Reduction of zinc emissions from buildings; the policy of Amsterdam

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Abstract In Amsterdam zinc coming from the roofs and gutters of the buildings accounts for about 50% of the zinc emissions into the surface water (i.e. canals and rivers). This causes water and sediment pollution. Dumping strongly polluted sediment costs ten times more then dumping less polluted mud. Therefore the City of Amsterdam has developed a policy for reducing the zinc emissions from buildings based on the current environmental legislation and the current national targets for surface water quality. Zinc roofs on new and renovated buildings are not permitted. Run off water from zinc roofs of existing buildings is allowed to contain a maximum of 200 µg/l zinc. For the zinc gutters of houses, Amsterdam will promote measures to reduce zinc emissions. To investigate the feasibility of measures, research has been carried out on the zinc emissions of gutters and the effect of covering gutters with an impermeable foil. This research shows clearly that covering zinc gutters with EPDM foil reduces the zinc emissions by 90% from 8.5 to 0.88 gram per square metre per year including the atmospheric deposition.

Keywords Emissions from buildings; emissions reduction; gutters; local policy; water quality; zinc

Introduction In The Netherlands the zinc concentration of surface water doesn’t meet the objectives (Commission on Integrated Water Management, 2001). In a recent report by the national government, zinc is mentioned as a substance that causes a significant environmental problem. From this the building materials are cited as the most significant source of zinc emissions into surface water (Dutch Government, 2001). Table 1 gives a survey of the sources of zinc emissions into the surface water of The Netherlands (Harmelen et al., 2000).

The zinc industry is working to improve zinc as a building material. Research is carried out on another alloy of zinc which causes less emissions and on the possibilities for coating (Dutch Government, 2001). In case of another alloy of zinc the total zinc emissions from buildings will only be reduced, if this new alloy of zinc is used and the total amount of zinc on buildings doesn’t increase subsequently. The Dutch government and the zinc industry have agreed that if product innovation and the actual application of the new or the coated zinc is successful, the Dutch government will not take action to reduce the application of zinc. However, the Dutch government acknowledges the local government’s responsibility for solving their local environmental problems and for executing the environmental regulations.

In Amsterdam, zinc coming from the roofs and gutters of buildings accounts for about 50% of the zinc emissions into the surface water (Lugt, 1994). Table 2 gives survey results of the sources of zinc emissions into the surface water of Amsterdam. In 70% of the city, the sewerage system is separated from the rainwater system. The advantage of this system is that the sewage treatment plant functions better because the sewage water is not diluted by relatively clean rain water. On the other hand, polluted run off water runs directly into the surface water. As a result of the zinc emissions into the surface water, the sediment is strongly polluted with this zinc. In Amsterdam there is a high correlation between the...
outlets of the rainwater system and the concentration of zinc in the sediment (Clewits, 1996; Sluis, 1999).

According to the regulations in The Netherlands, the sediment is analysed before dredging and dumping. The results of the 1999 and 2000 analysis clearly show that fifty per cent of the mud with the highest degree of pollution falls within this category as a result of zinc alone. Dumping this mud costs ten times more than dumping of the less polluted mud. For this reason Amsterdam wants to reduce the emissions of zinc.

National policy in The Netherlands for reducing emissions of run off water gives priority to preventing pollution and where this is not reasonable, to treat the run off water at the source. The City of Amsterdam has developed a policy for reducing the zinc emissions from buildings, based on this general Dutch policy. To investigate the feasibility of measures, research was carried out on the zinc emissions of gutters and the effect of covering the gutters with an impermeable foil.

Legislation and national policy in The Netherlands

The Dutch environmental legislation is based on the principle: “As Low As Reasonably Achievable”. This means, that everyone has to do everything that is reasonable to limit the emissions of zinc into the environment (Dutch Government, 2001). In this context everything is considered reasonable, if the costs are recoverable within five years. These actions have to be set out in the Environmental Permit.

In 1998 the Dutch government laid down objectives for the maximum pollution of surface water. The interim target is that all surface water falls below the values of Maximum Permissible Concentration. At this value, 95% of the species in the water are protected. For many components a Maximum Permissible Concentration has been determined. For zinc this concentration is determined at 40 $\mu$g/l. In the long run the water quality has to be below the Negligible Concentration. The Negligible Concentration for zinc is determined at 12 $\mu$g/l.

As a basis for emission policy the National Commission on Integrated Water Management has developed a method to evaluate the acceptability of a discharge (Commission on Integrated Water Management, 2000). The main principle of this method is, that a discharge of zinc may not contribute significantly to the quality objectives for the surface water in which the discharge is deposited, being exceeded. Also the quality of the receiving surface water shall not deteriorate significantly.

<table>
<thead>
<tr>
<th>Source</th>
<th>% Zinc pollution of surface water</th>
</tr>
</thead>
<tbody>
<tr>
<td>Industry and agriculture directly</td>
<td>14</td>
</tr>
<tr>
<td>Road traffic and transport directly</td>
<td>29</td>
</tr>
<tr>
<td>Household, roofs and gutters of buildings directly</td>
<td>3</td>
</tr>
<tr>
<td>Industry, road traffic and transport, household, roofs and gutters via sewage treatment plant and overflow sewerage systems</td>
<td>39</td>
</tr>
<tr>
<td>Road traffic, roofs and gutters via run off sewerage systems</td>
<td>12</td>
</tr>
<tr>
<td>Atmospheric deposits directly into surface water</td>
<td>3</td>
</tr>
</tbody>
</table>

Table 1 Sources of zinc emissions into the surface water in The Netherlands (Harmelen et al., 2000)

<table>
<thead>
<tr>
<th>Source</th>
<th>% Zinc pollution of surface water</th>
</tr>
</thead>
<tbody>
<tr>
<td>Industry</td>
<td>28</td>
</tr>
<tr>
<td>Household</td>
<td>12</td>
</tr>
<tr>
<td>Road traffic</td>
<td>7</td>
</tr>
<tr>
<td>Roofs and gutters of buildings</td>
<td>52</td>
</tr>
<tr>
<td>Atmospheric deposits</td>
<td>1</td>
</tr>
</tbody>
</table>

Table 2 Sources of zinc emissions into the surface water of Amsterdam (Lugt, 1994)
As mentioned above the national policy for reducing the emissions of zinc is through making improvements in zinc as a building material. At the same time the Dutch government expects local governments to develop a policy to reduce the emissions of zinc and takes this into consideration when making environmental regulations (Dutch Government, 2001).

The policy of Amsterdam to reduce zinc emissions from buildings

Amsterdam has developed a policy to reduce the emissions of zinc from buildings into the surface water. This policy is based on the current environmental legislation and on the above mentioned current national targets for surface water quality. The starting point of this policy has been recorded in the Water Plan of Amsterdam. This plan describes all aspects of the surface water in Amsterdam and has been laid down by the Council of Amsterdam and the relevant Waterboards.

The zinc policy of Amsterdam makes a distinction between zinc roofs and zinc gutters. The zinc emissions from gutters are handled as diffuse pollution, because the effort to make and uphold demands for the run off from every individual household is not realistic. Therefore, the gutters are being approached differently. Zinc roofs on the other hand are a relatively big source of emissions but from fewer buildings. It is realistic to regard zinc roofs as a normal local source of emissions. A further distinction is made between zinc roofs of new buildings and those of existing buildings. For the zinc roofs of monuments a special approach is in force where replacement of the roof is not desirable.

Zinc roofs of new buildings

In the case of new buildings where the zinc roof hasn’t been fitted Amsterdam requires the use of a material which is not emitting to the environment. Because such a material is not necessarily more expensive than zinc, it meets the requirement of the principle of “As Low As Reasonably Achievable”. Applying a coating to the zinc is an alternative.

Zinc roofs of existing buildings

In the case of renovation, the roof of an existing building is considered to be a new roof. As mentioned above, this means that materials without emissions are required. In other cases it may not reasonable to demand the replacement of zinc. Where replacement is expensive it is therefore not according to the principle of “as low as can be achieved reasonably”. This does not mean that the run off water can be discharged as such. According to the national environmental legislation, demands for the run off quality are necessary to ensure the water quality of the surface water. Run off water that is led into the surface water directly or by a drainage system for run off water is allowed to contain a maximum of 200 µg/l zinc. This concentration is five times higher than the Maximum Permissible Concentration. As a result of dilution from other rainwater, it is expected that the desired surface water quality will be achieved. To comply with the demand of a maximum of 200 µg/l zinc a sophisticated treatment system is necessary.

The Council of Amsterdam sets out the maximum concentration as one of the requirements in the Environmental Permit of the building. If the run off water is led directly into the surface water, the building needs a special permit from the relevant Waterboard. The Waterboard also sets out the maximum concentration for zinc in this permit.

Zinc roofs of monuments

Amsterdam has a historic city centre with many monuments. Where a zinc roof forms an essential part of the appearance of a monument, it is usually not desirable to replace the zinc roof. Just as in the case of zinc roofs of existing buildings, the run off water must be treated
before discharge. Because the appearance of a monument should not be changed, not all
treatment systems are possible. This means that it is uncertain if a treatment system can be
selected whereby the concentration is below the maximum of 200 µg/l zinc. Setting out this
concentration in the Environmental Permit is therefore not realistic. The Environmental
Services Department will consult with the owner of the building about possible measures to
reduce the emissions of zinc. Then the most effective measure is entered in the
Environmental Permit.

**Zinc gutters**

Almost all gutters in Amsterdam are made of zinc. In relation to the run off water, there are
still no requirements for reducing the emissions. As mentioned above, efforts to make and
uphold demands on the run off from every individual house are not realistic. Therefore,
Amsterdam prefers to communicate with the house owners and promote measures to
reduce the emissions of zinc.

To investigate the feasibility of measures, research has been carried out on the zinc
emissions of gutters and the effect of covering gutters with an impermeable foil. The results
will be used to make an emissions survey of the total area of Amsterdam. Based on this
emissions survey, areas will be selected which are the most in need of emissions reduction.
In these areas Amsterdam will start promoting measures to reduce the emissions of zinc and
will try to reach an agreement with the housing associations not to use zinc for the renova-
tion of the gutters in future.

**Research on zinc gutters in Amsterdam**

**Introduction**

In The Netherlands there were no actual data on zinc emissions from gutters. Moreover there
is little experience with treatment of gutters to prevent emissions of zinc. Therefore the
Environmental Services Department of the City of Amsterdam together with the Waterboard
for Amstel, Gooi and Vecht has carried out research on zinc gutters. For this research two
identical blocks of houses in the North of Amsterdam with the same wind orientation of the
roofs were selected. On one block the gutter remained unchanged, on the other block the gut-
ter was covered with EPDM (Ethylene Propylene Di-Monomer rubber) foil. At both blocks of
houses the same sampling equipment was installed. At a distance of 100 metres from the
blocks of houses a rain gauge and a rain collector were placed. Samples were taken over a full
year to average the effects of the seasons. The sampling started in September 2001.

**Methods**

Of both gutters, the unchanged gutter and the one covered with EPDM foil, a length of
twelve metres was isolated. From this section of each gutter all the run off water was col-
lected and led to the sampling equipment. This equipment sampled the run off water in pro-
portion to the volume. Each 400 litres of run off water provided a 0.8 litre sample. When a
sample was completed, the time was recorded. A run off of 400 litres corresponded to a
rainfall of about 7 mm. The width of the gutters was 44 cm, the length of the roofs was 5.4
metres from gutter to the ridge and the angle of the roofs was 30.6 degrees. During the first
month of sampling all samples were analysed. The rest of the sampling period the samples
were analysed at a maximum of once a week.

The rain gauge recorded the amount of rainfall continuously as a variable over time in a
cumulative way. The rain collector collected reference rainwater via a simple funnel so that
atmospheric deposition was also collected during dry weather. The rain collector was emp-
tied every month. All samples were analysed with regard to zinc and pH. The results have
been compared with each other and with the standards for surface water.
The EPDM foil used for covering the gutter has been tested for emissions of zinc. The foil was put on the bottom of a beaker and the beaker was filled with rainwater from the rain collector. After 72 hours the water was analysed and compared with the original zinc concentration of the rainwater.

**Results**

The average zinc concentration in the reference rainwater was 77 µg/l at an average pH of 5.7 (Table 3). This means that the atmospheric deposition from rainwater was higher than the Maximum Permissible Concentration for surface water, which is 40 µg/l for zinc.

Table 4 shows the results of the emissions test for the EPDM foil. The results indicate that a slight amount of zinc is emitted from the EPDM foil. The explanation for this probably lies in the fact that zinc was used in the EPDM foil as a catalytic agent.

The graph in Figure 1 shows the zinc concentration from both gutters as a variable of the time necessary to collect 400 litres of run off water. This time is an indicator of rain intensity. As seen in the graph, there is not a clear correlation between rain intensity and the zinc concentration in the run off water. The Maximum Permissible Concentration of zinc is shown in the graph as a dotted line at the amount of 40 µg/l.

The zinc concentration in the run off from the zinc gutter varied from 96 to 3,660 µg/l. The average zinc concentration was 904 µg/l. In September, October, November and March the zinc concentration of the EPDM foil covered gutter varied from 25 to 101. In December, January and February the variation was from 134 to 514. This difference corresponds with the different amounts of zinc in the reference rainwater (Table 3). The average zinc concentration in the run off from the gutter with EPDM foil over the whole period was 103 µg/l. The average zinc concentrations in the run off from both gutters were higher than the Maximum Permissible Concentration, but it was evident that the zinc concentration in the run off from the covered gutter was much lower than the zinc concentration in the run off from the zinc gutter.

On the basis of the average zinc concentration, 840 mm rainfall a year and the dimensions of the isolated section of gutter (12 m × 0.44 m) the amount of zinc emitted has been

<table>
<thead>
<tr>
<th>Period</th>
<th>Zinc concentration (µg/l)</th>
<th>pH</th>
</tr>
</thead>
<tbody>
<tr>
<td>September 2001</td>
<td>59</td>
<td>5.9</td>
</tr>
<tr>
<td>October 2001</td>
<td>50</td>
<td>5.2</td>
</tr>
<tr>
<td>November 2001</td>
<td>46</td>
<td></td>
</tr>
<tr>
<td>December 2001</td>
<td>(1,630*)</td>
<td></td>
</tr>
<tr>
<td>January 2002</td>
<td>114</td>
<td></td>
</tr>
<tr>
<td>February 2002</td>
<td>120</td>
<td></td>
</tr>
<tr>
<td>March 2002</td>
<td>71</td>
<td>6.0</td>
</tr>
<tr>
<td>Average</td>
<td>77</td>
<td>5.7</td>
</tr>
</tbody>
</table>

* The reason for this extremely high value has not been found. In Hoorn an extremely high value of zinc in rainwater was also found at the same time. This high value has not been taken into account in the calculation of the average concentration

<table>
<thead>
<tr>
<th>Test</th>
<th>Zinc concentration in reference rainwater (µg/l)</th>
<th>Zinc concentration in rainwater after 72 hours of contact with EPDM foil (µg/l)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>16</td>
<td>86</td>
</tr>
<tr>
<td>2</td>
<td>36</td>
<td>128</td>
</tr>
<tr>
<td>3</td>
<td>32</td>
<td>100</td>
</tr>
<tr>
<td>4</td>
<td>34</td>
<td>182</td>
</tr>
<tr>
<td>Average</td>
<td>30</td>
<td>124</td>
</tr>
</tbody>
</table>
calculated in grams per square metre per year. The zinc emissions from the zinc gutter were 8.5 g/m²·y and the zinc emissions from the gutter with EPDM foil were 0.88 g/m²·y including the atmospheric deposition. For an accurate correlation between the rainfall and zinc concentration, the rainfall at the time of sampling was used. The rainfall data is obtained from the rain gauge with its time recordings and is combined with the recording of the sampling times.

**Results of other research on zinc emissions in The Netherlands**

The research on zinc gutters in Amsterdam is not the only research on zinc in The Netherlands. In Hoorn the run off from an isolated section of a zinc roof has been sampled and analysed proportional to the volume. In ’s Hertogenbosch the run off from test gutters and test plates of old zinc and zinc with titanium has been sampled and analysed. Moreover in several locations, samples have been taken from the run off from zinc roofs and gutters (Lycklama à Nijeholt, 2001; sampling by the Environmental Services Department). Table 5 gives the results of the various studies. A comparison of the results of the research on zinc gutters as shown in Figure 1 with those of the samples taken from roofs with only zinc gutters as shown in Table 5, clearly shows that they are in the same range.

**Concluding remarks**

The policy for reducing zinc emissions from buildings was developed in 2001. Since then the Environmental Services Department of the City of Amsterdam has gained experience with this new policy. The policy has been set out in the standards for Environmental Permits. The promotion campaign for measures to reduce the emissions of zinc from houses will be held after the completion of the research on zinc gutters and the emissions survey for the total area of Amsterdam. The results of this research to date make it clear that the emissions of zinc from gutters can be reduced by 90% by covering the gutters with EPDM.
Because of the atmospheric deposition, the run off water can never meet the current objective for surface water, the Maximum Permissible Concentration. The zinc concentrations of the run off water from zinc gutters in Amsterdam correspond to the results of the research in other cities of The Netherlands.

The results of the research at zinc gutters together with the estimated areas of zinc gutters and surface water indicate that in Amsterdam the contribution of zinc emissions from zinc gutters is about two times higher than the contribution of atmospheric deposition directly into surface water. This does not correspond with the Literature Survey of Lugt (1994) which indicates that the emissions from zinc roofs and gutters is about fifty times higher than the atmospheric deposition directly into the surface water. Therefore it is necessary to investigate the cause of the atmospheric deposition of zinc. Based on the results an investigation will be conducted in Amsterdam where problems can be expected with the quality of the surface water. For this purpose the method of prioritising will be used from the Emission-Immission Report of the Commission on Integrated Water Management (2000).

### References


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