science summary

Environment Agency

www.environment-agency.gov.uk

SCHO0508BOAD-E-P

Highway runoff: Effects of soluble pollutants on the ecology of receiving waters

Science Summary SC020033

A tool to assess the risks to aquatic organisms from highway runoff has been developed by scientists from WRc and King's College London, working with the Environment Agency and Highways Agency. Using this tool, engineers can assess the environmental aspects of new road projects whilst Environmental Agency staff can advise on the risks from highway runoff and pinpoint sites of particular concern.

After a period of rain, surface water from highways is often drained into nearby streams and rivers. However, we know that this runoff can contain pollutants, either in solution or bound to sediment particles. The Highways Agency has embarked on a programme to improve its methods for predicting the ecological impacts of new or modified highway drainage schemes. This would be used to highlight those schemes where risk reduction steps might be necessary to ensure they would not affect local ecology. Schemes should also satisfy the chemical requirements of the Water Framework Directive in the receiving water by not breaching Environmental Quality Standards (EQSs).

The research programme comprises three projects:

- *Improved determination of pollutants in highway runoff*
- *Effects of insoluble pollutants on the ecology of receiving waters*
- *Effects of soluble pollutants on the ecology of receiving waters*

This summary refers to the last project, carried out in collaboration with the Environment Agency.

The first step was to develop runoff-specific thresholds (RSTs). These are water quality benchmarks designed to protect organisms from short-term (six and 24 hour) exposure to substances which have previously been measured in the dissolved phase of highway runoff at significant concentrations (such as cadmium, copper, zinc, fluoranthene and pyrene). Although EQSs are already available (or are near completion) for these substances, they protect against long-term exposure and do not adequately account for the very short periods of exposure typically seen with highway runoff (where the average duration is four hours).

RSTs were derived by analysing published ecotoxicity data from experiments carried out over short periods or studies initiated by Kings College London for this project. Thresholds were generated using a probabilistic or deterministic approach depending on the quantity and quality of available short-term (six and 24 hour) toxicity data. Two RSTs were developed for each substance: the RST_{24h} is a stringent threshold below which aquatic organisms are not expected to be at risk. In contrast, exceeding an RST_{6h} would mean receiving water organisms are probably at risk. Where samples have concentrations between the RST_{24h} and RST_{6h} values the receiving water organisms are probably not at risk, but this requires confirmation. Metals are problematical because their toxicity is affected by water hardness, so the effects of hardness need to considered.

Chemical analyses of sampled highway runoff showed that mean concentrations for cadmium, fluoranthene and pyrene were always markedly lower than the derived RSTs, and so these substances are not likely to pose a risk. Only the RSTs for copper and zinc are required to assess the impact of highway runoff on receiving water communities. For these substances, the RSTs are more likely to be exceeded in undiluted highway runoff when traffic density is high (band 5: AADT 80,000 to 119,999 and band 6: AADT 120,000 to 200,000). However, we saw no effect of climatic zone. For both copper and zinc, more than 97 per cent of runoff samples posing a potential risk would require less than five times dilution to satisfy the RST_{6h} values, but a small group of samples contained high dissolved zinc concentrations that would need greater dilution.

We validated this approach using previously collected chemical and biological data. Information on pollutant concentrations in highway runoff and biological survey data from a previous project were used to compare

predicted and measured effects of a range of runoff events on the receiving water organisms.

The tool uses a two-tier approach. In the first tier, levels of substances in highway runoff (before and after treatment) at several sites are compared with RSTs to assess whether there is a potential for ecological impact. The second tier focuses on locations where pollutant concentrations in untreated and/or treated runoff have exceeded one or more RST. The method determines whether the RST exceedance(s) would be removed by dilution downstream of the runoff or by local water quality conditions (such as hardness).

We were concerned not to propose thresholds that were too precautionary (which might prompt unnecessary action) or which were not stringent enough (and thus fail to protect aquatic organisms). Therefore, we compared our predictions with the results of biological surveys (*in situ Gammarus* deployments) carried out at the Voss Stream site, near Plympton, Devon which receives runoff from the A38. The available evidence was limited but there was no indication that the RSTs were too precautionary. We could not tell from the limited data whether or not they were under-precautionary.

To summarise, RST_{24h} values are derived using 24-hour exposure data for soluble pollutants. This is precautionary because 24 hours is longer than the average exposure of four hours that organisms are likely to experience in receiving waters during highway runoff events. RST_{6h} values for copper and zinc are more realistic thresholds for assessing risks.

If the design process shows that the RST_{24h} will be achieved, it is predicted that highway runoff (either before or after treatment) will not cause short-term adverse effects in a receiving water.

If the design process shows that the RST_{24h} will not be met, there is a possibility of short-term adverse effects in the receiving water. The tool uses a graded classification: 'not at risk', 'probably not at risk' and 'probably at risk' using RST_{24h} and RST_{6h} values for copper and zinc.

Based on these principles, we have developed an assessment tool to predict the impact of highway runoff discharges on the ecology of receiving waters. This can be used by engineers and by Environment Agency staff to assist in the future design of highway drainage schemes. It will help focus attention on those sites where there is a risk from pollutants in road runoff and, also, to avoid investing resource in situations where there is no risk to ecology.

The tool: (1) predicts the range of concentrations of copper and zinc in untreated undiluted highway samples over a long release period (ten years); (2) identifies how frequently (and for what duration) the RST_{24h} and RST_{6h} for copper and zinc may be exceeded at a given site; and (3) identifies the level of treatment and/or dilution required to achieve the RSTs in the receiving water.

In Tier 1 of the tool's approach, RST_{24h} values are used as stringent design standards and these can be compared to predicted runoff concentrations of zinc and copper in undiluted highway runoff at a location (effectively a "worst case" scenario). Further precaution is provided by setting the frequency of exceedance at a stringent level (such as only once per year) so that non-risky schemes can quickly be screened out.

In Tier 2, the assessment becomes more realistic and includes the use of RST_{6h} values which are designed to protect receiving water organisms against exposure to copper and zinc over timescales typically found during highway runoff events. It also takes into account factors such as treatment prior to discharge, available dilution in the receiving water as well as the physico-chemical characteristics of the receiving water (like hardness).

This summary relates to information from Science Project SC020033, reported in detail in the following output(s):

Science Report published by the Highways Agency:
Title: Highway Runoff: Effects of soluble pollutants on the ecology of receiving waters

Internal Status: Released to all regions
External Status: Publicly available

Project manager: Paul Whitehouse, Environment Agency Science Department

Research Collaborator: Highways Agency

Research Contractor: WRc, Kings College London

This project was part-funded by the Environment Agency's Science Department, which provides scientific knowledge, tools and techniques to enable us to protect and manage the environment as effectively as possible.

Further copies of this summary and related report(s) are available from our publications catalogue on or our National Customer Contact Centre T: 08708 506506 or E: enquiries@environment-agency.gov.uk.