roughness. The equation is given by:

\[
Q = \gamma h^{1/3} \cdot A \cdot R^{2/3} \cdot s^{1/2}
\]

where \( Q \) is the discharge, \( \gamma \) a roughness coefficient of which the value is set equal to the value of the otherwise used Manning coefficient, \( A \) the cross sectional area, \( R \) the hydraulic radius, and \( s \) the bed slope. Veldman [4] performed a comparison study where five different vegetation roughness descriptions were compared based on calculated discharges for a typical drainage canal, different water levels and roughness scenarios. In this study the method of De Bos and Bijkerk gave similar results as the method of Baptist et al. [5]. The method of Baptist et al. is derived by genetic programming and appears to be a good approximation for a wide range of vegetation types and flow conditions. This gives confidence in the suitability of the De Bos and Bijkerk method in describing vegetation roughness.

To model the effect of different vegetation developments five scenarios were used corresponding to different values for \( \gamma \) of the De Bos and Bijkerk method: a clean canal (\( \gamma = 30 \) s\(^{-1}\)), limited growth (25 s\(^{-1}\)), moderate growth (15 s\(^{-1}\)), significant growth (10 s\(^{-1}\)) and extreme growth (5 s\(^{-1}\)). The same roughness was applied to the entire watercourse.

4. Results

4.1. Field experiment

Figure 1 gives an impression of the vegetation growth in the Fliert at different dates during the growing season. It is clear from this experiment that when mowing is omitted extensive plant growth occurs in the canal and on the banks. This can be expected when sufficient nutrients are supplied by surrounding farm lands. Unfortunately the summer of 2006 was very dry causing very little flow. As a consequence the model could not be validated with data from the field experiment.
4.2. Model study

For the 2 mm/day and T=1 rainfall scenario the drainage capacity of the Fliert remains sufficient even for the case with extreme vegetation growth. Problems start with the T=10 scenario. Figure 2 shows the maximum water levels calculated during the 14 days simulation period for the T=10 rainfall event and the five roughness scenarios. Also given are the elevation of the streambed and ground level. Longitudinal changes in water level are due to weirs or changes in width of the Fliert. After 9.5 km the Fliert flows into another drainage canal which is under influence of a pumping engine that maintains the water at a constant level. It can be seen that for the extreme and significant roughness scenarios ($\gamma = 5 \text{ and } 10 \text{ s}^{-1}$) inundation may occur at a distance of about 6.5 km from Lake Bussloo. This location is known by water board Veluwe as prone to flooding. For the T=100 rainfall event, inundation takes place at the same location for all roughness scenarios except the clean canal ($\gamma = 30 \text{ s}^{-1}$). The extreme rainfall event causes flooding for all roughness scenarios at this and other locations.

Although the total rainfall during the T=100 and the extreme case are similar (133 vs. 125 mm) the inundation problems for the extreme case are more severe. This can be explained by the discharge distribution: the discharge generated by the T=100 rainfall event is more evenly distributed, while the extreme event, with nearly all rainfall in the first three days, results in a more pronounced discharge peak. With increasing vegetation roughness the maximum value for the discharge...
decreases but elevated discharges extend over a longer time. Although the maximum discharge is

Figure 2. Maximum water levels along the Fliert calculated for different vegetation roughness values and an 8-day rainfall event with recurrence time of 10 year (T=10).

reduced by the vegetation, the water level increases with increasing roughness. This means that the $Q$-$h$ curve is significantly altered by plant growth. The average increase in maximum water level along the Fliert from a clean canal to a canal with extreme growth is approximately 30 cm for all statistical rainfall events. Locally the vegetation can cause the maximum water level to increase up to 50 cm or in some cases more than triple the water depth for a clean canal. Although the maximum water levels for the extreme case are higher than for the statistical rainfall events, the increase in maximum water level due to vegetation is less, ca. 15 cm. This is similar to the increase in maximum water level for the nearly stationary case with a constant rainfall of 2 mm/day.
5. Conclusions

The central question of this research was: will the new restrictions to mowing and clearing of drainage canals lead to water management problems? The field experiment in the Fliert shows that when maintenance of the drainage canals is omitted extensive vegetation growth occurs. The model study indicates that inundation problems may occur for statistical rainfall events with a recurrence time of 10 years or more and increase with increasing vegetation roughness. A calculation based on a real rainfall event measured in November 2005 showed inundation problems at more than one location for all vegetation scenarios. It can be concluded that vegetation growth in drainage canals hampers the discharge and increases the probability of flooding during high rainfall events. If mowing is not allowed during part of the growing season alternative measures are necessary to avoid inundation problems. Effective measures are widening the stream or construction of retention ponds.

References

1. http://delftsoftware.wldelft.nl/