Reported and potential occurrence of ether oxygenates on water resources in the UK

REPORTED AND POTENTIAL OCCURRENCE OF ETHER OXYGENATES ON WATER RESOURCES IN THE UK

July 2009

Published by
ENERGY INSTITUTE, LONDON
The Energy Institute is a professional membership body incorporated by Royal Charter 2003
Registered charity number 1097899

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The EI gratefully acknowledges the financial contributions towards the scientific and technical programme from the following companies

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ISBN 978 0 85293 515 6

Published by the Energy Institute

Further copies can be obtained from
Portland Customer Services, Commerce Way, Whitehall Industrial Estate, Colchester CO2 8HP, UK. Tel: +44 (0) 1206 796 351
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FOREWORD

Ether oxygenates such as MtBE (methyl tertiary butyl ether), EtBE (ethyl tertiary butyl ether), TAME (tertiary amyl methyl ether) and DIPE (di-isopropyl ether) can be added to gasoline as octane enhancers. Their use has facilitated the desired replacement of lead and a decrease in the benzene content of gasoline. In addition, the presence of oxygen in the molecules improves combustion of the gasoline, thereby improving the quality of engine exhaust emissions to the atmosphere.

Following leaks or spills of gasoline into the ground, ether oxygenates are more mobile in groundwater than gasoline-range hydrocarbons (GRH), because they are more soluble in water, less biodegradable and sorb less strongly to aquifer soils than GRH. The potential to reach a down-gradient drinking water well is thus greater for ether oxygenates than GRH. There is relatively little difference in the drinking water risk potentials of MtBE, EtBE, TAME and DIPE.

The risk posed by gasoline ether oxygenates (GEOs) to potable groundwater resources is one of taste and odour rather than human health. Taste and odour thresholds in water are very low and several orders of magnitude below which health effects have been observed in laboratory animals.

In 1999/2000, the Soil,Water and Waste Working Group of the Energy Institute (EI), under its previous name the Institute of Petroleum, joined forces with the Environment Agency to carry out a study on the occurrence of GEOs in UK groundwater to assess the risk to potable water resources. The study was initiated following several States in the US banning the use of MtBE in gasoline, because of its occurrence in groundwater and the perceived risk to drinking water resources.

The EA/EI 1999/2000 study concluded that MtBE did not pose a widespread risk to potable groundwater resources in the UK and modelling predicted that the risk was unlikely to change in the future, so long as there was not a major increase in MtBE usage in the future. However, the project team recommended that the study be repeated in approximately five years' time to monitor the situation and test the predictions. Consequently, the study was repeated in 2007 – 2008. This report contains the findings of the recent study and compares them to those from the original study.

ACKNOWLEDGEMENTS

This project was commissioned by the Energy Institute's Soil Waste Groundwater Group and was jointly funded by the Energy Institute and the Environment Agency of England and Wales.

The work was undertaken by the WorleyParsons Komex Ltd project team: Simon Firth, Cathy Coldrey, Ciara Meehan and Alec Taylor.

The project was steered by members of the Energy Institute's Soil Waste Groundwater group and representatives of the Environment Agency:

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Chris Hughes	Chevron
Martyn Lambson	BP
Matthew Lahvis	Shell
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Jenny Lyn	Energy Institute
Martin Maeso	Energy Institute
Chris Moody	Environment Agency
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The Energy Institute wishes to record its appreciation of the work carried out by the project team and also its gratitude for the valuable contributions made by the steering panel during the course of the project. In particular the EI would like to acknowledge Simon Firth as the principal author and express its thanks to him.

Furthermore, the Institute would like to thank the companies/organisations which provided data for this study. Without their cooperation, this study would not have been possible.

1 INTRODUCTION, SCOPE AND STATUS OF PUBLICATION

1.1 BACKGROUND TO THE PROJECT

Methyl tertiary butyl ether (MtBE) and other ether oxygenates (ethyl teriary butyl ether [EtBE], tertiary amyl methyl ether [TAME] and di-isopropyl ether [DIPE]) may be added to petrol (gasoline)[1] (although not all petrol) to enhance performance (boost octane). Additional environmental benefits include the replacement of lead and reduction of aromatics in petrol, and improved combustion resulting in reduced atmospheric emissions. The potential risks include those to potable groundwater following spills or leakage and the increased environmental significance (compared to petroleum hydrocarbons) of smaller losses arising from vapour leaks (ether oxygenates being more volatile than gasoline range hydrocarbons).

Ether oxygenates degrade more slowly and are more mobile in groundwater than gasoline range hydrocarbons and therefore tend to travel in groundwater further following a leak or spill. This increased mobility coupled with a low taste and odour threshold means that a leak or spill of petrol containing ether oxygenates has the potential to render large volumes of potable groundwater undrinkable. The taste and odour thresholds of ether oxygenates defined in the US EPA Drinking Water Advisory (0,020 to 0,040 $mg.L^{-1}$) are approximately four to five orders of magnitude less than the concentrations that may cause human health effects. In essence, exposure to water containing ether oxygenates would be so unpleasant from a taste and odour standpoint that it would not be expected to be consumed at the concentrations that may affect health. In the US, the use of oxygenates as a component in petrol was encouraged by regulatory authorities to improve air quality but concerns over potential effects on potable groundwater later resulted in the use of MtBE as a fuel oxygenate being phased out.

In 1999, following the concerns in the US, a study on the usage and occurrence of MtBE in groundwater in England and Wales was commissioned by the Environment Agency and Institute of Petroleum (now the Energy Institute). This study, conducted by Komex (now WorleyParsons Komex), concluded that ether oxygenates at that time did not pose a major threat to public water supplies in England and Wales (Environment Agency, 2000a). A number of reasons were given for why MtBE appeared to be less of an issue in the UK than in the US and these are discussed further in section 6.2.

One of the recommendations of the UK study was that the occurrence of ether oxygenates in water resources should be re-assessed in five years' time. This report, commissioned by the Energy Institute, and jointly funded by the Energy Institute and Environment Agency, presents the results of work conducted to fulfil this recommendation. The scope of the present study has been expanded from the previous project to include impacts to surface water as well as groundwater and to consider the entire UK.

1.2 OBJECTIVES

The objectives of the study were to:

— assess the current usage of ether oxygenates in petrol sold in the UK;

[1] Note that petrol is synonymous with gasoline.

- assess the occurrence of ether oxygenates in water resources in the UK by analysing data from petroleum facility site investigations (retail stations, distribution depots/terminals and refineries) and water quality data held by the Environment Agency and Water Supply Companies;
- determine whether the occurrence of MtBE in UK groundwater resources is changing;
- assess the state of knowledge concerning the impact of ether oxygenates on surface water resources; and
- draw conclusions about the current level of potential environmental risk from ether oxygenates and make predictions about the future.

1.3 METHODOLOGY

The above objectives were realised by conducting the following work:

- **Questionnaires**
  Questionnaires were sent to oil companies, water companies and water resources regulators in the UK. Oil companies were asked to provide data on the usage of ether oxygenates in petrol and their occurrence in soil and groundwater from site investigations conducted at their sites. Water companies were asked to provide monitoring data for ether oxygenates in public water supplies. Regulators were asked to provide monitoring data for ether oxygenates in surface water and their network of groundwater quality monitoring wells and supporting information for use in the risk modelling.

- **Data interpretation**
  Data gathered from completed questionnaires were analysed to assess:
  - the current and likely future usage of ether oxygenates in petrol sold in the UK; and
  - the occurrence of ether oxygenates in water resources in the UK and whether this has changed since the previous study.

- **Risk assessment**
  A probabilistic risk model was developed and used to complement the water quality data collected and further assess the risk that ether oxygenates potentially pose to groundwater. The risks to surface water were assessed qualitatively.