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River restoration what does it mean: the restoration of the ecosystem and/or the restoration of dynamics (Monitoring the embankments of the river Hollandsche IJssel)

J.H. Doze, M.A.A.J. Kamps-Mulder, F.C.M. Kerkum, J. Oosterbaan and H.G. van Bommel

ABSTRACT: The Hollandsche IJssel is a severely polluted tidal river in the southwest of the Netherlands, between the cities of Rotterdam and Gouda. Due to its canal-like character, the river does not have any dynamic tidal zones, for which reason the relevant authorities want to focus on a cleaner and a more scenic Hollandsche IJssel. To achieve these objectives, the polluted sediment will be cleaned up and the river restored to its original values. However, the ultimate effects of such interventions are not yet known. The RIZA (Institute for Inland Water Management and Waste Water Treatment) has set up a seven-year monitoring programme to gain an understanding of these effects. The monitoring centres on ecological, ecotoxicological and morphological aspects. The innovative set-up of this programme should make it possible to use the research results for the restoration of other riverbank areas. The monitoring checks unwelcome developments so that new management measures can be put forward or designed. After five years of monitoring, the first results have become known: insight into the decontamination and restoration, for example. In general, the ecological quality has improved since the intervention. The ecological risks ("ongoing poisoning") and the effects of pollution on the aquatic system have decreased or even disappeared.

KEYWORDS: ecosystem, restoration, dynamics, monitoring, ecological quality

Introduction

The Hollandsche IJssel is a tidal river in the southwest of the Netherlands between the cities of Gouda and Rotterdam. Due to its canal-like character, the river has no dynamic tidal zones. At the same time, the river bed and the embankments of the Hollandsche IJssel are severely contaminated with sludge. The embankments have been raised with contaminated waste material. In addition, intensive shipping has caused erosion of the sediment layers and the embankments. To bring about a cleaner and more natural Hollandsche IJssel again, it was decided to have the river completely cleaned up. The purpose of the integral clean-up operation is to remove contaminated sediment and redevelop the embankment.

In 2000, the Moordrecht-Oost site was cleaned up and redeveloped. These clean-up and redevelopment processes have resulted in a nature-friendly riverbank characteristic of a freshwater tidal river. Since redevelopment, a gully has developed at an upstream fork. The resulting mini peninsula has been reinforced with a layer of rubble. Furthermore, the mudflats which are so characteristic of a tidal river can be found here; they are flooded at high tide and emerge at low tide. In 2001, the Nieuwerkerk aan den IJssel site was also cleaned up and redeveloped, which resulted in a nature-friendly embankment.

The slope of the embankment is very gentle and it has been filled in with sea sand. The fairway side has a rubble dam, which is submerged most of the time. The area shows an occasional low relief, and in the lower spots the water is stagnant at low tide. The area has an open character.

The study

There is, at this moment, a need for knowledge about the effects of the clean-up and redevelopment operations. That's why the Department of Transport, Public Works and Water Management, Directorate South-Holland commissioned the RIZA, to develop a monitoring programme to improve this knowledge. The project involves a seven-year monitoring programme to evaluate the effects of the combined clean-up and redevelopment operations at the two embankment sites of the Hollandsche IJssel. The programme will also evaluate the need to clean up and/or redevelop the embankment sites. This objective will be accomplished by monitoring ecological, ecotoxicological and morphological developments. Data are collected according to the following parameters: macrofauna, nematodes, ecotoxicology, vegetation, birds, fish, river bed and sediment quality, morphology and water quality. For the purposes of this study, three sites were chosen to represent żwhat goes on' in the Hollandsche IJssel, namely: Moordrecht-Oost, Nieuwerkerk aan den IJssel and reference site Balkengat. The study has been specifically designed so that research results can be converted for use in other areas.

After five years of research, the first results have become known. The most indicative results will be discussed below.

Results

Sediment quality

The sediment quality at the Balkengat reference site is quite stable and is a good reflection of current contamination levels in the non-cleaned section of the river (Dutch quality standards: category 3 to 4). At Moordrecht-Oost, the overall sediment quality after clean-up is Dutch quality standards: category 2. At Nieuwerkerk aan den IJssel, the quality after clean-up is Dutch quality standards: category 0 to 2.

Ecotoxicology

The ecotoxicological study provides an understanding of the impact of chemical contamination on the aquatic ecosystem. By using bioassays, the resulting effects in the field inventory can be linked to the sediment and site-specific conditions.

To gain insight into the ecotoxicological consequences of the clean-up and redevelopment of the Hollandsche IJssel sites, effects in bioassays have been classified by colour, which range from dark red (great deal of effect) to green (no effect) (see figure 5). Another point of study was whether effects were explainable on the basis of substance levels measured. If this was the case, it would mean that an ecotoxicological risk existed. This is shown in the diagram by hatching. Diagonal hatching means that ecotoxicological risk was apparent. The interpretation of an ecotoxicological risk was carried out with the result of the bioassays and field-assays (macrofauna not included); the effect data must therefore be viewed separately from the chemical data.

Table 1: Overview of the effects found in bioassays, and the ecotoxicological risks at the Moordrecht-Oost, Nieuwerkerk aan den IJssel and Balkengat sites for wet and wet/dry zones during the three years of research. "after" = after the operation, "before" = before the operation.

Moordrecht-Oost	**2000 T0 after**	**2001 T1 after**	**2002 T2 after**
wet			
wet/dry			

Nieuwerkerk aan den IJssel	**2000 T0 before**	**2001 T0 after**	**2002 T1 after**
wet			
wet/dry			

Balkengat	**2000 T0**	**2001 T1**	**2002 T2**
wet			
wet/dry			

No effect
Minimal effect
Noticeable effect
Strong effect
Ecotoxicological risk found

Moordrecht-Oost

For the wet zone, effects on organisms were found immediately after the operation and there was clearly an ecological risk factor. One year after the operation, effects were found on organisms, but no further ecotoxicological effect/risks could then be shown. In the second year after the operation, no further effects were found on the organisms. There had been a clear decrease in effects on organisms, a decrease in contamination and a decrease in the availability of the contamination present at the site.

For the wet/dry zone, many effects were found immediately after the operation and there was clearly an ecological risk factor. One year later, a slight decrease in effects on organisms was found, but the ecotoxicological risk was still present. The second year after the operation shows a continued decrease in the effect on organisms, but there was still an ecotoxicological risk even at this time. It is expected that, in particular, the sedimentation of cleaner sediment will increase, and the effects on organisms and the presence of contamination will further decrease.

Nieuwerkerk aan den IJssel

For the wet zone, effects on organisms were found, but no ecotoxicological risk could be shown. Effects were still found on organisms immediately after the operation, and because of an increased availability of the contamination, a risk of biomagnification

was also established. One year after the operation (T1 after), a slight decrease was found in the effects, but the contamination was still present. Ecotoxicological risk was still apparent in the wet zone. There does, however, seem to be a slight improvement.

For the wet/dry zone, many effects were found on organisms before the operation, and an ecotoxicological risk could be shown. Immediately after the operation, a slight decrease was found in the effects on organisms, but the ecotoxicological risk was still present. One year after the operation, the effects on organisms in laboratory bioassays had decreased considerably and there were no longer signs of ecotoxicological risk.

Balkengat

The Balkengat site serves in this study as a "polluted" reference, which has not been cleaned up. For the wet zone, many effects were found on organisms in all three research years and an ecotoxicological risk was also shown. For the wet/dry zone, effects were found on organisms in T=0 and T=1 and an ecotoxicological risk could be shown. In 2002 (T=2) no effects were found on organisms, and no ecotoxicological could be shown. No reason was found for this.

Macrofauna & Nematodes

Within a water-ecosystem, the river bed is an important factor and serves, among other things, as a habitat for macro and meiofauna. Macrofauna and nematodes are used as representatives of meiofauna to evaluate the clean-up and redevelopment measures. Because of their strong interdependence on the sediment they are sensitive to contamination. Where cleaning up resulted in an improvement of the sediment quality, this is reflected in the recovery of the biotic community of the sediment. Macrofauna reproduces relatively fast, so that the effects are quickly visible within a few generations. Nematodes are still present when the macrofauna has already disappeared because of contamination. The testing of macrofauna, together with the testing of nematodes gives a good understanding of the situation of the relevant ecosystem. Cleaning up and redeveloping the sites can create conditions in which the desired species can be restored.

Macrofauna

Information about the numbers of species, densities and biomasses macrofauna that should be present in a clean, non-contaminated river bed is available. If these numbers lag behind, we can speak of a disturbed biotic community. The extent of this disturbance is an indication of whether we can speak of no, a noticeable or a strong effect.

Figure 1 shows that after cleaning up the Moordrecht-Oost site, the strong effects (red) are clearly decreasing. Cleaning up has therefore had a positive impact on the biotic community. The decrease is not shown for the Balkengat reference site, because no measuring took place there. The development of the density of characteristic macrofauna for the freshwater-tidal area at the Moordrecht-Oost site, which was cleaned up and redeveloped in 2000, and the Balkengat reference site is shown in figure 2 (Balkengat was not measured in 2000). It is clear that the cleaning up and redevelopment at Moordrecht has brought about a positive development, because the characteristic species of the freshwater tidal area have returned.

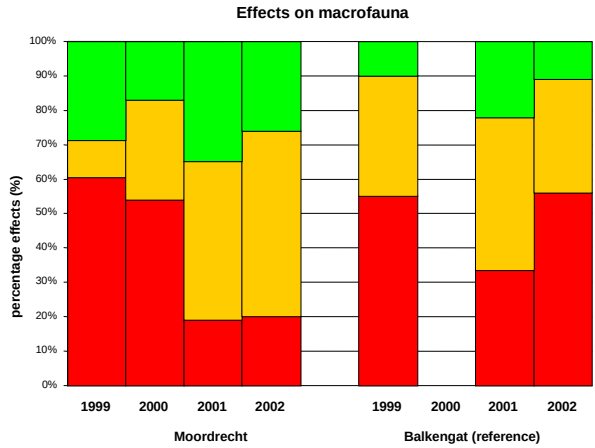

Figure 1: The effects of the contaminated sediment on macrofauna near Moordrecht-Oost and Balkengat in the period 1999-2002. No macrofauna sampling took place at Balkengat in 2000.

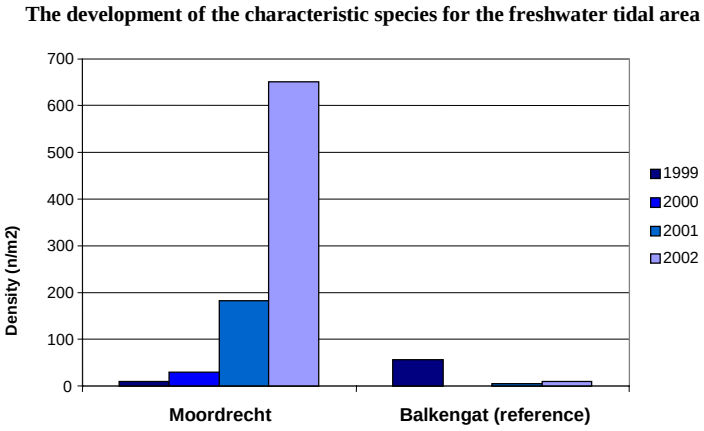

Figure 2: The development of the characteristic species for the freshwater tidal area at Moordrecht-Oost and Balkengat in the period 1999-2002. No macrofauna sampling took place at Moordrecht-Oost in 2000.

Nematodes

Over the years, nematodes have developed two strategies to maximize the number of their progeny. Characteristic for the first strategy is a short life cycle and high reproduction rate, while the second has a long life cycle and a low reproduction rate. The species with a short life cycle are highly effective in quickly colonizing new areas – cleaned up and redeveloped sites – and they are consequently known as colonizers. The species with a long life cycle are well able to compete with other species and they occur in stable habitats, which change very little. These species are known as persisters.

Factors that determine the ratio of colonizers to persisters are the food supply and the presence of contamination. To determine the ratio between colonizers and persisters, an index has to be calculated. This index, known as the Maturity Index, is the calculated average of soil borne colonizers and persisters. The nematode groups are classified on a scale of 1 to 5, whereby 1 represents a true colonizer and 5 a real persister. The higher the value of this index, the more stable the habitat.

The Hollandsche IJssel study shows that nematode populations react positively to their new habitat after the clean-up and redevelopment operations of some embankments, and they are therefore an indicator for whether or not the sediment is functioning properly. This is represented in diagrams 3 and 4 for the non-cleaned-up Balkengat site and the cleaned-up Moordrecht-Oost site. A position top left in the diagram suggests eutrophic conditions, a position bottom left suggests contaminated conditions and a position bottom right suggests optimum conditions. No changes were found at the Balkengat site. The Moordrecht site, however, first turned eutrophic (nutrient-rich), after which the change to optimum conditions commenced.

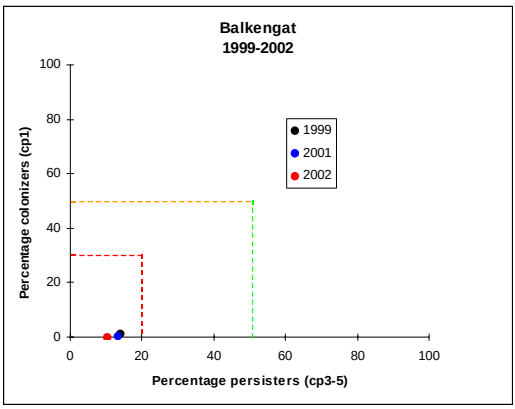

Figure 3: Diagram of the changes in habitat conditions at the non-cleaned-up Balkengat site.

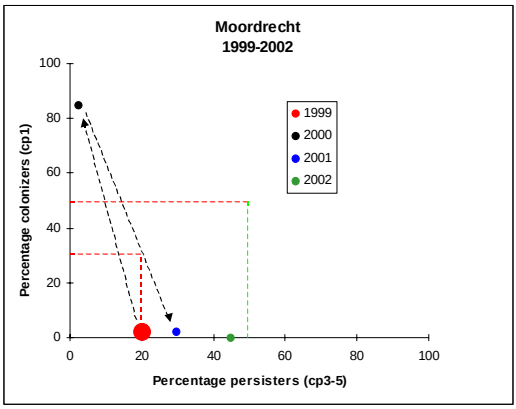

Figure 4: Diagram of the changes in habitat conditions at the cleaned-up Moordrecht-Oost site. The large red dot represents the situation before the clean up. The arrows represent the sequential habitat conditions.

Conclusion

Densities, numbers of species and ecological quality have generally increased, as compared with the situation before the clean up. The biotic communities are more in balance. This tendency can be attributed to the almost complete elimination of the contamination (clean-up). Generally speaking, we can conclude that there is a definite decrease in the effects of the contamination on organisms, a decrease in the amount of contamination, and a decrease in the availability of the contamination present. Risks of biomagnification and the effects on organisms are rarely, if ever, found again, which is due to the clean-up operation. However, the situation is not quite stable yet.

Contamination is still present in small quantities. Some ecological risks are still shown at places in the wet/dry biotope of Moordrecht-Oost. These are probably areas where the contaminated sediment has not been completely cleaned up. A clean-up operation such as the one at Moordrecht-Oost does not remove the contamination for a full one hundred percent. In practice, some eighty percent of the contamination can be eliminated. The effects and risks which were found immediately after the cleaning up and redevelopment at Nieuwerkerk aan den IJssel are probably the result of the increased availability of contamination because of the presence of lutum-poor and organic-poor sand, which types do not bond well to contamination. The situation may improve over the years.

A combined approach of cleaning up and redevelopment measures is feasible, responsible and ideal for the Hollandsche IJssel.

This combined approach also preserves the reed border (dry biotope), which means there is no foreseen ecological risk of natural degradation, and the first metres of the wet/dry and wet biotopes are removed and refilled with clean sediment (organic, clayey sediment). Selective monitoring is strongly recommended in such a combined approach.

Discussion

Redevelopment is also an important link in the restoration of the river. This will encourage the development of biotopes and processes in the Hollandsche IJssel that are part and parcel of a clean freshwater tidal river. The ecosystem can recover more fully and more quickly in this new environment. The consolidation of the natural processes is probably a 'must' for the restoration and development of the new ecosystem.

Literature

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Authors:

J.H Doze (project leader), M.A.A.J. Kamps-Mulder (ecotoxicology), F.C.M. Kerkum (nematodes), M. Kolen (water quality), E.M. van der Laar (multivariate statistics), J. Oosterbaan (macrofauna), A, van der Scheer (sediment quality), T.A.H.M. Pelsma (vegetation and fish) and R.A. Struijk (measuring coordinator).

RIZA (Institute for Inland Water Management and Waste Water Treatment), J.H. Doze, P.O. Box 17, 8200 AA Lelystad, The Netherlands, j.doze@riza.rws.minvenw.nl