Ethanol effects on the fate and transport of gasoline constituents in the UK

ETHANOL EFFECTS ON THE FATE AND TRANSPORT OF GASOLINE CONSTITUENTS IN THE UK

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1 INTRODUCTION

1.1 BACKGROUND

Ethanol is broadly being used as both a fuel oxygenate in reformulated gasoline and as an alternative fuel/fuel supplement. In the UK, use of ethanol as a fuel/fuel supplement is currently limited with ethanol comprising 3 % of the total volume of petrol sold in the UK for road transport between April 2010 and April 2011[1]. However this could rise in an effort to meet the requirements of the European Biofuels Directive (2003/30/EC) (EC, 2003) which sets targets for the percentage of road fuels supplied that are from renewable sources. This directive has been transposed to UK legislation in the form of the Renewable Transport Fuels Obligation (RTFO) which, in its most recent version (April 2009), sets a target of 5 % of sales comprising renewable fuels (such as bioethanol or biodiesel) in the UK by April 2013.

In 2000 and 2008, occurrence studies were undertaken by the EI to assess the risk posed by ether oxygenates[2] on drinking water supplies in the UK (IP & EA, 2000; EI, 2009). These studies concluded that ether oxygenates do not pose a widespread risk to potable water resources provided there is no major increase in usage. Indeed, it is likely that increased use of ethanol would result in a corresponding decrease in use of ether oxygenates as a gasoline component in the UK.

The potential risks to water resources from increased use of ethanol were not considered in these studies. Literature reviews (EI, 2008; API, 2010) have shown that ethanol from ethanol-containing fuel releases is unlikely to directly create significant risks to groundwater resources but that it has the potential to indirectly increase risk through its effect on the persistence of other fuel components. These reviews have also identified possible impacts to surface water and from methane generation (as a result of ethanol's degradation) as potential risks associated with use of ethanol as a fuel/fuel component.

Given the possibility of a future increase in use of ethanol as a fuel/fuel component there is a need to evaluate these potential risks further within the UK context to help ensure that any such risks are managed appropriately.

Although ethanol is the focus of this report, attention is also given to butanol. Technological developments could mean that butanol becomes a more cost effective and readily available biofuel than ethanol, resulting in future use of butanol exceeding that of ethanol as a gasoline component in the UK.

1.2 OBJECTIVES

The key objectives of this study were to:

- Improve the understanding of potential environmental risks associated with current and future use of ethanol in gasoline in the UK.
- Determine whether the current and future use of ethanol in gasoline alters the conclusions from previous EI assessments on the risks posed by ether oxygenates usage in the UK (i.e. that ether oxygenates do not pose a widespread risk to potable water resources in the UK).

1 Bioethanol accounted for approximeately 3 % (by volume) of UK petrol consumption in 2010/11 financial year, based on figures presented in DFT, 2011.

2 Ether oxygenates considered in the study were MtBE, ethyl tertiary butyl ether (EtBE), tertiary amyl methyl ether (TAME) and di-isopropyl ether (DIPE)

Although the study has focused on ethanol, a further objective was to make overall conclusions with respect to risks from butanol if this were to become a common UK gasoline component in the future.

1.3 SCOPE OF WORK

The following work was undertaken to achieve these objectives:

- A literature review relating to ethanol and butanol focusing on the following themes was undertaken:
  - fate and transport of ethanol and butanol in the subsurface;
  - their effect on the fate and persistence of gasoline constituents (such as BTEX and MtBE;
  - the potential for methane generation from degradation of ethanol and butanol and the subsequent creation of explosive atmospheres, and
  - the risk to surface water from use of ethanol and butanol in gasoline.
- A modelling study analogous to the one presented in the EI report on ether oxygenates (EI, 2009) was undertaken with the goal of:
  - evaluating the effects of ethanol-blended gasoline on enhanced migration of BTEX and ether oxygenates, and
  - predicting the vulnerability of drinking water receptors in the UK to incidental releases of ethanol-blended gasoline in the subsurface.
- This technical report describes the work undertaken and findings.

1.4 UK CONTEXT

The use of ethanol (or butanol) as a fuel component may increase in the UK to help meet the objectives of the RTFO. At this stage the use of 5 to 10 % v/v ethanol in gasoline is envisaged as this helps to meet the objective of the RTFO without the need to modify engines.

For the purposes of this report and to be consistent with American Petroleum Institute (API) terminology the term EBG is used for gasoline containing ethanol such as E5 (5 % ethanol), E10 (10 % gasoline) and E24 (24 % gasoline). Highly concentrated ethanol, such as E85 (85 % ethanol with 15 % gasoline) and denatured ethanol are termed FGE. In the UK, 1 % methanol and 10 ppm denatonium benzoate are added as the denaturant to ethanol used for fuel, whereas in the US 2 to 5 % gasoline is typically added as the denaturant.

Ethanol is miscible with water (See section 2.1) and this creates practical difficulties in the storage and transport of EBG, as the introduction of small amounts of water can result in ethanol partitioning to the water phase causing the fuel to fall out of specification. This makes transport over large distances by pipeline untenable and so denatured ethanol will likely be transported in the UK by tanker. Blending of ethanol and gasoline is expected to occur at the refinery or at bulk storage depots with subsequent transport of EBG to petrol stations.

Various release scenarios are plausible in which ethanol-containing fuel could be released to the environment:

- Spills or leaks of FGE from bulk storage facilities or refineries where ethanol is stored or manufactured. Relative to the number of petrol stations in the UK, the number of these facilities is small. Risks from loss of containment of fuel are assessed and managed under the IPPC permit for each site. Design measures will likely be onerous at these facilities to avoid loss of containment of denatured ethanol.

– Spills of FGE from road or rail tankers. Fuel tanker accidents are rare in the UK and although they do occasionally occur the effects are likely to be localised.
– Subsurface leaks of EBG from petrol stations. The EI study on ether oxygenates (EI, 2009) showed a high variability in the occurrence of MtBE below petrol stations in the UK. This is partly due to variability in the use of MtBE in the UK but is also a reflection of variability in nature and volume of releases that occur. For the vast majority of sites, leaks and spills will be relatively minor, with losses of less than one litre per day. Larger leaks may occur but losses of more than several litres per day will tend to be detected and repaired. Sudden catastrophic leaks of several hundred or thousand litres per day are rare. An on-going programme of infrastructure improvements at petrol stations across the UK means that the probability of loss of containment is declining.
– Surface spills of EBG at petrol stations. Spills of EBG that are not contained will enter the site drainage system. For some sites this will discharge via an oil interceptor to a nearby watercourse. Other than in exceptional circumstances are such spills likely to be greater than a small volume (a few litres or less).

FUEL GRADE ETHANOL VS ETHANOL-BLENDED GASOLINE

As will become apparent later in this report, the proportion of ethanol in a gasoline can have a marked effect on risk and it is therefore useful to distinguish between the two types of ethanol-containing fuel:

– **FGE** — Fuel that is highly concentrated in ethanol, e.g. E85 or E95 (gasoline containing 85 % or 95 % ethanol by volume, respectively) and denatured ethanol (almost 100 % ethanol containing a small amount of denaturant).
– **EBG** — Gasoline that contains some ethanol, e.g. E5 or E10 (gasoline containing 5 and 10 % of ethanol by volume, respectively).

Currently in the UK, the vast majority of ethanol used in road transport fuel is supplied as EBG such as E5 and this situation is unlikely to change in the foreseeable future. The blending of gasoline with FGE to make EBG generally occurs at the refinery or distribution depots within the UK. Thus, releases of FGE are likely to be associated with these facilities or from road or rail tanker spills. Releases of EBG are likely to be associated with retail filling stations or road tanker spills. Given that there are around 10 000 retail filling stations in the UK compared to eight oil refineries and a similar number of distribution depots, releases of EBG from retail sites are expected to have a far greater influence on risk to water resources on a national level than releases of FGE.