Public Health England

Protecting and improving the nation's health

Chemical Hazards and Poisons Report

Issue 26 April 2016

About Public Health England

Public Health England exists to protect and improve the nation's health and wellbeing, and reduce health inequalities. It does this through world-class science, knowledge and intelligence, advocacy, partnerships and the delivery of specialist public health services. PHE is an operationally autonomous executive agency of the Department of Health.

Public Health England
Wellington House
133-155 Waterloo Road
London SE1 8UG
Tel: 020 7654 8000
www.gov.uk/phe
Twitter: @PHE_uk
Facebook: www.facebook.com/PublicHealthEngland

For queries relating to this document, please contact: chapreport@phe.gov.uk

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Editorial

Editors: Dr Naima Bradley and Professor Raquel Duarte-Davidson

Associate Editors: Lydia Izon-Cooper and Lorraine Stewart

Centre for Radiation, Chemical and Environmental Hazards, Public Health England

Articles presented in this April 2016 edition of the Chemical Hazards and Poisons Report illustrate PHE's environmental public health activities in responding to chemical incidents, collaborating with external stakeholders, and developing the evidence base, with the ultimate aim of providing effective and efficient management of the environmental public health risks.

This edition presents a summary of the acute chemical incidents which occurred in England and Wales throughout the period from 1 January to 31 December 2015, collating information from internal resources and supplemented by the National Chemical Emergency Centre (NCEC). This review highlights a trend in the need to respond to large waste fires and reports on key national collaborative projects undertaken to reduce the prevalence of such fires and ultimately allow for better protection of public health. This theme is explored further in an article reporting on national and local strategies for fires at waste sites and recycling processes. Another article summarises the key findings from a project (INGRESS) which aims to add to the evidence base to inform protective public health advice during chemical incidents, such as long running fires.

The importance of collaborative working for effective regulation and use of public resources is explored in this edition through two articles: the first by providing updates to the 2015 COMAH regulations, which now name PHE, NHS England and clinical commissioning groups (CCGs) as consultees; and the second by providing a brief overview of the public health benefits of engaging with regulators for large commercial and industrial activities through the environmental permitting regime. Another paper on land contamination explores some recent developments in risk assessment, which are being led by private enterprise, with government support and specific input from scientists within PHE's Centre for Radiation, Chemical and Environmental Hazards.

This edition also presents a number of articles on the theme of air pollution and public health, including regional work on the establishment of air quality networks to facilitate multi-agency working, and ultimately support regional as well as national level action on air pollution. This work specifically aims to bring together key stakeholders and decision makers, including planners and environmental and public health practitioners. The need for such work is further supported by an article on environmental inequalities.

The quality of air in the indoor environment is also important to public health, especially where chemical sources in indoor environments have had the potential to impact upon public health; a number of papers present case studies highlighting this for mercury, formaldehyde and carbon monoxide.

The next issue of the report is planned for summer 2016; this will be a special edition looking at the health impact of environmental chemicals. The next regular issue of the report is planned for spring 2017; please contact us if you would like to contribute to this edition. Guidelines for authors and a permission to publish form can be found on the website at www.gov.uk/government/collections/chemical-hazards-and-poisons-reports.

Feedback on the contents of this edition should be sent to chapreport@phe.gov.uk. Centre for Radiation, Chemical and Environmental Hazards, Public Health England, Chilton, Didcot, Oxfordshire OX11 0RQ.

We are very grateful to Karen Hogan, Andrew Tristem and Matthew Pardo for their support in preparing this issue.

Acute chemical incident review: 1 January – 31 December 2015

Lorraine Stewart
Environmental Hazards and Emergencies Department, Centre for Radiation, Chemical and Environmental Hazards, Public Health England
Email: lorraine.stewart@phe.gov.uk

Summary

This review provides a summary of the acute chemical incidents which occurred in England and Wales throughout the period from 1 January to 31 December 2015.

Information was collated from events recorded on the Public Health England (PHE) online Centre for Radiation, Chemical and Environmental Hazards (CRCE) Incident Reporting and Information System (CIRIS) for England and Wales and supplemented with that from the National Chemical Emergency Centre (NCEC). The data is analysed in order to identify key acute environmental public health issues and inform the planning and development of guidance and interventions. The key findings for 2015 include:

- a total of 808 incidents were managed and recorded for the reporting period, with 793 involving one or more identified chemicals and the agent/compound remained unidentified in the remaining 15 events
- the number of fatalities (36) resulted from 34 separate acute incidents reported in the period; this was lower than that for last year (44). 27 deaths were recorded as intentional exposures to chemicals
- 6% (n = 52) of the acute incidents resulted in evacuation of the nearby (usually within 100 m) population
- 2% (n = 16) of acute incidents resulted in *shelter-in-place* advice being given to the nearby (usually within 250 m) population
- the chemical mixture most frequently notified was products of combustion (47%, n = 378). This was followed by “other inorganic” chemicals (11%, n = 89) and “other organic” chemicals (9%, n = 75)
- 33% (n = 265) of acute events occurred at industrial sites, 25% (n = 203) in residential settings and 13% (n = 103) in commercial locations
- for the reporting period, the highest number of chemical incidents was reported in the South East (16%, n = 133), London (14%, n = 116) and the South West (13%, n = 109). This was observed in 2014 but differs from the trend over the past 8 years
- the most common sources of reports (notifying organisation) for incidents, were the fire and rescue services (43%, n = 346) and PHE’s health protection teams (17%, n = 141) followed by the ambulance service (8%, n = 65)

Introduction

CRCE manages an online CRCE Incident Reporting and Information System (CIRIS) for England and Wales. Collation of the data has been an ongoing process for over 10 years. Annual analyses of the data help PHE to identify emerging issues related to chemicals incidents and informs business planning and resource management (staff time as well as information resources) for the effective and efficient planning of, and response to, chemical incidents. This report provides a summary of the characteristics and distribution of chemical incidents, recorded in England and Wales between 1 January and 31 December 2015.

Method

The method used to carry out the collation, analyses and interpretation of the chemical data has been described in previous reports[1]. Data is primarily obtained from CIRIS and supplemented by information from the NCEC.

The incidents included in this report occurred within England and Wales and match the definition for chemical events shown in the box.

Box: Definition of chemical incident
All incidents representing "an acute event in which there is, or could be, exposure of the public to chemical substances which cause, or have the potential to cause, ill health" meet PHE's definition of a chemical incident. Chemical incidents also include all events with an off-site impact as well as on-site incidents where members of the public are affected.

Results

After screening for duplicates, exercises, events outside England and Wales and those not meeting PHE's definition of a chemical incident (see the box), 808 acute incidents were recorded between 1 January and 31 December 2015 (in England and Wales). A summary of the characteristics and distribution of the incidents is outlined below.

Temporal trend

Despite the lack of a discernible trend for the reporting period, Figure 1 shows that the lowest number of incidents occur during the winter months (December, January and February). This is consistent with the long-term trend. The annual number of incidents has consistently been in the range 800–900 for the last 5 years.

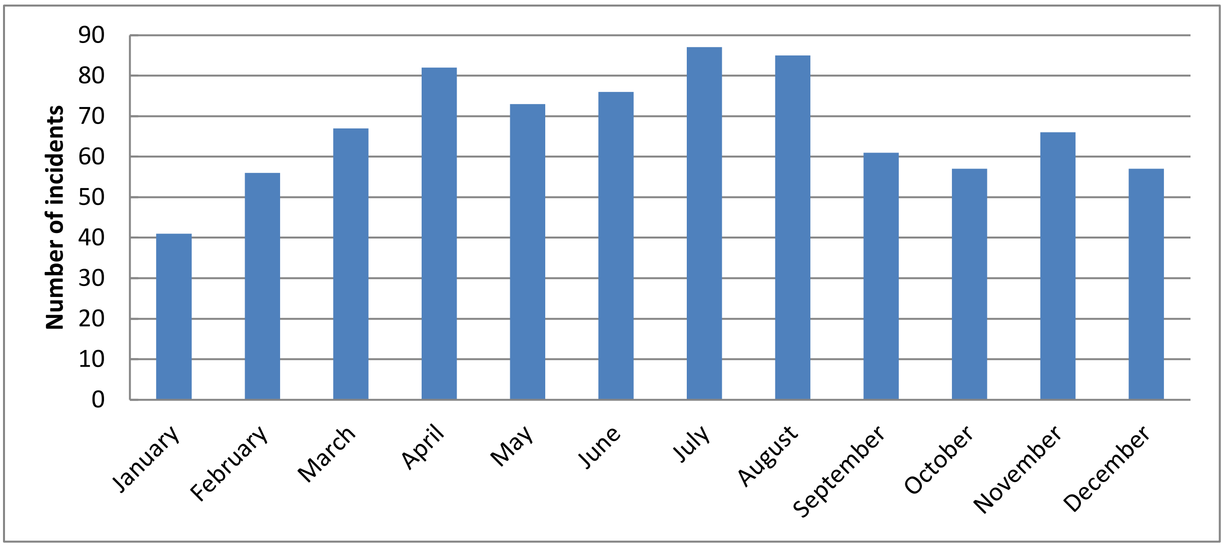


Figure 1: Monthly distribution of incidents in 2015

Estimated exposure at time of incident

During the reporting period, 150 incidents resulted in an estimated 894 people being exposed to chemicals, 209 of whom developed symptoms. It is difficult to estimate with a high degree of accuracy those directly exposed, as protective measures such as sheltering indoors or, if there is imminent risk to life, evacuation, will be implemented. Of the chemical events collated on CIRIS and NCEC, 6% (n = 56) resulted in evacuation, and shelter-in-place advice was issued during 16 incidents.

A total of 36 fatalities were recorded as a result of 34 events for the reporting period. The general trend in the numbers of deaths resulting from chemical exposures is shown in Figure 2. Deliberate exposure to chemicals has increased over the last few years and, during 2015, the number peaked at 27 fatalities. This is shown in Figure 3, together with the other types of incident which resulted in fatal exposure to chemicals.

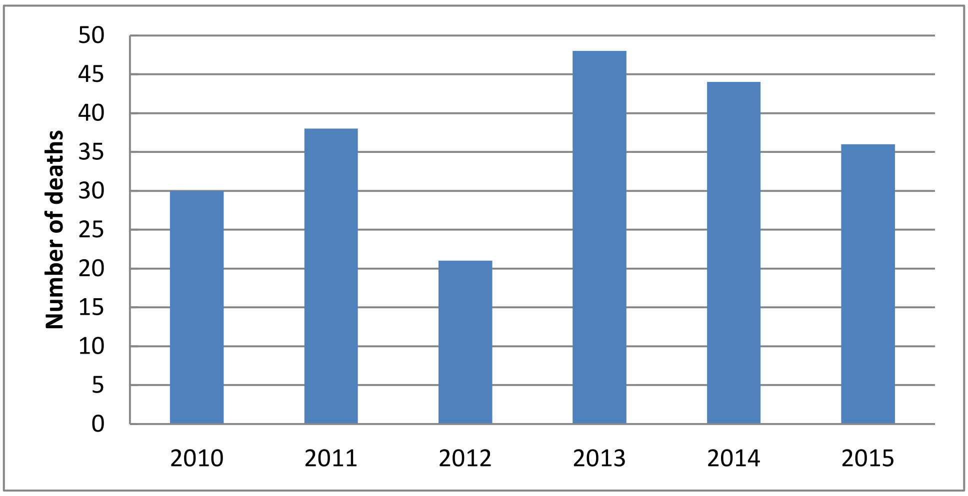


Figure 2: Number of fatalities for the period 2010–15

Carbon monoxide is one of the chemicals commonly involved in fatalities (Figure 4), both deliberate and accidental. Accidental deaths mainly occur in residential settings and are often a result of poorly maintained or faulty gas and solid fuel appliances. The implementation of the new regulations, in October 2015, requiring carbon monoxide alarms to be fitted in rented properties using gas appliances is likely to have a positive impact on injury and death from carbon monoxide poisoning. Helium is not toxic but if breathed instead of air can cause asphyxiation.

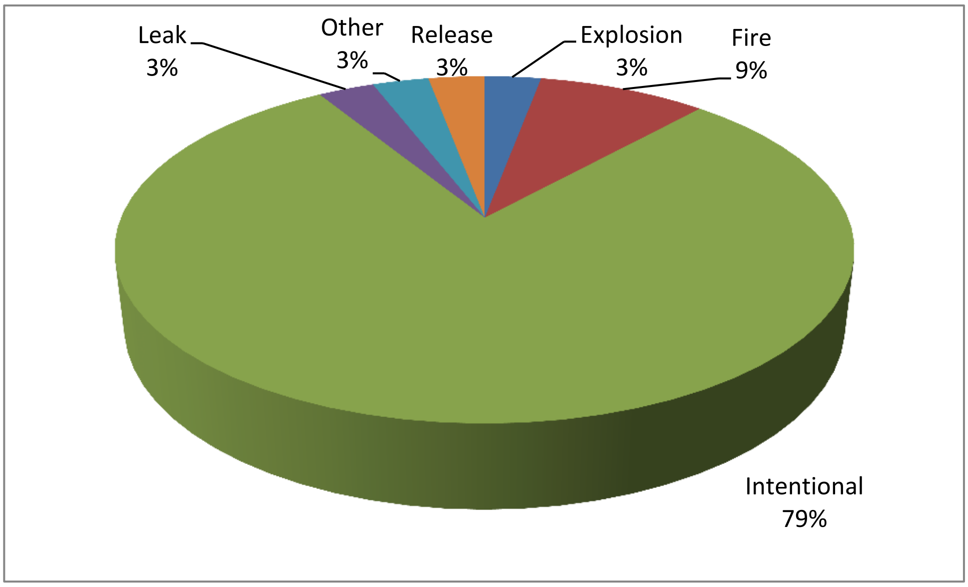


Figure 3: Type of incident resulting in fatalities in 2015

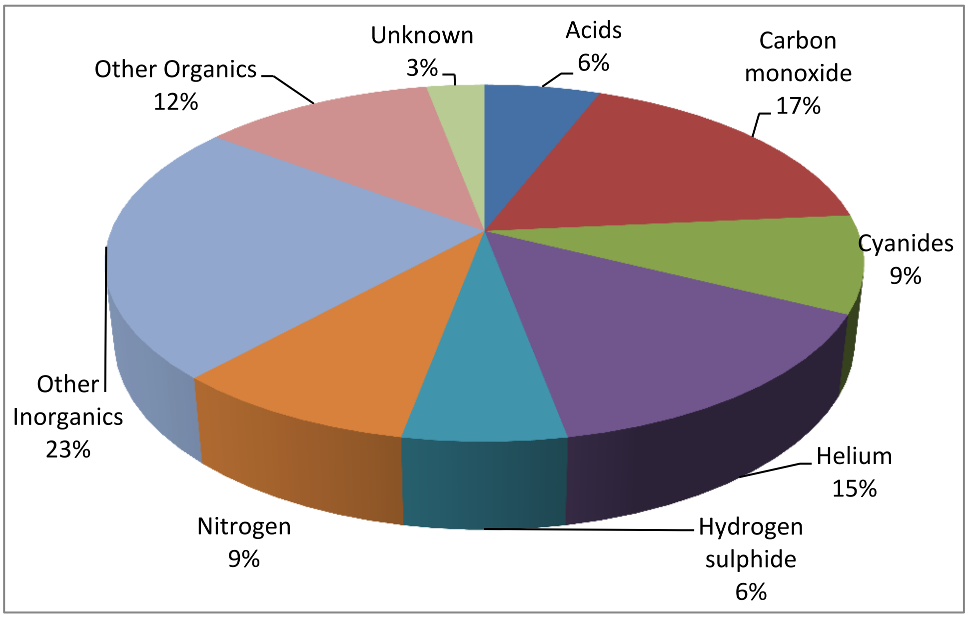


Figure 4: Chemicals involved in fatalities in 2015

Nearby populations

There were 388 uncontained chemical incidents; such incidents have a wider impact – for example, a fire plume can impact populations several hundred metres from the source. A total of 378 incidents had sufficient information regarding the postcode to enable population exposure assessment to be undertaken. It is estimated that over 246,000 people lived within 250 m of uncontained chemical incidents in 2015, the majority of which were fires. Exposure to products of combustion can exacerbate respiratory illnesses in vulnerable groups such as people with pre-existing respiratory diseases, the elderly and children. PHE is exploring the use of real time syndromic surveillance to assess health impacts from prolonged, large-scale fires that may continue for weeks or months. The total population within 250 m and 500 m buffer zones of the nucleus of a chemical incident is given in Table 1.

Table 1: Estimated total population near uncontained incidents in England and Wales in 2015

Geographical region	Number of incidents	Population	
		0–250 m	Up to 500 m
North East	11	4,599	16,004
North West	31	10,068	46,865
Yorkshire and The Humber	35	19,868	77,180
East Midlands	32	10,785	38,733
West Midlands	62	30,505	126,787
East of England	23	6,532	27,744
London	62	109,772	432,109
South East	42	15,708	57,201
South West	40	23,815	83,545
Wales	40	14,226	56,078
Total England	338	231,652	906,168
Total England and Wales	378	245,878	962,246

Regional distribution

For the reporting period, incidents were most frequently reported in the South East and London (see Figure 5). The number of incidents recorded for London for each of the three years 2010–12 was nearly twice the numbers reported in 2015 (Table 2). This may be due to the implementation of early alerting procedures at different times across England. Not surprisingly, when early alerting arrangements with fire and rescue services are first implemented, there is a substantial rise in the number of incidents reported to PHE. However, this tapers off after a few years post-implementation, once the reporting criteria are understood and embedded within routine procedures.

Table 2: Annual regional distribution of incidents for the period 2010–15

Geographical region	Total number of incidents					
	2010	**2011**	**2012**	**2013**	**2014**	**2015**
North East	51	24	14	30	23	21
North West	78	71	65	72	61	69
Yorkshire and the Humber	88	74	47	98	100	67
East Midlands	103	104	60	64	68	72
West Midlands	163	122	117	85	78	102
East of England	58	41	59	49	35	54
London	243	243	213	162	120	116
South East	113	93	119	163	191	133
South West	93	114	140	120	116	109
Wales	38	37	43	49	29	65

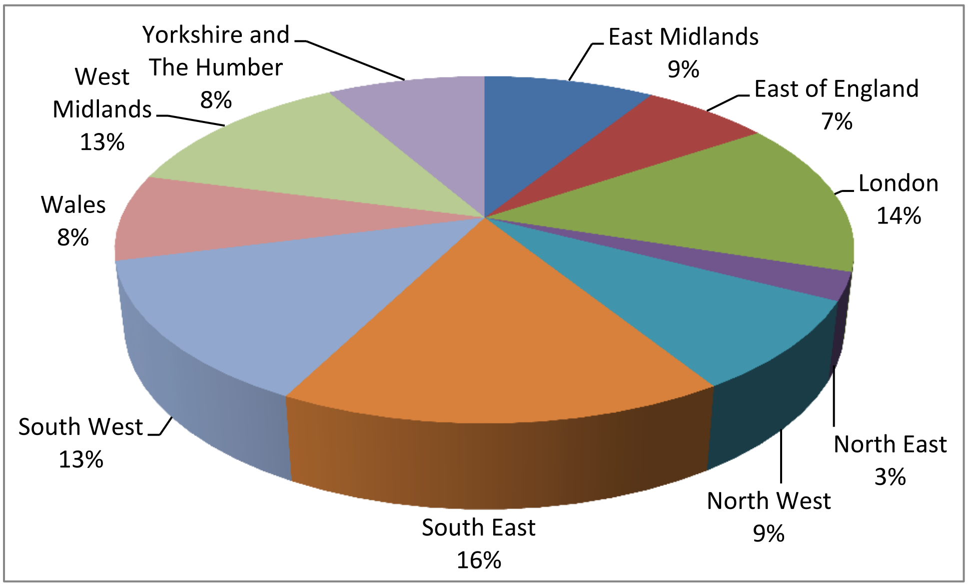
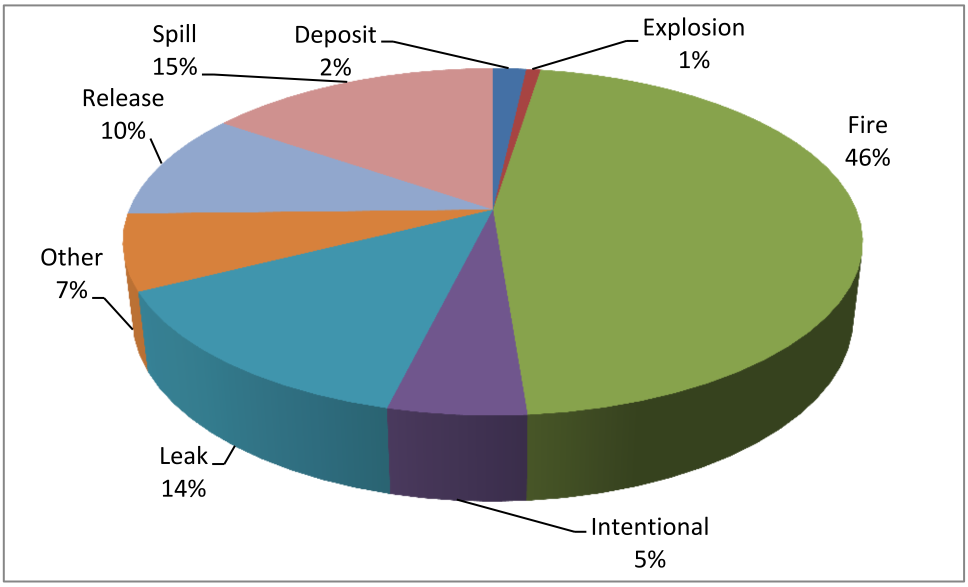


Figure 5: Regional distribution of incidents in 2015

Type of chemical incident

Figure 6 shows that fires (46%, n = 374) were the most common type of incidents during 2015, resulting in the release of a mixture of airborne chemicals. The composition of these products of combustion is dependent on the material involved and the temperature of the fire; however, typically it comprises sulphur dioxide, oxides of nitrogen, carbon dioxide, carbon monoxide and particulate matter. In previous years, fire accounted for approximately a third of all acute chemical incidents but there has been a marked increase in this reporting period. This is followed by spills (15%, n = 124) and then leaks (14%, n = 111). The trend for the last 5 years is shown in Figure 7. There is no data on intentional exposures for 2011 and 2012 as this category was introduced in 2013. The ability to identify trends in the type of acute events allows for longer term engagement with regulators, operators and public health professionals and development of evidence-based advice and information.



"Other" includes odour, nuisance and air quality issues, water contamination, ingestion of chemicals

Figure 6: Types of incident in England and Wales in 2015

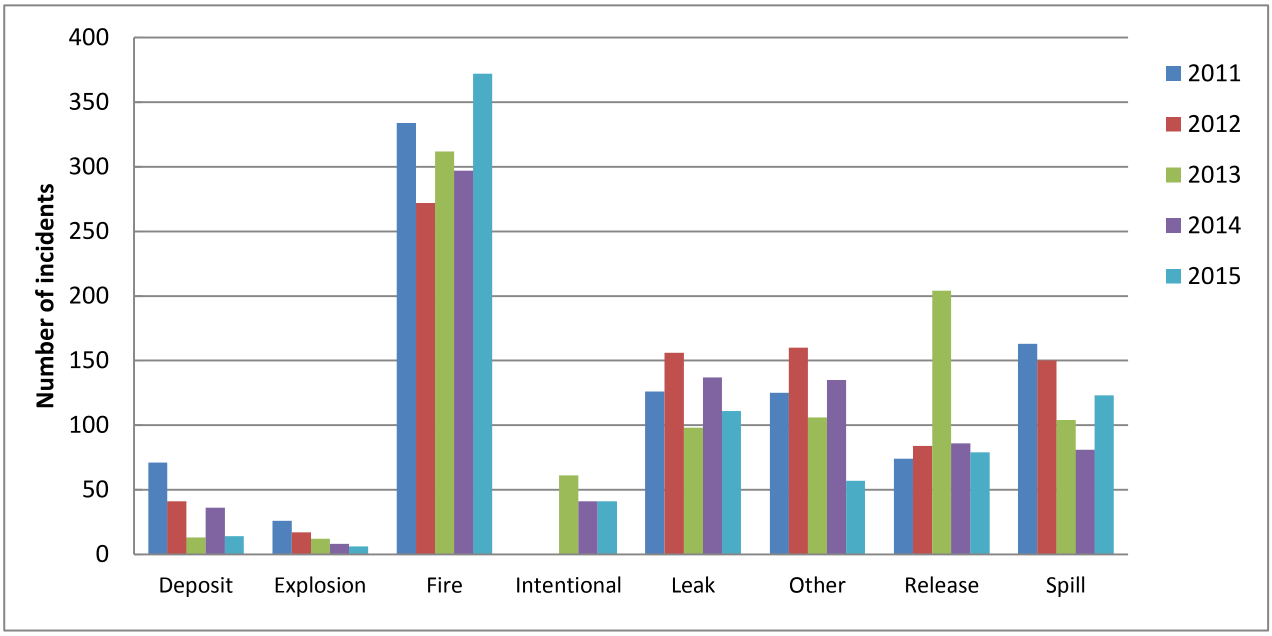


Figure 7: Trends for incident type for the period 2011–15

Products of combustion or emissions from fires have the potential to cause adverse public health impacts to exposed populations. A working together agreement (WTA) between the Environment Agency (EA), PHE and the Met Office allows for the establishment of an air quality cell (AQC) in the early stages of a major chemical incident. The establishment of an AQC provides: (a) a forum for partner agencies to have discussions on whether air monitoring is required for an acute incident; (b) a medium to agree the location of monitoring teams when they are deployed; and (c) a primary vehicle for the partner agencies to agree a common interpretation of the air pollution climate in the vicinity of major incidents, informed by air monitoring and air dispersion modelling. In 2015 there were two protracted fires at waste sites which involved the establishment of AQCs and deployment of air monitoring capabilities.

A WTA between the Environment Agency and PHE on the regulation of industry, including the waste management sector under the environmental permitting regime, is underpinned by regular liaison meetings to discuss issues relating to public health risks from potential fires at waste sites and how these risks can be minimised.

During the past 5 years (2011–15) air quality monitoring has taken place during 12 incidents at waste/recycling sites. This has highlighted the need for tighter guidelines/regulations for operators of these sites and also the identification of sites that are more vulnerable to fires. PHE, in collaboration with the Met Office, EA, Chief Fire Officers Association (CFOA), the waste industry and other partner organisations, is addressing the issue through a number of projects and initiatives. Table 3 highlights the number of fires reported to PHE, which occurred at waste sites between 2011 and 2015. The numbers of waste fires peaked in 2014 (43); however, the work in progress to address the issue appears to be having a positive impact as 30 fires were recorded in 2015. The primary work currently in progress is briefly stated in the conclusions.

PHE is also developing the evidence base relating to the ingress of airborne chemical pollutants into buildings during uncontrolled chemical events such as fires. The resulting model (called INGRESS) will inform when sheltering may no longer be appropriate/ effective due to the build-up of chemical contaminants indoors and, therefore, when doors and windows should be opened to ventilate properties. This is the initial phase of a long-term programme of work planned to develop the evidence base on the public health impact of large protracted fires involving chemicals.

Asbestos was involved in a number of fires (12%, n = 44) during the reporting period. Gas cylinders (7%, n = 28) are also involved in a number of incidents; however, emergency responders have well-established protocols for the effective management of such incidents. There were 18 fires which involved waste tyre material for the reporting period. Tyre fires have the potential to be protracted, difficult to extinguish and release a cocktail of toxic chemicals into the atmosphere. The trend for the past 5 years is given in Table 4.

Table 3: Waste fires sites for the period 2011–15

Year	**2011**	**2012**	**2013**	**2014**	**2015**
Number of incidents	27	22	28	43	30

Table 4: Fires involving tyres for the period 2011–15

Year	**2011**	**2012**	**2013**	**2014**	**2015**
Number of incidents	20	17	9	10	18

Chemicals involved

Figure 8 shows that the chemicals most frequently involved were products of combustion (47%, n = 378), “other inorganics” (11%, n = 89) and “other organics” (9%, n = 75).

Although the proportion of incidents involving metals is low at 5%, 90% of such events were due to spills or leaks of mercury primarily from broken thermometers, compact fluorescent light bulbs or barometers in residential settings. Guidance on the management of mercury spills is available online[2] and an updated document on the management of such incidents and health effects of exposure is being developed based on questions received by PHE from members of the public and public health professionals.

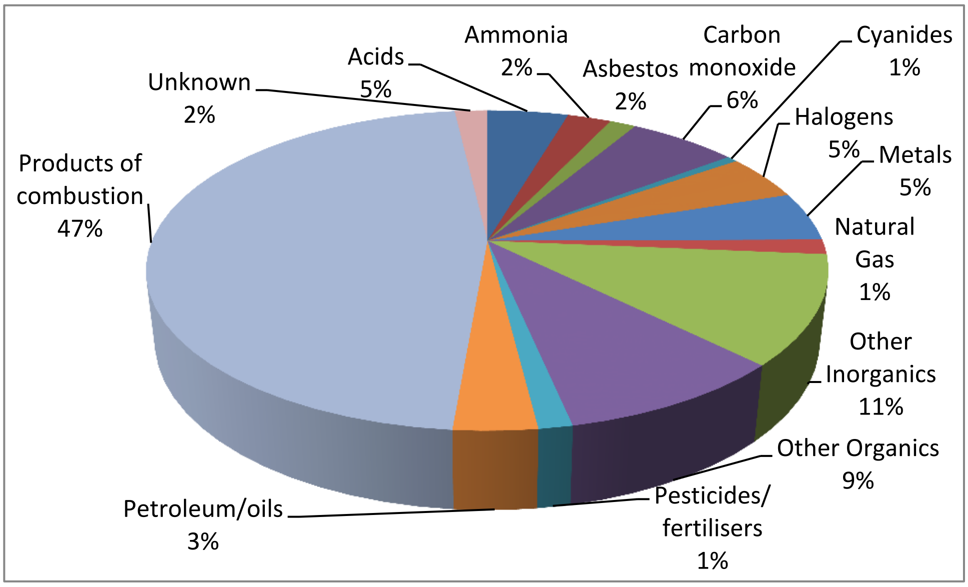


Figure 8: Chemicals involved in incidents in 2015

Incident location

Figure 9 shows that, in 2015, most acute incidents occurred most frequently in industrial settings (33%, n = 265). In previous years, most acute events occurred in residential settings, as shown in Figure 10. Very few incidents occur at Control of Major Accident Hazards (COMAH) sites as they are highly regulated. These industrial sites are required to take necessary measures to prevent major accidents involving dangerous substances and limit their consequences to people and the environment.

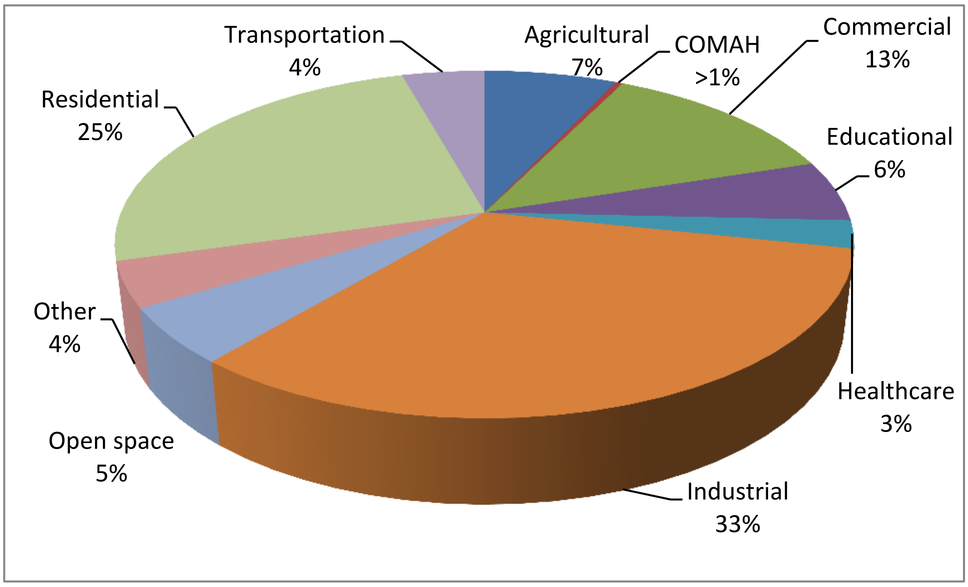


Figure 9: Location type of incidents in 2015

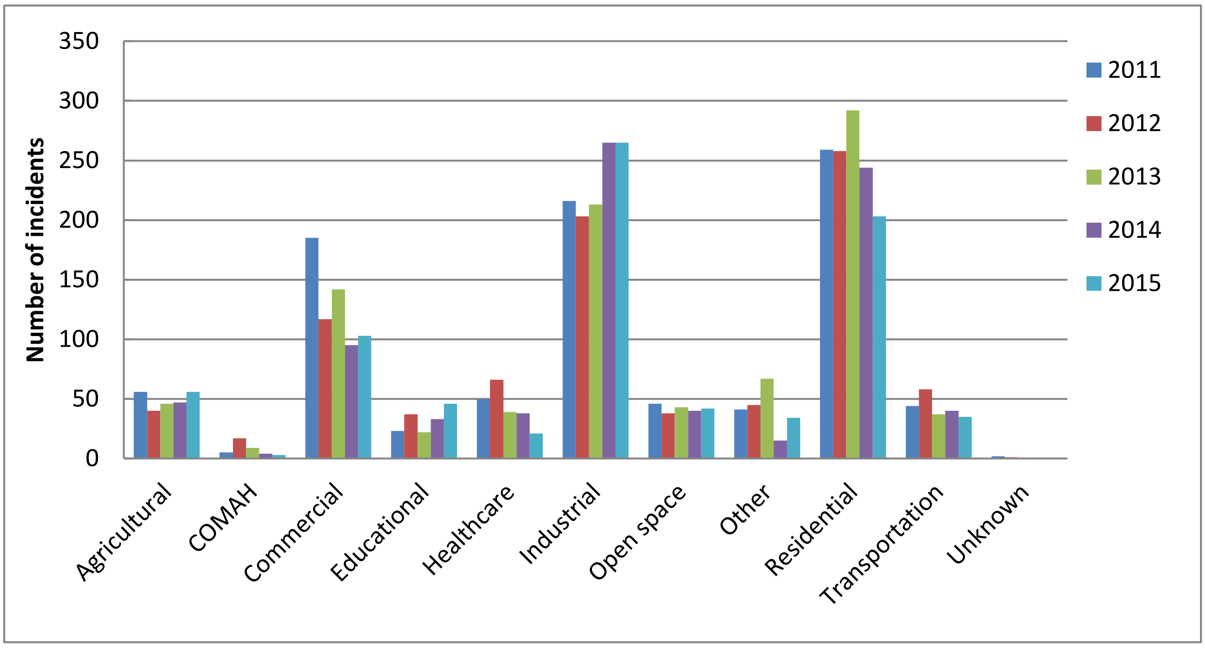
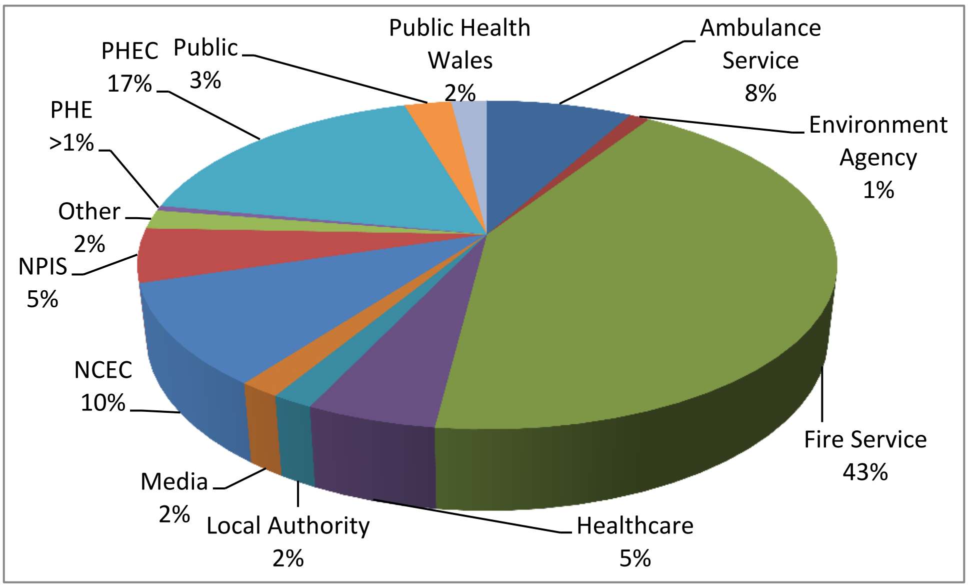


Figure 10: Incident location trend for the period 2011–15

Organisations notifying PHE of incidents

Figure 11 shows that the fire and rescue services reported the largest number of incidents (43%, n = 346). This may be mainly due to the implementation of early alerting arrangements in many areas and the development of close working relationships with them. This is followed by PHE's health protection teams (17%, n = 141) and the ambulance service (8%, n = 65). The health protection teams based at the PHE centres (PHEC) are the frontline responders for PHE; hence they liaise with the local community and request specialist chemical protection advice from CRCE.



Abbreviations: NPIS – National Poisons Information Service, NCEC – National Chemical Emergency Centre, PHEC – Public Health England Centre, Other – notification by HAZMED reports, Drinking Water Inspectorate etc

Figure 11: Notifying organisation for events in 2015

Progress and future work

- there is an increasing trend for the deployment of the air quality cells in response to large fires at waste/recycling sites. Therefore it is important for PHE to engage pro-actively with the regulators, emergency responders and policy makers to manage the risks associated with this type of fires. Currently work is in progress to identify waste sites which are considered high risk and develop plans to minimise the impact of any fires from those sites
- collaborative work with the Environment Agency, Chief Fire Officers Association (CFOA) and the waste management sector is in progress to improve the operations and prevent fires at waste sites. The group is also working towards the production of improved guidance for the waste industry
- PHE and the Environment Agency are also working together to ensure that the environment permitting regulatory regime is sufficiently protective of the public's health
- the Waste Industry Safety and Health (WISH) Forum has produced guidance[3] for site operators to help to reduce fire risk at waste sites. Additionally, a multi-agency project in progress is aiming to address issues including: a risk-based approach to limiting the size of waste stacks; and selection of a suitable method for the determination of the separation distances to help prevent and limit the size and impact of any fire
- the need to provide further evidence-based advice to members of the public on whether to shelter or evacuate during uncontained releases of chemicals and protracted fires has resulted in the development of the INGRESS model, which will be used by public health professionals during 2016/17

Acknowledgements

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References

1. Health Protection Agency (HPA). Chemical surveillance reports. Available at http://webarchive.nationalarchives.gov.uk/20140629102627/http:/www.hpa.org.uk/Publications/ChemicalsPoisons/ChemicalsSurveillanceReports/ (accessed 14/03/2016).
2. Health Protection Agency (HPA). Mercury in residential settings: step-by-step guide to cleaning up spills. Available at http://webarchive.nationalarchives.gov.uk/20090709063949/http://www.hpa.org.uk/web/HPAweb&HPAwebStandard/HPAweb_C/1195733821650 (accessed 14/03/2016).
3. Waste Industry Safety and Health Forum (WISH). Reducing fire risks at waste Management sites, 2015. Available at http://ciwm.org.uk/web/FILES/WISH/WISH_WASTE_28_Reducing_fire_risk_at_waste_management_sites_2015.pdf (accessed 15/03/2016).

Public health risk assessments for waste sites and recycling processes: national and local strategies

Henrietta Harrison[1], Mark Andrews[2], Heather Barker[3]

1. Environmental Hazards and Emergencies Department, Centre for Radiation, Chemical and Environmental Hazards, Public Health England
2. Chief Fire Officers Association
3. Environment Agency

Email: henrietta.harrison@phe.gov.uk

Introduction

During the last 10–15 years there have been changes in the waste industry, with a shift from landfilling in more remote locations, towards recycling and treatment facilities in the heart of cities and towns. This, combined with other societal and economic factors, has led to increased storage and stockpiling of waste that has the potential to ignite. These changes in waste management and the sites used for waste storage (before onward recycling or reuse) have resulted in an increased risk of fires, and has highlighted the need to protect the public and also minimise impacts on critical infrastructure. The national fire service incident database indicates that between 2001 and 2012 there was, on average, one fire a day at waste processing or recycling facilities.

In 2012, 166 million tonnes of waste material were handled in waste and recycling plants in the UK. A large quantity of this recycled waste is eminently marketable, but operators tend to stockpile the waste to accommodate the fluctuating market demand. Stockpiling can increase the risk of combustion of compacted material due to self-combustion or the risk of arson.

There have been a number of fires in the last few years which have generated considerable media interest. Some have led to disruption to rail and/or road networks, everyday life and business; potential environmental damage (to air, water or land); and risks to the health of the public. The box gives an example of a protracted fire and its impact. This fire highlighted the need for better guidance and emergency planning for waste sites in England.

These fires are a concern to responding agencies and the local communities who have to suffer the consequences[1], and also have resource implications in terms of the need to make commitments to manage such incidents.

Box: Smethwick Fire, West Midlands, June 2013

Smethwick fire involved 100,000 tonnes of baled plastic. The West Midlands Fire and Rescue Service (FRS) used the following resources to ensure the site was rendered safe:

- 50 firefighters required to tackle the blaze (of whom 10 were injured and hospitalised)
- approximately 14 million litres of water were used in the first 12 hours
- the fire led to approximately £6 million of damage
- local, national and international media attention required multiple press conferences and press releases

PHE input included:

- air quality cell (AQC) set up jointly between the Centre for Radiation, Chemical and Environmental Hazards (CRCE), Environment Agency (EA) and Met Office
- air quality monitoring was carried out by the AQC for 36 hours
- PHE attended the scene and provided face to face advice to the incident command centre, local health services (GPs) and media
- monitoring undertaken at sensitive receptor locations was used to support the public health risk assessment, public health advice and sheltering/evacuation decisions

Note: close working relationships with all agencies involved ensuring a cohesive, multi-agency response to the incident.

The EA regulates, through environmental permits, large waste sites in England that pose the greatest potential risk to the environment and public health. There are approximately 14,000 permitted waste sites in England, with around 1,000 new permit applications each year. Of the regulated sites, 585 are currently not demonstrating an acceptable level of compliance with their permit conditions, and approximately 300–400 sites are considered (by the EA) to be high risk.

The number of fires at regulated and unregulated waste sites in England has been relatively constant since 2004. However, publicity has increased, especially for long running incidents. Figure 1 illustrates the number of fires at regulated and unregulated waste sites in England from 2001 to 2014.

National strategic work

The EA, Chief Fire Officers Association (CFOA), waste industry, PHE and many others involved in emergency preparation and response in the sector are working together, or within their jurisdiction, to improve operations and fire prevention, as well as set out improved guidance for the industry.

Some examples to help improve regulation and operations at these sites and also highlights of strategic areas of work that will continue to improve emergency preparedness and response are outlined below.

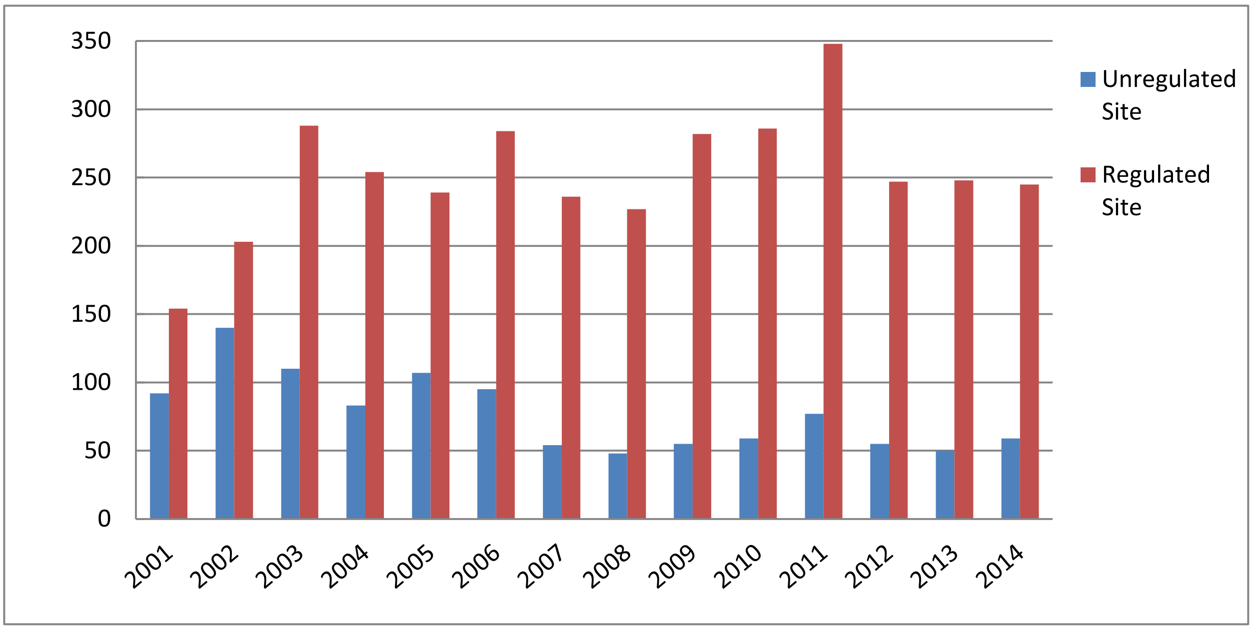

Figure 1: Number of fires at unregulated and regulated sites in England, 2001–14

Stricter controls on the storage of combustible wastes

The EA has published fire prevention plan guidance on the gov.uk website[2] that sets out minimum regulatory standards needed at permitted waste sites to minimise fires, with further guidance expected to be published later in 2016.

Control measures to reduce the impact on air quality

The EA requires sites to have appropriate control measures to reduce the impact of smoke on air quality and public health. All smoke can be potentially harmful to health, even at relatively low levels of exposure. Hence the use of water jets/sprays is recommended during active firefighting to reduce the concentration of asphyxiants, irritants, toxic chemicals and particulates.

Enforcement action

Where operators fail to meet the minimum regulatory standards, the EA is able to take enforcement action. However, there is an increased tendency for sites to be abandoned by operators at the onset of investigations or when it becomes evident that they are not compliant with their permit. Unmanaged sites have an increased risk of potential public health effects, including an increase in odour, dust, vermin and fire.

Refusal of environmental permits

The EA has developed rigorous checks when issuing permits to operators, especially where it is clear that they do not comply with the minimum regulatory standards. Currently the EA receives about 1,000 permit applications a year and the numbers that are being refused has increased to approximately 5–10% of the total (2013–14). In addition, the EA is able to revoke a pre-existing permit if it is evident that the operator is non-compliant with the standards outlined.

Identification of high risk sites

Of the 300–400 sites that the EA identified as high risk in England, approximately 150 are high risk due to fire risks, amenity issues and potential for abandonment. Local resilience forums (LRFs) have been asked to assist with emergency planning. While many sites have been the subject to tactical planning by the FRS and EA, some pose a wider range of threats (including health of the local community, neighbouring businesses, transport and utility infrastructure) and may need to be the subject of a site-specific multi-agency emergency plan.

WISH guidance – reducing fire risk at waste management sites

Given the number of fires within the waste sector, the Waste Industry Safety and Health (WISH) Forum has produced guidance for site operators, *Reducing Fire Risk at Waste Management Sites* (http://www.ciwm.co.uk/wish_web). This guidance aims to provide site operators with information and standards required to reduce fire risk in an appropriate and cost effective manner. There is a multi-agency project currently underway researching a number of areas including: a risk-based approach to limiting the size of waste stacks; selecting a suitable method for determining the separation distances to help prevent fires; and limit the size and impact of any fire should it break out. There is a potential for the WISH project trials to monitor the emissions of the combustion products from the simulated wastes fires.

Public health challenges

Fires at waste sites present many challenges: they can be difficult to extinguish and may burn for months, generating significant media coverage and public health concerns within affected local communities. Protracted fires can potentially lead to prolonged public health exposures for the local population.

National strategic workstreams have led to increased regulatory powers and multi-agency national programmes are improving local intelligence gathering, working practice and identification of sites with high potential fire risk. This has been invaluable in assisting the public health response in the event of these fires.

Working with multi-agency partners, CRCE is developing greater awareness of the location of high risk sites, enabling increased emergency planning in areas such as:

- health risk assessments detailing the potential hazards associated with sites, incident likelihood, potential public health impact and mitigating actions to minimise offsite implications
- production of offsite plans including emergency responder and public health roles and responsibilities, ensuring timely notification of incidents
- identification of sensitive receptors with the potential to be impacted by an incident at the site
- agreed communication plans, including tailored pre-prepared messages for use during the initial phase of a fire

Conclusions

It has been recognised that a multi-agency approach is required to improve the emergency planning and preparedness for high risk waste sites. Hence a multi-agency approach has been employed for the development of guidance, planning and identification of these high risk sites.

The continuation of the work outlined above, as well as new initiatives, should assist in reducing the number of fires at waste sites and, if they do occur, help with reducing their impact on local communities and responding agencies.

References

1. Hansard, 3rd September 2014.
2. Environment Agency (EA). Fire prevention plans. Available at https://www.gov.uk/government/publications/permitted-sites-fire-prevention-plans (accessed 02/03/16).

INGRESS project: providing the evidence base for shelter-in-place advice for chemical incidents

Lorraine Stewart[1], Henrietta Harrison[1], Nicholas Brooke[1], Naima Bradley[1], Vina Kukadia[2], Martin Liddament[2], Angela Spanton[2], Stuart Upton[2]

1. Environmental Hazards and Emergencies Department, Centre for Radiation, Chemical and Environmental Hazards, Public Health England
2. Building Research Establishment Limited

Email: lorraine.stewart@phe.gov.uk

Overview

During the early stages of incidents such as fires or uncontrolled chemical releases, there is often very little information available regarding the materials involved and the potential public health consequences of exposure. The default public health protection position in the UK, in line with the UK Cabinet Office guidance[1], is to shelter-in-place (SiP). SiP, in this instance, means that those potentially in the plume are advised to stay inside or move indoors to minimise their exposure. It should not be confused with relocation of members of the public to evacuation centres, which are sometimes described as “shelters” in government guidance. The public information messages are to “Go In, Stay In and Tune In”, with the initial SiP advice generally given by the emergency services at the scene.

Annually, the Centre for Radiation, Chemical and Environmental Hazards (CRCE) provides expert advice and support for approximately 300 uncontained chemical incidents in England and Wales which impact, or have the potential to impact, on public health. Following the initial decision to SiP or evacuate by the emergency services, CRCE assesses the risk to the affected population and contributes to multi-agency decisions relating to subsequent SiP or evacuation advice.

Until recently, there was limited information readily available: (a) to provide guidance on the ingress of contaminants into the indoor environment and the potential associated exposure risk to occupants and (b) to predict when the concentration of contaminants indoors exceeds that outdoors, thereby rendering SiP advice ineffective. CRCE commissioned the Building Research Establishment (BRE) to develop the scientific evidence to underpin such advice. The output of this project (*Physical modelling of contaminants to predict ingress into buildings*) includes a tool (the INGRESS tool) which provides the evidence base for the appropriateness of SiP or evacuation advice. This project is the initial phase in the process to address the information gap and the next steps in this work are outlined in the recommendations.

Objectives of the project

The overall objective of the project was to develop an evidence-based tool and guidance to support SiP decisions during chemical incidents, such as long running fires. The overall objective was underpinned by three sub-objectives. The first sub-objective was to review the literature for effects of external contaminant sources on buildings (different building density arrays such as urban and rural, building types, wind speeds and contaminant dispersion) and the potential ingress into the buildings. This confirmed that there was a gap in knowledge concerning the dispersion of pollutants in urban areas and their subsequent impact on surrounding buildings. The second sub-objective included using wind tunnel modelling experiments to investigate the dispersion of plumes released during fires and uncontrolled releases of chemicals under a variety of conditions. The third sub-objective was the development of a tool to estimate the ingress of contaminants into properties near the incidents and an accompanying user's manual as well as a guidance document.

The wind tunnel experiments represent a small-scale model of atmospheric events. Hence a number of scaling requirements are required to ensure that all results can be extrapolated to real environmental conditions as well as atmospheric events.

INGRESS tool

The quality and quantity of information improves and increases as an incident evolves. Sources of information include observations from emergency services at the scene, off-site emergency plans (particularly for COMAH – Control of Major Accident Hazards – sites), CHEMETs (modelling undertaken by the Met Office to track the dispersion of a chemical release) and air quality data generated by the air quality cell (AQC). These are used in the INGRESS tool to aid with the public health risk assessment.

The INGRESS tool is a Microsoft Excel™ spreadsheet which can be used to model:

- the concentrations of pollutants (released during incidents) at buildings downwind of a source
- the increase and subsequent decrease of the pollutant concentration indoor during the incident

The model provides the underpinning evidence base regarding the appropriateness of SiP and estimates with caveats the duration for which the indoor environment provides protection from the pollutants released.

It uses three main equations (pollutant plume, infiltration/ventilation equation and the dilution equations) to calculate the indoor and outdoor concentration of contaminants released during uncontained chemical incidents:

- the pollutant plume equation (derived from the wind tunnel experiments) determines the concentration of the pollutant at the building downwind of the event
- the infiltration/ventilation equation is used to determine the rate at which the pollutant enters the building
- the dilution equation is used to determine the variation of the pollutant concentration indoors

These equations are used in the modelling of the pollutant concentration at the building up to 500 m downwind of the source.

Figure 1 illustrates the use of information to generate the ambient and indoor concentrations of the contaminants.

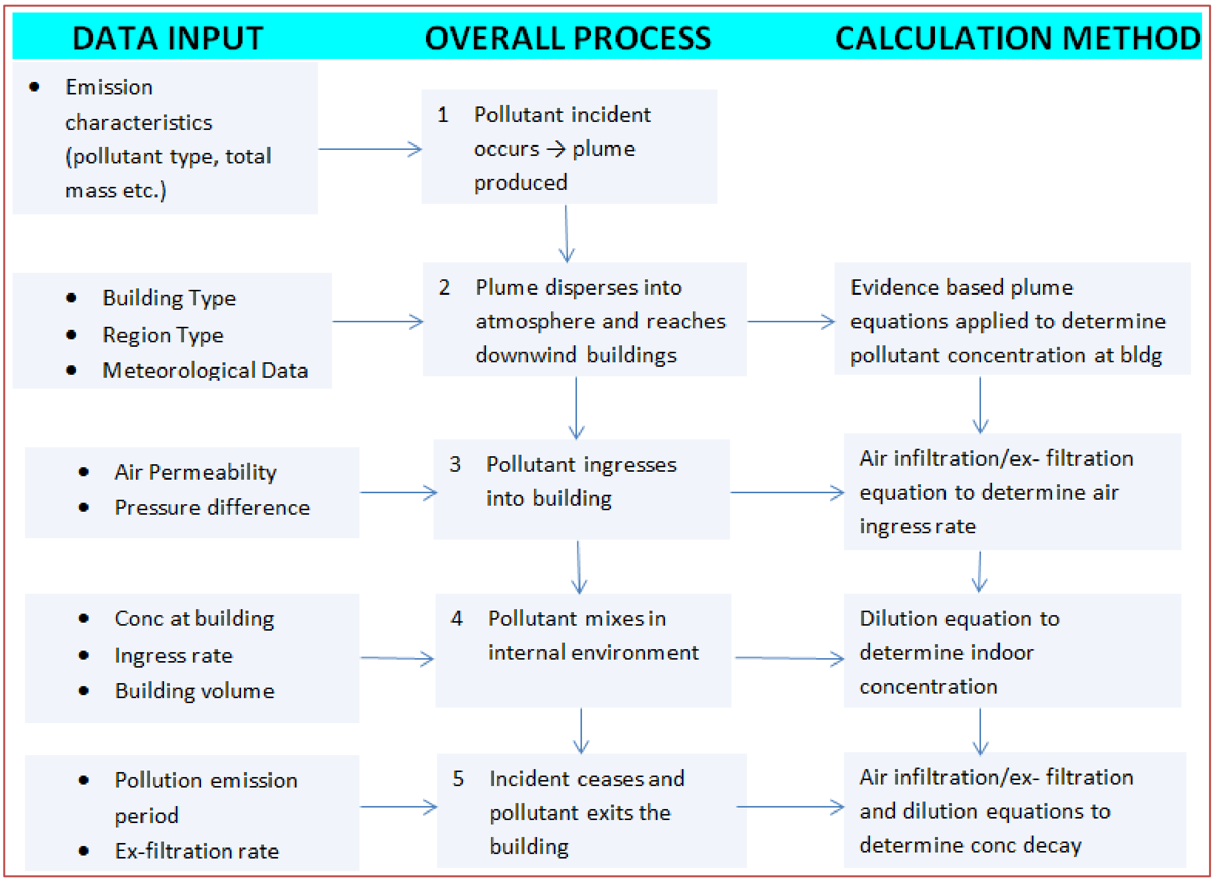

Figure 1: Processes and concepts used for the INGRESS tool

A number of assumptions have been included in the calculations within this tool, the main ones being: the indoor environment is assumed to be a single well-mixed zone so partition and concentration differences within rooms are not taken into account; the ingressed contaminants are assumed to rapidly and uniformly dilute into the indoor air;

it is assumed that the ingressed contaminants will rapidly and uniformly dilute into the indoor air; regular arrays of blocks were used to represent the urban arrays while, in reality, buildings will vary in size, shape and orientation in urban areas; and the plume equations used within the model are applicable up to a distance of 500 m, beyond which the extrapolated estimates are subject to increasing uncertainty. However, it provides basic guidance on the level of protection which can be offered during SiP.

There are four spreadsheets which can be used depending on the information available about the incident:

Relative calculation: this provides an estimate of the relative (to the source) potential pollutant concentration, outside and inside the building at a specified distance downwind of the source. This can be used during the early phase of an incident when limited information is available. Figure 2 shows a screenshot of the input data and the graph produced which shows the pollutant concentrations

Absolute calculation: this provides a modelled concentration (indoors and outside) based on the known chemical emission rate from the incident source. This calculation can be used as more information is gathered, for instance source term, details of the pollutant, quantities expected to be emitted and time period of release

Manual calculation: there are two versions of this spreadsheet which provides pollutant concentration indoors when the concentration outdoors in the vicinity is known. The calculations can either be over a 2- or 24-hour period at 5-minute or 1-hour intervals, respectively, and can be used when additional real time air quality data is available such as data from the AQC

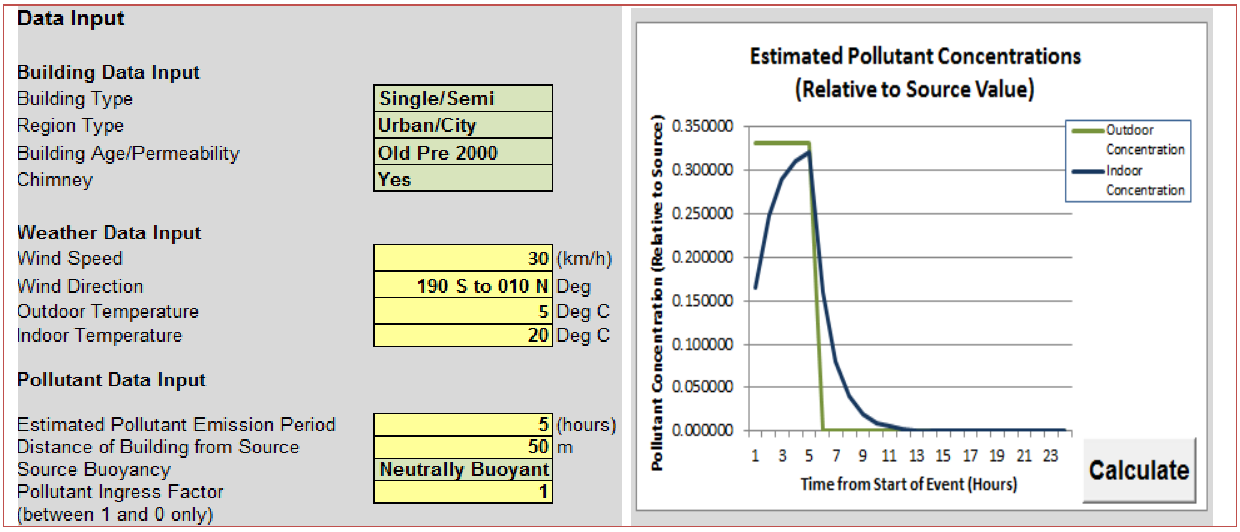

Figure 2: Rel_Calc input data display and concentration graph output

Conclusions

The INGRESS tool was developed to inform the risk assessment regarding SiP or evacuation decisions during uncontained chemical releases such as long running fires. The tool, together with reports from emergency responders at the scene, casualties' symptoms and any available monitoring data (for example, from an AQC), can be used as part of the overall risk assessment. The tool is likely to be of most benefit in long running incidents, lasting weeks or months.

Recommendations and future work

Further work is currently in progress to validate the ambient concentrations derived using this model. This will be done using air quality data measured during incidents which involved implementation of an AQC.

The tool has provided a useful starting point for obtaining scientific evidence to underpin SiP advice during uncontained chemical incidents. Further work will need to be undertaken to measure the concentration of the pollution that has ingressed into properties during such events. This will facilitate further validation of the model.

Reference

1. Cabinet Office. Evacuation and shelter guidance, 2014. Available at https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/274615/Evacuation_and_Shelter_Guidance_2014.pdf (accessed 02/03/16).

Legislative developments: the Control of Major Accident Hazards Regulations 2015

Jim Stewart-Evans
Environmental Hazards and Emergencies Department, Centre for Radiation, Chemical and Environmental Hazards, Public Health England
Email: james.stewart-evans@phe.gov.uk

Introduction

The Control of Major Accident Hazards Regulations 2015[1] replace its predecessor 1999 regulations and bring into force the requirements of the Seveso III Directive[2]. Referred to as the "COMAH regulations" and herein as "COMAH" or the "regulations", they aim to prevent major accidents involving dangerous substances and limit the consequences to people and the environment should they occur.

COMAH is not restricted to the chemical industry, but also applies to other industries where threshold quantities of dangerous substances identified in the regulations are kept or used. Operators of sites that hold larger quantities of dangerous substances – "upper tier" sites – are subject to more stringent requirements than "lower tier" sites. Previous articles in the Chemical Hazards and Poisons Report have discussed the relevance of COMAH to public health and provided related guidance[3,4]. This article summarises the main changes in the new regulations that are relevant to Public Health England (PHE).

Changes that affect PHE

Two types of emergency plans must be prepared for upper tier sites:

- internal (on-site) emergency plans prepared by the site operator
- external (off-site) emergency plans prepared by the local authority

Under the 1999 regulations, PHE was not a named consultee for internal (on-site) emergency plans; however, under the 2015 regulations, PHE, NHS England and clinical commissioning groups (CCGs) are now named consultees. CCGs replace the primary care trusts that were the previous "health authority" consultee. This increases the number of health organisations consulted on internal emergency plans and will result in PHE receiving new consultation requests from upper tier site operators during the preparation of these plans. If existing plans already meet the requirements of the 2015 regulations, new internal emergency plans are not required. Therefore, PHE is likely to receive most consultation requests from operators of new upper tier sites. Some consultation requests may be received from existing operators, should they decide to consult stakeholders when revising their existing internal emergency plans. Reviews are required at least every 3 years and the process for internal emergency plans should ideally dovetail with the preparation, review and testing of external (off-site) emergency plans.

PHE was not previously a named consultee for external (off-site) emergency plans; however, local authorities often consulted PHE when these plans were prepared and exercised. The 2015 regulations stipulate that PHE, together with other category 1 responders, is now a named consultee for external emergency plans.

The new regulations also give local authorities the option to formally request that category 1 responders (including PHE) cooperate in the testing of an external emergency plan. The HSE guidance on the regulations[5] recognises that in many areas there has been good practice in the testing of plans, with all parties working well together, and formal requests for cooperation would be a last resort.

Category 1 responders are now able to charge for the costs of participating in the testing of external emergency plans; this option was previously only open to the emergency services. These costs cover the staff time and travel expenses required to participate in the testing of the external emergency plan. The expenses are incurred by local authorities, which can incorporate the costs into the fees charged to site operators.

Changes to site status

The scope of the 2015 regulations accounts for European Regulation (EC) No. 1272/2008 on classification, labelling and packaging of substances and mixtures[6] (known as “the CLP Regulation” or “CLP”). CLP adopts the United Nations’ globally harmonised system on the classification and labelling of chemicals (GHS) across all European Union countries, including the UK. It is very similar to the old system (the Chemicals (Hazard Information and Packaging for Supply) Regulations – “CHIP”), but the effect on the 2015 COMAH regulations is to change some of the chemical inventory entries and the thresholds at which the regulations apply. As a result: (a) some new sites will come into the scope of the regulations (b) some existing COMAH sites will drop out of scope, and (c) the status of some COMAH sites will change from lower to upper tier or vice versa. Past estimates by the Health and Safety Executive (HSE) indicate that there may be approximately 40 new upper tier sites. New sites have until June 2016 to notify the HSE, and there will be subsequent consultations when their emergency plans are prepared. On the other hand, emergency plans for sites that are no longer subject to the upper tier of COMAH will be revoked. It is also possible that there may be some new “domino” groups – groups of establishments where the risk or consequences of a major accident may be increased because of their geographical position, proximity to each other, or inventories.

Changes to public information

The 2015 regulations require key information regarding both lower and upper tier COMAH sites, substances held, and emergency information be made permanently available to the public. Site operators must submit template information to HSE: this has been made available in a phased manner since June 2015 and can be accessed on the HSE website (see https://notifications.hse.gov.uk/COMAH2015/Search.aspx). It does not replace the comprehensive information available to emergency responders in external emergency plans.

Protecting public health

The changes to the COMAH regulations extend the provision of public information and broaden requirements to consult health organisations regarding emergency plans and involve them in the exercising of plans. This strengthens the regulations' contribution to health protection: the involvement of public health professionals in emergency plan preparation and exercising integrates and embeds the public health response within wider multi-agency preparedness and response. Input from public health professionals helps to ensure that emergency plans contain information vital to public health risk assessment, and that public health considerations are addressed during incident response.

PHE centres remain the first point of contact for local authorities or operators when consulting statutory consultees regarding external or internal emergency plans. Stakeholders can find their local centre's contact details on the PHE pages of the gov.uk website: https://www.gov.uk/guidance/contacts-phe-regions-and-local-centres.

References

1. The Control of Major Accident Hazards Regulations 2015. Available at http://www.legislation.gov.uk/uksi/2015/483/pdfs/uksi_20150483_en.pdf (accessed 08/01/16).
2. European Commission (EC). Directive 2012/18/EU of the European Parliament and of the Council of 4 July 2012 on the control of major-accident hazards involving dangerous substances, amending and subsequently repealing Council Directive 96/82/EC. Official Journal of the European Union 2012; 197. Available at http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2012:197:0001:0037:EN:PDF (accessed 08/01/16).
3. Kowalczyk G, Davison P, Stewart-Evans J. The Control of Major Accident Hazards (COMAH) Regulations – forthcoming legislative changes and the role of Public Health England – Part 1: COMAH and the role of Public Health England. Chemical Hazards and Poisons Report 2014(14).

4. Callow P, Stewart-Evans J, Stewart A, et al. The Control of Major Accident Hazards (COMAH) Regulations – forthcoming legislative changes and the role of Public Health England – Part 2: Public health information in COMAH off-site emergency plans. Chemical Hazards and Poisons Report 2014(14).
5. Health and Safety Executive (HSE). The Control of Major Accident Hazards Regulations 2015 – Guidance on Regulations L111. 2015. Available at http://www.hse.gov.uk/pubns/priced/l111.pdf (accessed 08/01/15).
6. European Commission (EC). Regulation (EC) No. 1272/2008 of the European Parliament and of the Council of 16 December 2008 on classification, labelling and packaging of substances and mixtures, amending and repealing Directives 67/548/EEC and 1999/45/EC, and amending Regulation (EC) No. 1907/2006. Official Journal of the European Union 2008; 353. Available at http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2008:353:0001:1355:en:PDF (accessed 13/01/16).

Environmental permitting regulations – benefits to the public's health?

Rebecca Gay, Naima Bradley
Environmental Hazards and Emergencies Department, Centre for Radiation, Chemical and Environmental Hazards, Public health England
Email: rebecca.gay@phe.gov.uk

Introduction

This article gives a brief overview of the public health benefits of engaging with regulators for large commercial and industrial activities and describes the contribution of Public Health England (PHE) to the environmental permitting regime.

Regulatory background

The current Environmental Permitting (England and Wales) Regulations 2010 (the regulations) came into force on 6 April 2010[1] to replace its predecessor, the Pollution Prevention and Control (England and Wales) Regulations 2000. Both regulatory regimes place a requirement on operators of certain industrial processes and activities to obtain an environmental permit before the process was allowed to operate. The permit, if granted, specifies conditions with which the operator must comply to ensure a high level of protection for the environment as a whole, including human health.

PHE provides comments to the regulator on aspects relating to potential human health impacts; this assists the regulator in making decisions on the type of conditions to impose and whether or not to grant permits. The public health community has been a key consultee in this regulatory regime since 2001.

There are different categories of process within the regulations. The Environment Agency (EA) regulates activities with the highest potential to pollute (termed 'A1'), while local authorities (LAs) regulate those with lesser polluting potential ('A2' and 'B'). Over the last three financial years, PHE has provided advice for approximately 270 permit applications a year, the vast majority of which were A1 applications.

Benefits to public health

Although PHE has no formal role in regulation, the EA and PHE's Centre for Radiation, Chemical and Environmental Hazards (CRCE) work closely together to ensure that public health is a fundamental consideration in the regulation and permitting of industries and waste management activities.

Since 2001, CRCE's environmental public health scientists have developed their competencies to ensure that any advice given is evidence based. Staff providing that advice have expertise in a range of disciplines such as environmental sciences, chemistry, toxicology, public health, radiation protection, environmental epidemiology, risk assessment, risk management and risk communication. CRCE scientists are responsible for identifying gaps in knowledge and undertaking evidence reviews and/or initiating longer term research projects in order to address these gaps. Development of position statements on landfill[2], intensive farming[3] and incineration[4] are examples of the outputs of such activities.

The regulations have allowed the public health community to build an understanding of a wide range of industrial and commercial processes, understand the emissions, how these can be assessed in terms of the impact on public health and advise on proportionate actions to protect population health. This knowledge has been used to protect communities from acute and chronic exposures to chemicals arising from regulated industrial and commercial activities.

In 2010, the EA and the Health Protection Agency (a predecessor body to PHE) entered into a working together agreement (WTA)[5] that formalised the provision of health protection advice for environmental permitting. The WTA includes screening criteria to provide a risk-based approach to permitting. This ensures that proportionate and targeted responses are provided on the public health risks from regulated activities where they are most needed. Both PHE and local directors of public health (DsPH) teams are consulted. DsPH may use their local knowledge to add to that response by identifying any existing local health issues that may be associated with the regulated facility or its location and discussing any concerns with their local communities.

The risk-based screening criteria are periodically reviewed by the EA and PHE and currently ensure that the EA will receive public health opinion on applications from the following activities: biomass combustion plants, waste incinerators, landfill sites, composting sites, sites for which a human health risk assessment or health impact assessment has been undertaken, control of major accident hazard (COMAH) sites and applications that relate to onshore oil and gas. Figures 1 and 2 show the type of application on which PHE was consulted during 2014/15.

PHE is also consulted on sites involving radioactive substances, including new nuclear sites, existing nuclear sites where the discharge limits or doses to the most highly exposed people are increasing and the estimated doses from the site exceed 20 microsieverts (μSv) in a year, and non-nuclear sites from time to time, as agreed between the agencies.

PHE has produced a guide which explains in more detail its role in environmental permitting[6].

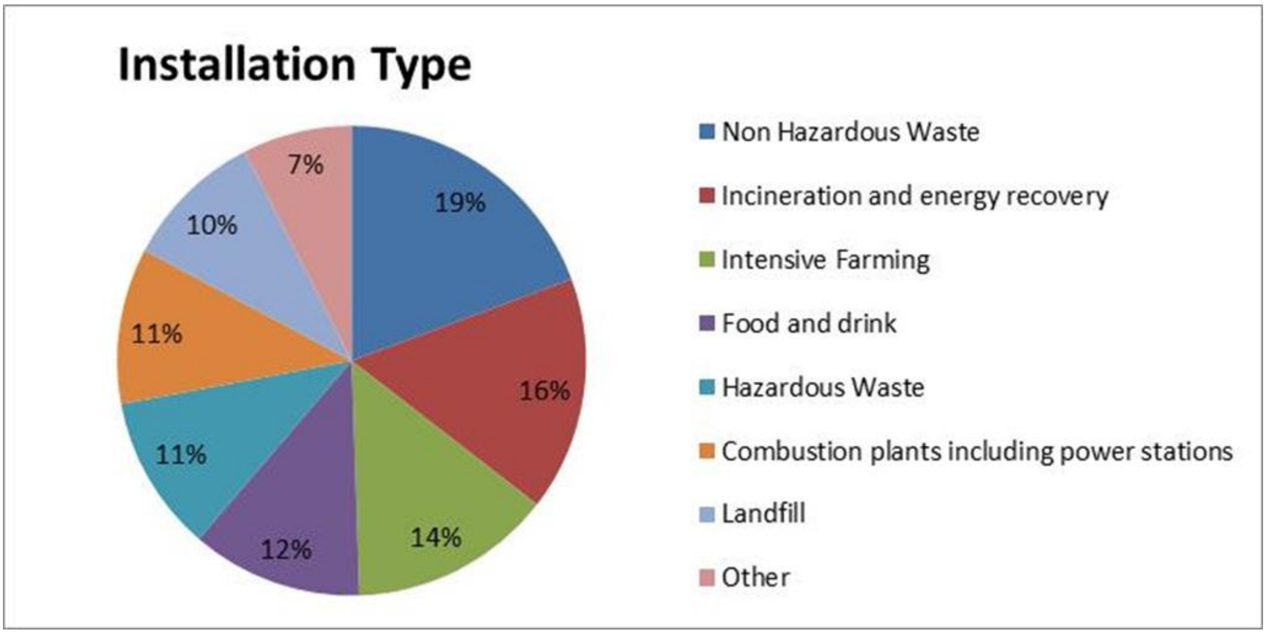

Figure 1: Types of installation (n = 93) on which PHE was consulted during 2014/15

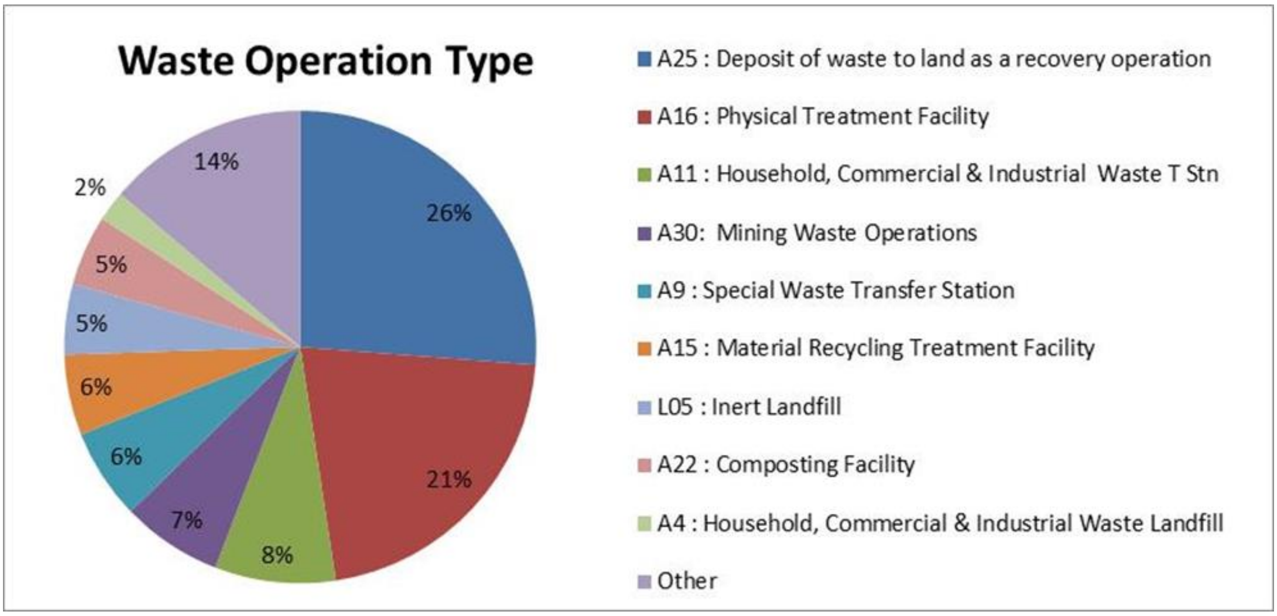

Figure 2: Types of waste operation (n = 145) on which PHE was consulted during 2014/15 (source: Environment Agency)

Summary

Regulations state that certain industrial processes and activities require an environmental permit in order to operate. A risk-based screening tool is applied to applications and, where appropriate, the EA consults CRCE for an independent view on the potential impact on public health. This informs the EA's decision to grant or ask for amendments to the permit conditions or reject the permit application. In addition to commenting on individual applications, PHE produces position statements on certain industrial sectors and comments on sector-wide regulatory proposals.

Acknowledgements

The author would like to thank Richard Hadley of the Environment Agency for providing the data for the figures.

References

1. The Environmental Permitting (England and Wales) (Amendment) (No. 3) Regulations 2015. Available at http://www.legislation.gov.uk/uksi/2015/1756/pdfs/uksi_20151756_en.pdf (accessed 29/03/16).
2. Health Protection Agency (HPA). Impact on health of emissions from landfill, 2011. Available at https://www.gov.uk/government/publications/landfill-sites-impact-on-health-from-emissions (accessed 29/03/16).
3. Health Protection Agency (HPA). Position statement on intensive farming, 2006. Available at http://webarchive.nationalarchives.gov.uk/20140714084352/http://www.hpa.org.uk/webc/HPAwebFile/HPAweb_C/1194947378905 (accessed 29/03/16).
4. Health Protection Agency (HPA). Municipal waste incinerator emissions to air: impact on health, 2013. Available at https://www.gov.uk/government/publications/municipal-waste-incinerator-emissions-to-air-impact-on-health (accessed 29/03/16).
5. Environment Agency (EA) and Public Health England (PHE). Working together agreement: Environment Agency and Public Health England, 2014. Available at https://www.gov.uk/government/publications/working-together-agreement-environment-agency-and-public-health-england (accessed 29/03/16).
6. Public Health England (PHE). Environmental permitting and the role of Public Health England, 2015. Available at https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/477277/Environmental_permitting_guide_Nov_2015.pdf (accessed 29/03/16).

Contaminated land – an update

Sarah Dack, Sian Morrow, Lydia Izon-Cooper
Environmental Hazards and Emergencies Department, Centre for Radiation, Chemical and Environmental Hazards, Public Health England
Email: sarah.dack@phe.gov.uk

PHE and contaminated land

Public Health England (PHE) frequently supports local authorities (LAs) in their assessment of land contamination at a local level; this is often for complex health risk assessment at specific sites. Figure 1 shows a breakdown of the types of enquiries received by PHE's Centre for Radiation, Chemical and Environmental Hazards (CRCE) between November 2010 and September 2015. This illustrates that the majority of enquiries related to toxicological or exposure assessment advice for large LA Part 2A sites (Part 2A of the Environmental Protection Act 1990) or other LA sites with sensitive land uses, such as schools and allotments, where children could be present or food produce is grown. Some LAs asked PHE to review their contaminated land strategy; however, this was not consistent across England.

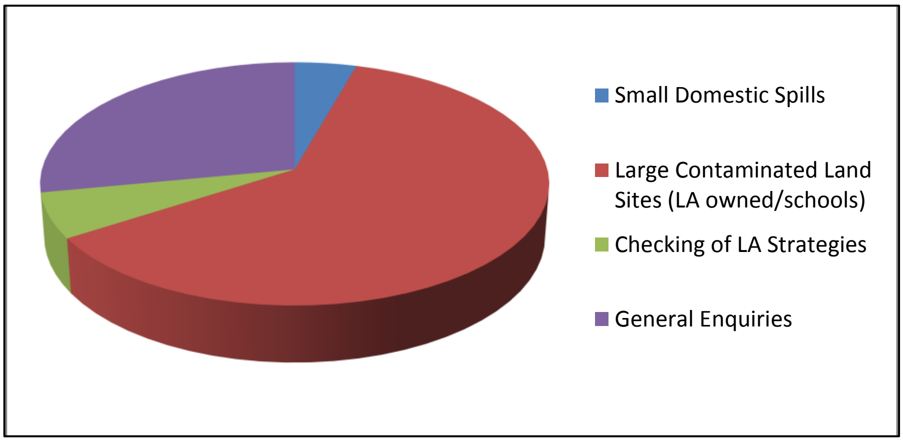

Figure 1: Nature of land contamination enquiries received by CRCE (November 2010 – September 2015)

PHE has an important role to play through collaborative working with national stakeholders and through contribution to the development of new guidance documents. PHE also indirectly assists the industry response to land contamination (through industry forums and non-profit groups) though these means. In this article PHE's contribution to some land contamination workstreams is discussed, including category 4 screening levels (C4SLs) and the Society of Brownfield Risk Assessors (SoBRA) acute risk assessment methodology.

Category 4 screening levels

The C4SLs project was a contaminated land research project funded by Defra (Department for Environment, Food and Rural Affairs) in 2012–13[1]. The overall objective of the project was to assist in the provision of technical guidance, in support of Defra's revised statutory guidance (SG) for Part 2A (published in 2012)[2].

The SG introduced a new four-category system for classifying land under Part 2A for cases of *significant possibility of significant harm* to human health. Category 1 includes land where the level of risk is unacceptably high and category 4 includes land where the level of risk posed is low, such that there is no significant possibility of significant harm. Land is determined as "contaminated land" under Part 2A if it falls within categories 1 or 2, such that the category 2/3 border defines the point at which land is determined under the legislation.

The C4SLs were proposed to represent a new set of generic screening levels that were pragmatic (but still strongly precautionary) compared to the existing soil guideline values (SGVs) and other generic assessment criteria. The C4SLs, within the context of Part 2A, combine information on toxicology, exposure assessment and representative levels of exposure to these contaminants.

Defra awarded the project to a consortium led by CL:AIRE (Contaminated Land: Applications in Real Environments, an independent not-for-profit organisation). The project aims were to deliver a methodology for deriving C4SLs for four generic land uses and demonstrate the methodology, through the derivation of C4SLs for six substances: arsenic, benzene, benzo(a)pyrene (B(a)P), cadmium, chromium (VI) and lead. The consortium's methodology for the derivation of the C4SLs involved the use of modified CLEA (contaminated land exposure assessment) model parameters and the development of new health criteria values which are termed low level of toxicological concern (LLTCs)[3].

PHE was represented on the project steering group, provided feedback on the project work package reports, and supported Defra in the preparation of papers on the toxicological aspects for review by the Committees on Toxicity and Carcinogenicity of Chemicals in Food, Consumer Products and the Environment (COT and COC). The report and the policy companion document were published in 2014, with comments that the C4SLs were suitable for both Part 2A and planning use[3,4] being received from Defra, DCLG (Department for Communities and Local Government) and the Welsh Government.

Since the original publication, the PHE contributors have again been asked to support the new C4SL project steering group, and have so far helped define a list of priority contaminants to be considered for C4SLs. To inform these discussions, CRCE reviewed enquiries received in recent years to identify the contaminants of concern which were the subject of these enquiries, as discussed below.

Land contamination enquiries to PHE

A review of chemical land contamination enquiries received by CRCE from external agencies (most often LAs) between 2010 and 2015 showed that hydrocarbons – often PAHs (polycyclic aromatic hydrocarbons), in particular B(a)P – were the most common subject of enquiries. Gas works and associated chemicals also featured in a number of enquiries (including BTEX – benzene, toluene, ethylbenzene and xylene – methylphenols, phenols and tars), as did asbestos, lead, arsenic, cadmium and mercury. Figure 2 provides a break-down of those contaminants on which PHE was most consulted. These contaminants were also many of the priority contaminants for the C4SL work as detailed above.

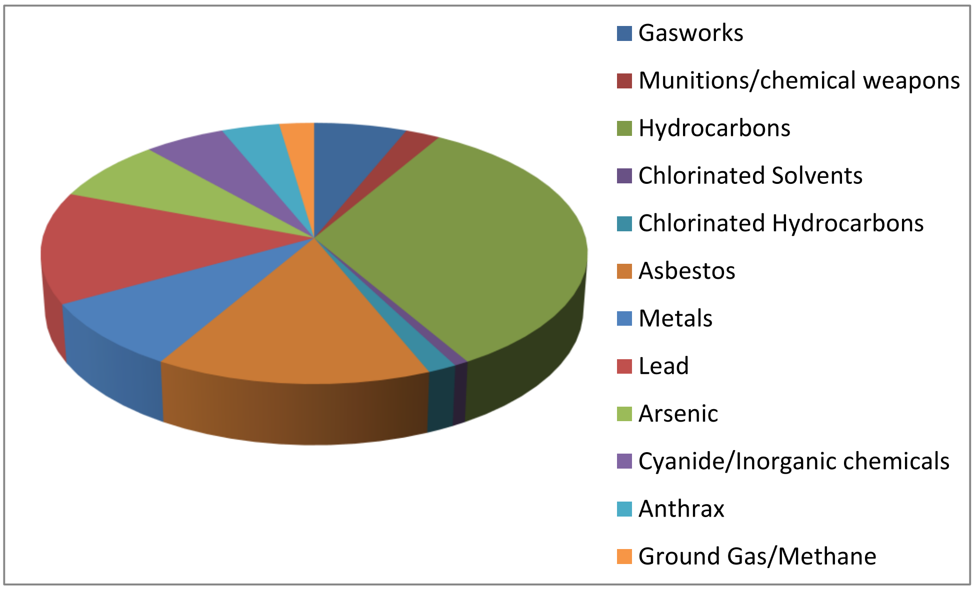

Figure 2: Chemical contaminants most commonly consulted on (2010–15)

Acute risk assessment

There are currently no UK guideline values to identify the level of risk to the public from short-term (acute) exposure to land contamination. Therefore, SoBRA has been working on a methodology to derive acute generic assessment criteria (AGAC) for contaminants that could potentially pose an acute risk. Acute effects have been assessed in the Netherlands for cyanides and guideline values have been produced for public acute exposure, by inhalation, in the US (AEGLs)[5]. Both the US and UK (EH40, 2011)[6] have occupational levels suitable for acute assessment, but these are not suitable for public receptors due to considerations such as protective clothing and age of vulnerable members of the public.

Members of the public could become exposed to high levels of contamination over a short time period when, for example, land remediation work uncovers higher levels of contamination than identified during site investigation works, or contamination is identified in isolated hotspots in a public space, for instance. PHE's advice is most frequently sought where acute risk assessment is required for public open spaces, where a change in land use (such as the use of rally bikes) has uncovered previously unknown contamination, or where the probability of acute exposure has been used to prioritise the order of remediation. The case study provides an example of a situation where an acute risk from land contamination was assessed. PHE provided toxicological support and PHE and LA staff attended meetings to discuss the course of action.

PHE has provided comments to SoBRA in the production of AGAC, which will be published as an industry standard for the derivation of acute assessment criteria.

Case study

A site, which was formerly part of a chemical works, was found to have elevated levels of arsenic within the soil; the concentrations of arsenic were found to be as high as 15,000 mg/kg. The LA made the decision to determine the land as contaminated land under the Part 2A regulatory regime. Funding was received from Defra's capital grants fund to remediate 29 residential properties. However, in order to help the LA decide which houses should be remediated first, an acute risk assessment was undertaken using aspects of the approach being proposed by SoBRA to prioritise the order of remediation. A second area of land was identified with levels of arsenic up to 13,400 mg/kg. This was also subsequently remediated and the assessment methodology included a number of proposals being set out in the SoBRA acute subgroup. The SoBRA AGACs would have provided the LA with a methodology for the acute risk assessment, which had been agreed by a number of experts in the field and would have provided added confidence in the approach used.

Conclusions and recommendations

Over the last 5 years, there has been an increase in industry-led guidance. While the new guidance has been used successfully, there has been no clear trend in the type of contaminated land enquiries to PHE over time to identify further guidance topics. PHE will continue to support the continued development of the C4SLs and SoBRA AGACS to further support LAs and industry and, ultimately, to protect the health of the public.

References

1. Department for Environment, Food and Rural Affairs (Defra). Development of Category 4 Screening Levels for Assessment of Land Affected by Contamination – Policy Companion Document, December 2014. Available at

http://randd.defra.gov.uk/Default.aspx?Menu=Menu&Module=More&Location=None&Completed=0&ProjectID=18341 (accessed 17/03/16).

2. Department for Environment, Food and Rural Affairs (Defra). Environmental Protection Act 1990: Part 2A, Contaminated Land Statutory Guidance, 2012. Available at https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/223705/pb13735cont-land-guidance.pdf (accessed 12/04/16).
3. Contaminated Land Applications in Real Environments (CL:AIRE). Development of Category 4 Screening Levels for Assessment of Land Affected by Contamination – Contaminated Land: Final Project Report (Revision 2), September 2014. Available at https://www.gov.uk/government/collections/land-contamination-technical-guidance (accessed 17/03/16).
4. Welsh Government. Development of Category 4 Screening Levels for Assessment of Land Affected by Contamination – Policy Companion Document, December 2014. Available at http://gov.wales/docs/desh/publications/141211-screening-levels-assessment-contaminated-land-en.pdf (accessed 17/03/16).
5. US Environmental Protection Agency (USEPA). Acute exposure guideline levels for airborne chemicals. Available at http://www.epa.gov/aegl (accessed 17/03/16).
6. Health and Safety Executive (HSE). EH40/2005 Workplace Exposure Limits (2nd edition), 2011. Available for download at http://www.hse.gov.uk/pubns/books/eh40.htm (accessed 17/03/16).

Environmental inequalities: identification of opportunities for future research and policy development

Helen Cruickshank[1], Manpreet Bains[1], Rachel Moll[2]
1. Health Protection Directorate, Public Health England
2. Whittington Hospital NHS Trust

Email: manpreet.bains@phe.gov.uk

Introduction

Reducing health inequalities is a priority for Public Health England (PHE), not only to fulfil legal duties but as a driving principle to improve public health. Health inequalities are systematic, avoidable and unjust differences in health and wellbeing between different groups of people. As an organisation, PHE has developed a framework which aims to identify priority actions to reduce inequality and promote equity[1].

As part of this commitment to integrate health inequalities in work programmes across the organisation, a review of literature was conducted which specifically addressed inequalities relating to environmental exposures. The aim of this review was to identify current knowledge and gaps in evidence which informed recommendations for future targeted work. The key findings are presented in this article. In addition, a recent report from PHE's Centre for Radiation, Chemical and Environmental Hazards (CRCE) entitled 'The health impact of environmental chemicals in England' (to be published in mid-2016) highlighted the importance of furthering understanding of environmental inequalities, alongside developments in measuring the burden of disease relating to environmental exposures, in order to improve public health.

What is known

Environmental equity, or environmental justice (which addresses the disproportionate exposure of different social groups to environmental hazards), has been a high profile issue in the US since the 1980s[2] and there is mounting evidence that this also remains a substantive problem in the UK[3,4]. Those with lower socioeconomic status and those from ethnic minorities are disproportionately exposed to environmental hazards, including proximity to industrial facilities, hazardous waste sites, air pollution, noise and occupational exposures[5,6,7,8]. Environmental hazards may affect health outcomes directly, through physiological exposure, or indirectly, where concerns about perceived exposures are detrimental to mental health, for example[9,10].

While it is generally accepted that there are inequalities in exposure to environmental hazards, particularly with regards to socioeconomic status, reviews have identified that there are three key areas which would benefit from further research. First, there is a need for greater consensus on measurement of both inequality and exposure to assist comparisons[5,11,12]. Second, further research needs to be carried out to improve understanding of the relationship between multiple or cumulative exposures and inequalities[7,11,12]. Third, there is a lack of evidence about the extent to which indicators of inequality can act as effect modifiers on the relationship between environmental risks and health outcomes[7,13,14]. These three issues are discussed below in more detail.

Gaps identified

Measurement of exposures and inequality

Traditionally in environmental epidemiological studies, socioeconomic indicators have in the main been regarded as potential confounders and considered only for adjustment in statistical analysis. Such standardisation can decrease risk estimates and thereby effect modification has not previously been extensively studied[15].

Currently there is considerable variation in the definition of inequalities (for example, socioeconomic status, class, race, ethnicity or age) but most studies focus on socioeconomic indicators and “race” (as defined in the US). Exposures vary dependent on the measured parameter (for example, air pollution, waste, proximity to industrial sites or noise) and the measurement methodology (for example, at an individual or area level) as was verified by this review.

This review highlighted several quality issues which arise when studying environmental inequalities:

- there are limitations in the accuracy of how exposure is measured (and to what extent individuals are exposed in ecological studies)
- there is heterogeneity in how inequalities are defined
- there is heterogeneity in environmental risks described; some reviews focused on one issue such as air pollution and others on a range of risks

Multiple and cumulative exposures

One of the main gaps in evidence identified in the literature is the relationship between inequalities and multiple and cumulative (one or more exposures over a period of time) environmental hazards consideration has been given to the following three questions:

- to what extent are different groups exposed to multiple or cumulative hazards?
- what are the impacts on health of multiple or cumulative environmental exposures, relative to single exposures?
- how do multiple or cumulative environmental exposures impact on health inequalities?

Several studies hypothesise that there are differences in exposure to multiple or cumulative environmental hazards between social groups, these exposures could be harmful to health, and some groups are likely to be more vulnerable to the effects of exposure; however, supporting evidence is limited[5,6,11].

One of the key issues in studies of health outcomes where inequalities are taken into account is that there tends to be a focus on single, rather than multiple, environmental exposures (for example, focused on exposure to air pollution[16]). In the UK, indices have been developed which show that lower socioeconomic groups are more exposed to multiple adverse environmental hazards[8] and health outcomes at an area level become worse as multiple environmental deprivation increases[17]. Further research is needed to understand variations in vulnerability for different groups, but it is thought that children in particular may be more vulnerable than adults to multiple exposures because of developmental immaturity, their constitution and specific behaviours (such as ingestion of soil)[18].

The consequences of multiple and cumulative environmental impacts should not be viewed in isolation. While health outcomes are likely to be affected by different levels of exposure, we must also take into account that some individuals may be more sensitive to the effects of exposure. It is evident that health inequalities are influenced by a complex interplay of environmental, social and biological factors[6]. Therefore there is a need to further understanding on social vulnerability and biological susceptibility, as well as build the evidence base around the health impacts of multiple and cumulative hazards.

Inequality indicators as effect modifiers

It is unclear whether socioeconomic status acts as an effect modifier on the relationship between environmental hazards and health. It is important to understand whether there is an increased vulnerability in certain subsets of the population, to facilitate improved promotion of social justice, environmental protection and act to reduce health inequalities[19].

The majority of the research literature centres on air pollution as an environmental hazard[7,13,20,21]. The heterogeneity among study designs and populations makes comparison difficult. There may be some evidence to suggest an effect modification by socioeconomic status in relation to air pollution and effects on health; however, the evidence base is not strong and further research is required.

There is a wide variation of indicators for socioeconomic status used between papers, including income, education and occupation examined separately or in combination. Bell et al[20] in their systematic review and meta-analysis noted that age is the most consistent effect modifier of the association between short-term exposure to particulate matter and death or hospitalisation, with older people experiencing higher risks. There is weak evidence that women are at a higher risk of hospitalisation and death and suggestive evidence that those with lower income, education and employment status have a higher risk of death. Interestingly the resolution at which socioeconomic characteristics are measured influences the results. Studies that used individually measured socioeconomic characteristics found that disadvantaged subjects were more affected by pollution. Socioeconomic characteristics measured at coarser geographical resolutions demonstrated no effect modification, but those using finer geographical resolutions found mixed results[21].

A review of environmental inequalities among children in Europe noted that there were no studies that explicitly investigated the effect modification of socioeconomic position on the relationship between air pollution and health among children in Europe. However, based on that review, it is thought likely that children are more susceptible to a variety of toxicants[7].

Proposed mechanisms for increased susceptibility of some groups to the health impacts of air pollution include: higher prevalence of existing chronic diseases, access to healthcare, psychosocial stress, occupational exposures and nutritional status[20,22]. The main issue with the existing literature is around limited comparability of studies due to variations in study design (for example, geographical measurement scales, study population and time frame), the lack of evidence for exposures other than air pollution, the definition of socioeconomic status and whether measurements are taken at individual or ecological level. There is the risk of publication bias[21] and underestimation of the extent of social inequalities due to less participation by socially disadvantaged people.

Conclusions

It is established that exposures to environmental hazards can have an impact on health and this review has shown that there is some evidence that it is not uniform across different social groups. However, heterogeneity in measurement of exposures, inequalities and health outcomes makes comparisons of different studies difficult.

The complex relationship between multiple or cumulative environmental hazards, inequalities and health outcomes is not well understood. It is likely that differences in environmental exposures may be an underlying factor that contributes to health inequalities, but the evidence base is insufficiently developed to conclude that exposure to multiple or cumulative environmental hazards is a driver of health inequalities.

It appears there is some limited evidence to suggest that socioeconomic status may act as an effect modifier between air pollutant exposure and health outcomes, but there is a need for further research on whether health outcomes related to broader environmental hazards differ across social groups.

Recommendations

- establish a PHE working group to coordinate and oversee PHE's work on environmental inequalities. To inform the scope of this group, conduct a review of each relevant work programme to understand the extent to which inequalities are currently addressed, and identify the opportunities for future inclusion
- consider whether PHE should initiate specific research in environmental inequalities to meet the gaps identified by this review, including systematic reviews on multiple/cumulative exposures and vulnerability of different social groups to the health effects of environmental exposures
- investigate the feasibility of collecting data on indices of inequalities, both for existing activity and as a requirement for future programmes
- as part of PHE's role in providing support to local authorities, review current practice in England to ascertain how inequalities are included in planning processes where proposed developments could result in detrimental environmental exposures. This should include whether multiple or cumulative exposures are considered and how health inequalities are assessed in health impact assessments

References

1. Public Health England (PHE). Achieving Good Health for All. A framework for PHE action on health inequalities 2015–2020, 2015.
2. US Environmental Protection Agency (USEPA). Environmental Equity: Reducing Risk for All Communities, 1992.
3. Lucas K, Walker G, Eames M, Fey H, Poustie M. Environment and Social Justice: Rapid Research and Evidence Review, 2004.
4. Environment Agency (EA). Stephens C, Willis R and Walker G. Addressing environmental inequalities: cumulative environmental impacts, 2007. Available at https://www.gov.uk/government/publications/addressing-environmental-inequalities (accessed 29/03/16).
5. Evans GW, Kantrowitz E. Socioeconomic status and health: the potential role of environmental risk exposure. Annual Review of Public Health 2002;23:303-331.
6. Morello-Frosch R, Zuk M, Jerrett M, Shamasunder B, Kyle AD. Understanding the cumulative impacts of inequalities in environmental health. Health Affairs 2011;30(5):879-887.
7. Bolte G, Tamburlini G, Kohlhuber M. Environmental inequalities among children in Europe – evaluation of scientific evidence and policy implications. The European Journal of Public Health 2009;20(1):14-20.
8. Pye S, King K, Sturman J. Air Quality and Social Deprivation in the UK: an environmental inequalities analysis, 2006. Final Report to Defra, Contract RMP/2035. London: PHE.

9. Fairburn J, Butler B, Smith G. Environmental justice in South Yorkshire: locating social deprivation and poor environments using multiple indicators. Local Environment 2009;14(2):139-154.
10. Peek M, Cutchin M, Freeman D, Stowe R, Goodwin J. Environmental hazards and stress: evidence from the Texas City Stress and Health Study. Journal of Epidemiology and Community Health 2009;63(10):792-798.
11. Braubach M, Fairburn J. Social inequities in environmental risks associated with housing and residential location – a review of evidence. The European Journal of Public Health 2010;20(1):36-42.
12. Sampson N. Environmental justice at school: understanding research, policy, and practice to improve our children's health. Journal of School Health 2012;82(5): 246-252.
13. Deguen S, Zmirou-Navier D. Social inequalities resulting from health risks related to ambient air quality – a European review. The European Journal of Public Health 2010;20(1):27-35.
14. Heinrich J, Mielck A, Schäfer I, Mey W. Social inequality and environmentally-related diseases in Germany: review of empirical results. Soz Präventivmed, 2000:45(3):106-118.
15. Martuzzi M, Mitis F, Forastiere F. Inequalities, inequities, environmental justice in waste management and health. European Journal of Public Health 2010;20(1): 21-26.
16. Finkelstein M, Jerrett M, Sears MR. Environmental inequality and circulatory disease mortality gradients. Journal of Epidemiology and Community Health 2005;59(6):481-487.
17. Pearce J, Richardson E, Mitchell R, Shortt N. Environmental justice and health: the implications of the socio-spatial distribution of multiple environmental deprivation for health inequalities in the United Kingdom. Transactions of the Institute of British Geographers 2010;35(4):522-539.
18. Hornberg C, Pauli A. Child poverty and environmental justice. International Journal of Hygiene and Environmental Health 2007;210(5):571-580.
19. O'Neill MS, McMichael AJ, Schwartz J, Wartenberg D. Poverty, environment, and health: the role of environmental epidemiology and environmental epidemiologists. Epidemiology, 2007;18:664-668.
20. Bell M, Zanobetti A, Dominici F. Evidence on vulnerability and susceptibility to health risks associated with short-term exposure to particulate matter: a systematic review and meta-analysis. The American Journal of Epidemiology, 2013;178(6):865-876.
21. Laurent O, Bard D, Filleul L, Segala C. Effect of socioeconomic status on the relationship between atmospheric pollution and mortality. Journal of Epidemiology and Community Health 2007;61:665-675.
22. Forastiere F, Stafoggia M, Tasco C, Picciotto S, Agabiti N, Cesaroni G, Perucci CA. Socioeconomic status, particulate air pollution, and daily mortality: differential exposure or differential susceptibility. American Journal of Industrial Medicine, 2007;50:208-216.

Implementation of local stakeholder air quality networks

Stuart Aldridge, Jim Stewart-Evans, Alec Dobney
Environmental Hazards and Emergencies Department, Centre for Radiation, Chemical and Environmental Hazards, Public Health England
Email: stuart.aldridge@phe.org.uk

Introduction

Public Health England (PHE) is committed to developing a programme[1] in support of national and local government to reduce the 25,000 deaths each year in England attributable to air pollution[2]. While managing national and local air quality is primarily the responsibility of Defra (Department for Environment, Food and Rural Affairs) and of local authorities (LAs), PHE can influence and support national and local action on air quality.

PHE develops and interprets the available scientific evidence on the health effects of air pollution and on assessing interventions to reduce exposure to air pollution and improve health and wellbeing. PHE also has an advisory and advocacy role, highlighting the scale of the public health problem associated with air pollution. It encourages healthcare and public health professionals to support local, national and international initiatives to reduce emissions of pollutants. In this way, PHE helps reduce exposure of the population to these emissions.

At a local level, PHE is supporting professional networks whose work relates to air quality and public health. Where no such LA-led networks exist already, PHE has begun work to develop them through its regional centres. PHE East Midlands (PHE EM) hosted a local air quality workshop in Nottingham on 15 December 2014 for LAs; the consensus among attendees was that a PHE-facilitated local network would be of benefit. On that basis, and supported by a local PHE business plan objective to provide support to partners on air quality and health, PHE EM established the “East Midlands Air Quality Network” (EMAQN). The network’s core members comprise representatives from county and district council environmental and public health teams. The network held its inaugural meeting on 13 October 2015.

The PHE West Midlands (PHE WM) business plan also has an objective to address the health burden of air pollution and establish a “West Midlands Air Quality Network” with partners. As a result, a West Midlands air pollution and health stakeholder event was held on 7 December 2015.

Based on the initiation of these new Midlands air quality networks, this article discusses the value of such networks and the practicalities of setting them up.

Aims and benefits of a local air quality network

Network members' organisations have their own business plans and objectives, which include work areas related to air quality and health. A network aims to draw together LA and PHE work related to air quality and public health into a collaborative network work plan.

The high level aims of a network have to be defined by its members, along with the way the network will work. The EMAQN agreed three high level aims at its inaugural network meeting:

- health improvement: improving physical and/or mental health
- health protection: source reduction – reducing the sources of air pollution
- health protection: exposure reduction – reducing people's exposure to air pollution

Once agreed, these high level aims inform a network work plan. Deliverables must relate to air pollution and public health and help to achieve one or more of these high level outcomes. For example, an intervention that encouraged people to cycle along low pollution routes rather than drive could provide all three of EMAQN's desired outcomes. An intervention to reduce end-of-pipe emissions (for example, a transport switch to cleaner fuelled vehicles) could provide source and exposure reduction (and associated health benefits), though not necessarily health improvement in the wider sense. Network work plans may reference existing LA action plans and strategies that aim to deliver interventions that benefit air quality and health. The PHE component of the work plan includes proactive and responsive work to support LA actions, informed by network member discussions and prioritisation of areas of work where PHE coordination and support are most needed.

Networks can improve cross-working and support between environmental health and public health functions and between individual authorities, especially when these are located at separate LA tiers. Through the inclusion of air quality and public health within joint strategic needs assessments (JSNAs), LA public health teams can ensure that the local impacts of air pollution are considered and accounted for. This informs the joint health and wellbeing strategy (JHWS), puts air quality on the public health agenda and supports wider LA actions. This process is informed by local pollutant monitoring data held by environmental health teams and measures of health impact, such as PHE's public health outcomes framework (PHOF) indicator 3.01 "Fraction of all-cause adult mortality attributable to long-term exposure to current levels of anthropogenic particulate air pollution" [3].

Actions to address the health impacts of air pollution can help to deliver other local priorities such as: active travel; health inequalities; self-management and integrated care; sustainability and climate change; growth and regeneration; and localism and community engagement. Air pollution is a cross-cutting issue: to deliver effective actions, the challenge is to join up and work across different LA functions and professional groups. Networks highlight the importance of engaging local spatial and transport planners; planning and transport agendas are critically important in delivering many interventions related to air quality. The box presents some of the outcomes of discussions held during the West Midlands event, which highlight the importance of collaborative working to influence forward planning (though JSNAs, JHWS and town and transport planning).

Box: PHE West Midlands air pollution and health stakeholder event: discussions highlighting the importance of collaboration in influencing forward planning

The purpose of this event was to bring together key air quality stakeholders at a regional level to explore ways of working together to reduce the burden of air pollution on public health and to determine whether there is an appetite for developing a local strategic air quality network. Key issues, illustrated by case studies, were presented and discussed during seminar sessions that covered:

- collaboration between local authority and public health teams – the importance of JSNAs and how the impact of air pollution can be more significant in deprived areas. Examples were provided of cases using a public health transformation fund[4] to support air quality interventions
- negotiating the planning system, presented by a local head of planning – discussing relevant aspects of the planning framework and the importance of air quality being considered as an element of planning. Open spaces, cycle networks, JSNAs, 'green gyms', 'health hubs' and the West Midlands Good Practice Air Quality Planning Guide (2014)[5] were given as examples of good practice. Stakeholders were reminded of the importance of getting involved early on in the stages of planning, when there is most opportunity to influence development
- an overview of the integrated transport plan/strategic transport plan, presented by the policy adviser to the West Midlands Integrated Transport Authority. The plan considers 'clean air' and 'healthy places' and has a long, 20-year capital programme – encouraging ultra-low vehicle uptake and clean air zones. There was emphasis on the importance of looking ahead and considering how things will be in the next 5–10 years

There was unanimous support from attendees for the creation of a West Midlands Air Quality Network (WMAQN). PHE West Midlands will now take this forward through the its environment and sustainability working group and its 2016/17 business plan.

Roles and responsibilities

The air quality and public health agenda overlaps with public health objectives to increase physical activity, decrease obesity and improve cardiovascular and respiratory health. Interventions that improve air quality can, as a result, directly benefit nine further PHOF indicators[3] relating to road injuries, physical activity, obesity and mortality.

The core membership of a network may, therefore, involve:

- PHE – within PHE, air quality networks promote and support the work of the health protection and health and wellbeing functions:
    - Centre for Radiation, Chemical and Environmental Hazards (CRCE)
    - health protection teams
    - health and wellbeing teams
    - in PHE-led networks, the PHE centre may provide the network chair and secretariat
- network members
    - environmental health
    - public health
    - representative(s) from spatial planning, transport and highways
    - in PHE-led networks, a network member from a LA may act as co-chair to the network

Delivering a collaborative work plan

At the outset, deciding what a network will deliver is important and requires agreement both at PHE regional level and within the network itself. The high level aims described earlier in this article provide a framework for subsequent work plan activities. When developing a work plan, it is important to consider the balance to be achieved between time spent by PHE staff on proactive work and reactive work. Proactive work areas must be set out in a plan that gives the network a clear direction in the longer term. The figure presents proactive activities taken from the initial work plan of the EMAQN.

Conclusions and recommendations

Collaborative air quality networks have been welcomed across the Midlands as the first step in developing an overarching local work plan and strategy for action on air pollution and public health. These networks will aim to make best use of finite resources and will seek to focus on the sharing of information, production of supporting information and ultimately influencing forward planning, through joint strategic needs assessments, joint health and wellbeing strategies and spatial and transport planning. PHE will continue to develop and support these networks across the country.

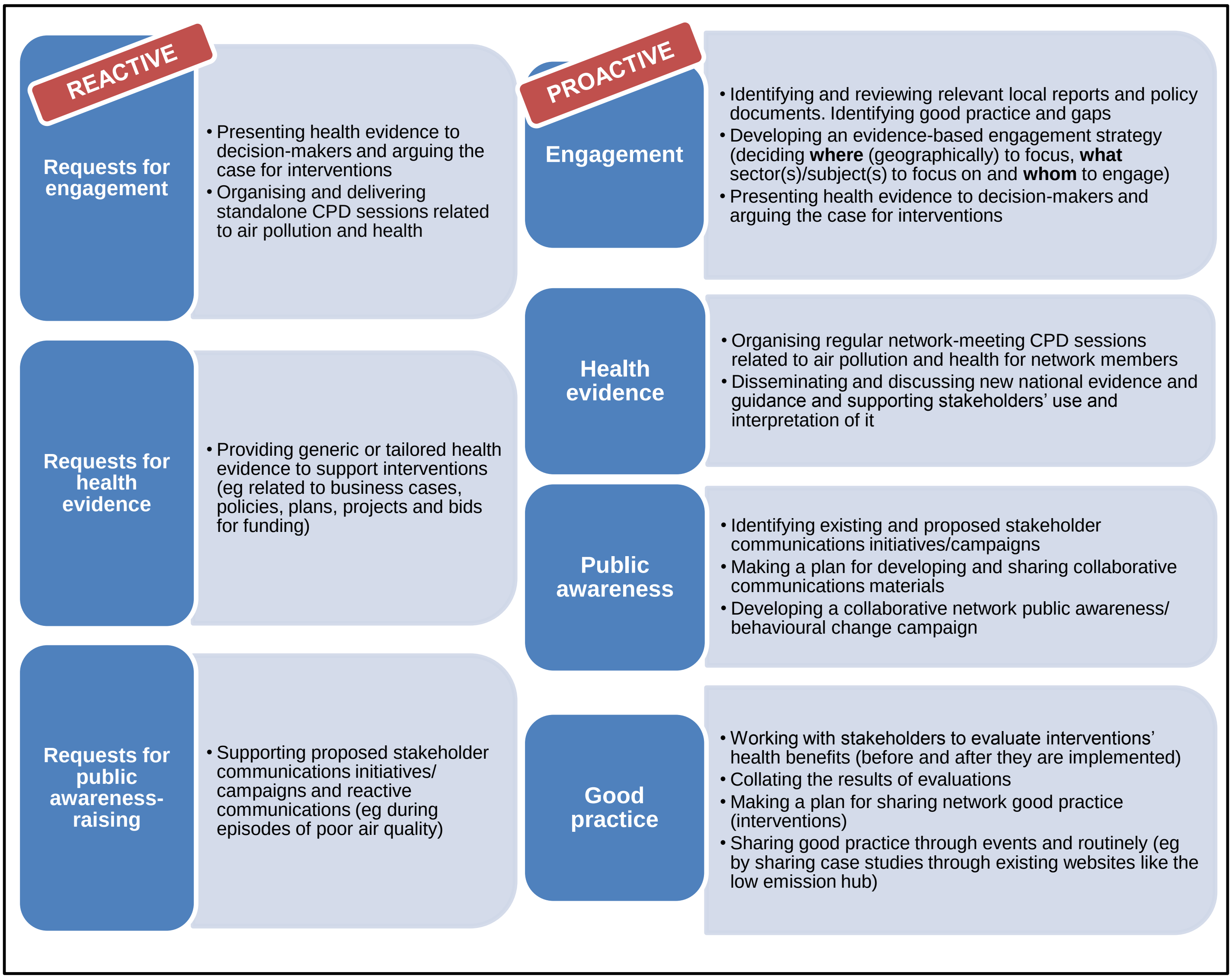

Figure: Reactive and proactive activities taken from the initial EMAQN work plan

References

1. Public Health England (PHE). Who we are and what we do: Annual Plan 2015/16, 2015. Available at https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/452328/Annual_plan_2015-_Aug7-web.pdf (accessed 09/03/16).
2. Committee on the Medical Effects of Air Pollutants (COMEAP). The Mortality Effects of Long-Term Exposure to Particulate Air Pollution in the United Kingdom, 2010. Available at https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/304641/COMEAP_mortality_effects_of_long_term_exposure.pdf (accessed 09/03/16).
3. Department of Health. Public Health Outcomes Framework 2013 to 2016, last updated 2015. Available at https://www.gov.uk/government/publications/healthy-

lives-healthy-people-improving-outcomes-and-supporting-transparency (accessed 09/03/16).

4. Walsall Council. Public Health Transformation Fund, 2014. Available at http://cms.walsall.gov.uk/index/public_health_consultation.htm (accessed 09/03/16).
5. West Midlands Low Emissions Towns and Cities Programme. West Midlands Good Practice Air Quality Planning Guide, 2014. Available at http://cms.walsall.gov.uk/letc_good_practice_air_quality_planning_guidance_may_2014.pdf (accessed 09/03/16).

Mercury contamination – a case study

Ceri Riley[1], George Kowalczyk[1], Kristina Poole[2], Nicola Schinaia[2], Lydia Izon-Cooper[1]

1. Environmental Hazards and Emergencies Department, Centre for Radiation, Chemical and Environmental Hazards, Public Health England
2. Health Protection Team, Public Health England

Email: ceri.riley@phe.gov.uk

Overview

During 2015, Public Health England's (PHE) Centre for Radiation, Chemical and Environmental Hazards (CRCE) was informed of an incident involving spillage of a substantial amount of mercury at a residential property. There followed several months of monitoring and decontamination activity to reduce the concentration of mercury vapours within the property. CRCE worked with local stakeholders, including the local authority (LA), to provide expert advice to ensure health would be protected on re-occupation.

Health risk assessment

The incident involved the spillage of an estimated 150 ml of mercury throughout the property. Following this spillage, a specialist chemical handling company was engaged and indoor air monitoring was carried out; levels of mercury up to 900 µg/m^3 were recorded.

CRCE provided initial advice to the LA on the health effects of mercury and liaised with the PHE health protection team and LA during the decontamination, monitoring and subsequent reoccupation of the property. CRCE advised that, ideally, levels should reach 1 µg/m^3 (WHO air quality guideline value[1]) or less before re-occupation. Occupational exposure evidence indicates that long-term continuous exposure to mercury vapour at levels above 4.8 µg/m^3 is associated with adverse health effects, such as damage to the nervous and renal systems.

Through the use of public health legislation, specifically the Health Protection (Local Authority Powers) Regulations 2010, the occupants agreed not to re-occupy the property[2]. Consideration was given to the application of Part 2A orders (Health Protection (Part 2A Orders) Regulations 2010)[3] to prevent re-occupation of the property as air concentrations in the property at the time (several hundred µg/m^3 of mercury) were considered to present a significant health risk. The purpose of a Part 2A order is to adopt an all-hazard approach, consistent with the International Health Regulations 2005[4]. These provisions therefore enable public authorities to respond to health hazards that could result in significant harm to human health[5]. However, this was not necessary in this case, because of the voluntary agreement.

Decontamination and monitoring

It was clear that levels of mercury were unacceptably high and decontamination was needed. The initial aim was to remove gross contamination by:

- syringing visible globules of mercury
- bagging and removing items that were visibly contaminated, especially soft furnishings and carpet
- using tape to remove smaller droplets from hard surfaces

Flowers of sulphur and zinc oxide (which are sometimes used for mercury clean-up) were not used, to avoid introducing additional pollutants; there is also a risk of fire if zinc oxide reacts with water. The Government Decontamination Service (GDS) was later able to provide support to the LA by giving advice on different decontamination techniques and actions during the recovery phase of this incident.

Monitoring was carried out to enable reliable comparison of data over time. Individual rooms were tested at both floor level and 1.7 m (representing breathing height). Mercury concentrations increased after movement within rooms, even where carpet and underlay had been removed; this was possibly because droplets underneath or within floorboards had been disturbed and therefore released more mercury vapour.

Decontamination proceeded in stages, beginning with surface decontamination, removing all contaminated items and furnishings first, ventilating the property with heating on and windows open; and then progressing to more structural approaches, such as removing floorboards and skirting boards to access residual liquid mercury.

After 6 weeks of decontamination, concentrations had fallen significantly but remained higher (over 10 µg/m^3) in upstairs rooms (where the initial spillages occurred) compared to downstairs ones, where levels were approaching 1 µg/m^3 (see the figure). Within 3 months, all visible mercury had been removed, but the levels in upstairs rooms were still higher than 1 µg/m^3. As further decontamination would have required significant structural work (such as removal of load-bearing walls), passive ventilation was agreed as a viable way to reduce levels further and the property was re-occupied.

Discussion and conclusions

This is the largest known spill of mercury in a domestic property and, despite extensive decontamination, mercury levels had not reached the target level of 1 µg/m^3. Re-occupation occurred, but only after the homeowners had been made aware of the risks and the importance of following mitigation measures to protect their health.

Although not used on this occasion, this incident demonstrated how a Part 2A order may be useful at the early stages of a chemical incident, when potential exposures are high, to prevent members of the public from being exposed to levels which could result in significant harm to health.

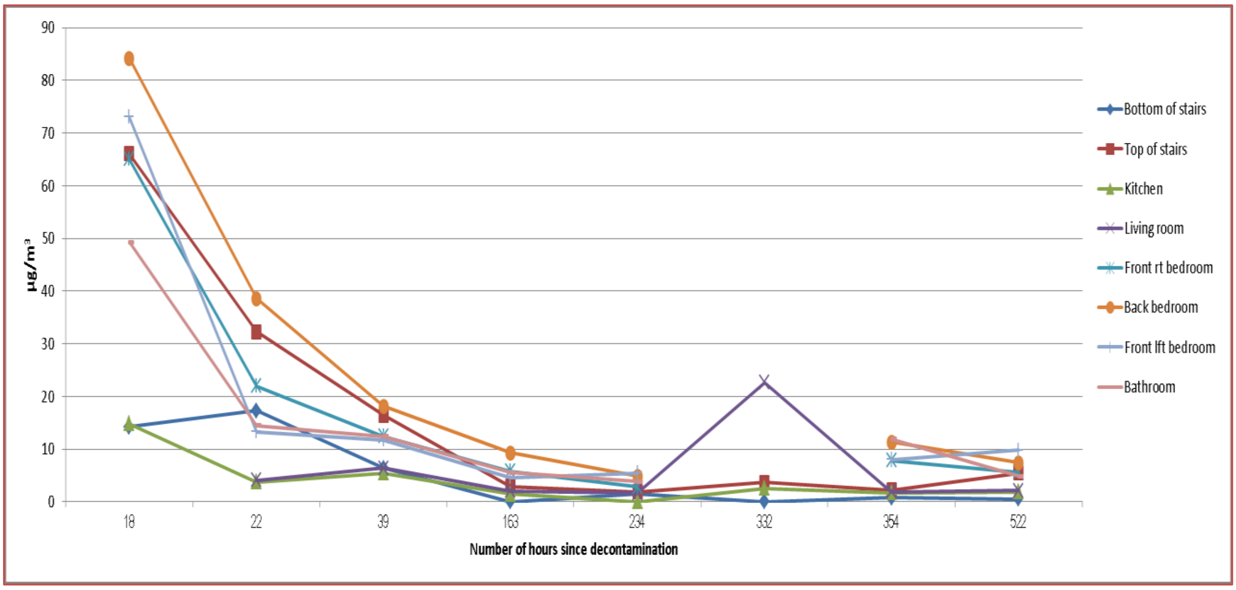

Figure: Decline of mercury levels during the first few weeks after the start of decontamination

Recommendation

This incident demonstrated the need for a thorough and timely response to large domestic mercury spills to prevent spread and facilitate clean-up. While incidents like this are uncommon, LAs may benefit from having access to monitoring equipment to avoid the high cost of employing contractors; for instance, this could be through shared agreements with other LAs or through hire agreements with suppliers.

References

1. World Health Organization (WHO). Air Quality Guidelines for Europe (2nd edition), 2000. Available at http://www.euro.who.int/__data/assets/pdf_file/0005/74732/E71922.pdf (accessed 09/03/16).
2. The Health Protection (Local Authority Powers) Regulations 2010 (SI 2010/657). Available at http://www.legislation.gov.uk/uksi/2010/657/contents/made (accessed 09/03/16).
3. The Health Protection (Part 2A Orders) Regulations 2010 (SI 2010/658). Available at http://www.legislation.gov.uk/uksi/2010/658/contents/made (accessed 09/03/16).
4. World Health Organization (WHO). International Health Regulations (2005), (2nd edition), 2008. Available at http://www.who.int/ihr/publications/9789241596664/en/ (accessed 13/04/16).
5. Chartered Institute of Environmental Health (CIEH) and Public Health England (PHE). Health Protection Regulations 2010 Toolkit, June 2011 (revisions made October 2015). Available at http://www.cieh.org/policy/health-protection-regulations-toolkit.html (accessed 11/03/16).

Formaldehyde in indoor air – school case studies

Manjit Singh, Chris Jewell, Lydia Izon-Cooper
Environmental Hazards and Emergencies Department, Centre for Radiation, Chemical and Environmental Hazards, Public Health England
Email: manjit.singh@phe.gov.uk

Introduction

Public Health England (PHE), the Health and Safety Executive (HSE) and local authorities (LA) were involved in responding to unrelated incidents involving two schools where children and staff reported feeling unwell and experiencing symptoms such as eye irritation. Investigations in both schools found formaldehyde in the indoor air; it was subsequently agreed that the schools would be closed. In both cases, investigations were required to find the source of the formaldehyde in the schools and risk assessments were required on the health impact on staff and students. PHE supported the response to these incidents through the provision of information for students, parents, staff and the media and through assistance with the risk assessment as part of a multi-agency group.

What is formaldehyde?

Formaldehyde is a colourless gas with a pungent odour; it is a naturally occurring volatile organic compound (VOC). Formaldehyde is an important precursor to many other materials and chemical compounds[1]. It is mainly used in the production of industrial resins, fibre board, coatings and glues. It is also used in the manufacture of carpets, furniture, foam insulation and household products; as an ingredient in glues; as a preservative in medical laboratories; and as an embalming fluid. Additionally, it is found as a byproduct of combustion in cigarette smoke, fuel burning appliances and kerosene heaters. The natural background concentration of formaldehyde in the environment is less than 1 μg/m^3 with an average of about 0.5 μg/m^3 [1].

Potential health effects

The predominant effects of formaldehyde are irritation and burning of the mucous membranes of the nose, mouth and upper respiratory tract following short-term (acute) inhalation. Following acute exposure to larger concentrations, weakness, eye irritation, headache, nausea, vomiting, pneumonia, difficulty in breathing, wheezing, coughing, central nervous system depression, convulsions and coma can occur[1].

The European Chemicals Agency (ECHA) Committee for Risk Assessment (RAC) recently considered whether a threshold could be established for carcinogenicity of formaldehyde: that is, a level below which an effect may not be observed[2]. ECHA concluded that there was insufficient information for a threshold to be derived. The general approach for non-threshold carcinogens is that exposure should be as low as reasonably practicable (ALARP).

Formaldehyde and effects during pregnancy

The published data concerning the effects of exposure to formaldehyde during pregnancy does not provide evidence of an increased risk of adverse fetal outcomes; however, data is limited and, thus, an increased risk cannot be ruled out completely[3].

As with all chemicals, unnecessary exposure to formaldehyde should be avoided. Clinicians are recommended to discuss all cases of exposure to formaldehyde, at any stage of pregnancy, with the UK Teratology Information Service (UKTIS) which provides a national service on all aspects of the toxicity of drugs and chemicals in pregnancy[3].

Case study 1

During the summer holidays of 2015, while a school was closed, external contractors undertook some minor refurbishment, including the addition of partition walls, new carpets using adhesives and redecoration of five classrooms, including the painting of ceilings and walls. It re-opened after the holidays for the new academic term in September 2015. The school was subsequently closed in mid-September 2015 following concerns about air quality as staff and pupils noticed an odour in the school and reported respiratory symptoms, headaches and sore throats. Following this, all staff and pupils were evacuated and temporarily relocated to other local schools. The school remained closed until the source of the odour was investigated; therefore there was no ongoing exposure to staff and pupils. It was speculated that the materials used during the refurbishment were a source of formaldehyde and other VOCs.

Contractors investigated the areas of concern and removed redundant materials, disused ventilation ducts and debris in the roof space. Air monitoring was undertaken, as instructed by the LA, to ascertain the potential source of the odour. Concentrations of VOCs and bioaerosols were measured and the monitoring found evidence of formaldehyde within some of the classrooms and cavity walls. Levels of total VOCs detected in some areas of the school were up to 466 $\mu g/m^3$ and formaldehyde was up to 4,362 $\mu g/m^3$. PHE's Centre for Radiation, Chemical and Environmental Hazards (CRCE) advised that these levels were high and that some further monitoring should be undertaken to include VOCs, once remedial work had been completed. This remedial work involved the replacement of the new partition walls, flooring and carpets, and installation of a new ventilation system and windows. After this remediation, the levels of formaldehyde and total VOCs reduced and the school was reopened in January 2016.

CRCE, in liaison with the LA, developed public health advice on formaldehyde for staff, parents and pupils in the form of letters and frequently asked questions.

Case study 2

While another school was closed during the summer months of 2015, contractors undertook some remedial work to resolve structural issues. Part of the work was to fill voids that were present in the floors of the classrooms and corridors of the school. Once all work was completed, the school re-opened in September 2015. Staff and pupils noticed an odour within some of the classrooms and corridors and began to experience respiratory symptoms and runny eyes. A precautionary decision was made to shut the school. Investigation by the school and LA identified that the expanding foam used as infill material in the floor voids may have been the source of the odours.

Air monitoring commissioned by the LA was undertaken and CRCE staff were asked to comment on the health implications. VOCs were identified throughout the school; elevated levels of formaldehyde up to 3,900 $\mu g/m^3$ were detected. At these measured levels, symptoms such as those reported by staff and pupils would be expected. The LA also commissioned a health risk assessment for repeated exposures to formaldehyde and to address the concerns of pregnant members of staff. The risk assessment concluded that exposure levels were unlikely to result in any long lasting health problems for staff and pupils.

The fire and rescue service investigated the potential for an explosive risk of formaldehyde vapour building up in the ducts. CRCE undertook a risk assessment and concluded that the concentrations of formaldehyde vapour were below those at which an explosive risk would occur.

CRCE, in liaison with the LA, developed public health advice for staff, parents and pupils in the form of letters and frequently asked questions. CRCE also advised on ventilation of the school building to help reduce VOC levels and organised referrals for pregnant staff members to the UKTIS.

It is understood that the school will remain closed until September 2016 while remediation works are carried out to remove the expanding foam. Staff and pupils have been relocated to other schools until the work is completed. CRCE has advised that further monitoring be undertaken once the remedial work has been completed, to provide reassurance.

Conclusions and recommendations

These incidents highlighted the importance of good indoor air quality, particularly where vulnerable members of the public are present, including children and pregnant women. It also highlighted the importance of effective communications, both between agencies and with members of the public. In this instance, timely protective action, in the form of evacuation and relocation of staff and pupils, meant that long-term health effects from short-term exposure to formaldehyde are not expected. PHE will continue to work closely with LAs to inform public health risk assessments, risk mitigation and risk communication.

References

1. Public Health England (PHE). Formaldehyde: health effects, incident management and toxicology, 2014. Available at https://www.gov.uk/government/publications/formaldehyde-properties-incident-management-and-toxicology (accessed 04/03/16).
2. EU European Chemicals Agency (ECHA) Committee for Risk Assessment (RAC). Opinion document on the harmonised classification and labelling of formaldehyde, 2012. Available at http://echa.europa.eu/documents/10162/254a73cf-ff8d-4bf4-95d1-109f13ef0f5a (accessed 18/03/16).
3. UK Teratology Information Service (UKTiS). Exposure to formaldehyde in pregnancy, 2012. Available at http://www.medicinesinpregnancy.org/bumps/monographs/exposure-to-formaldehyde-in-pregnancy/ (accessed 04/03/16).

Carbon monoxide – risks at go-karting venues

Rebecca Gay, Graham Urquhart
Environmental Hazards and Emergencies Department, Centre for Radiation, Chemical and Environmental Hazards, Public Health England
Email: rebecca.gay@phe.gov.uk

Introduction

Levels of carbon monoxide (CO) at indoor go-karting venues can exceed safety standards, such as workplace exposure limits (WEL) and World Health Organization (WHO) air quality standards, and result in adverse health effects if the tracks are not operated appropriately. Despite this issue being highlighted previously[1], it persists, as illustrated by the two cases described in this article. These incidents stimulated discussions with local health protection teams, which resulted in the provision of information to local authority environmental health officers about the potential risks from CO at karting venues. More recently, the National Karting Association has produced guidance for its members outlining the management of CO risks.

Health effects

Carbon monoxide is a colourless, odourless and tasteless gas, thereby making it difficult for people to detect. When inhaled, the gas binds to haemoglobin (forming carboxyhaemoglobin) which reduces the oxygen carrying capacity of blood. CO is produced by the incomplete combustion of carbon containing materials and common sources include natural gas, coal and petrol. Acute exposure to increasingly high levels of CO can cause headaches, nausea, vomiting, dizziness, weakness, collapse, unconsciousness and death due to cells not receiving enough oxygen, especially in the heart and brain[2]. Chronic exposure can cause flu-like symptoms, low birth weight, memory problems and emotional, physical or mental disability. The table shows a number of air quality standards which can be used for exposure assessments[3,4,5]. The half-life of carboxyhaemoglobin is variously reported as between 2 and 6.5 hours, depending upon individual characteristics and starting concentration. It is possible to estimate the level of CO in air from a measurement of carboxyhaemoglobin in blood[2].

Table: A range of air quality standards over different exposure periods

Exposure duration	Concentration of CO		Guideline
	ppm	mg/m^3	
24 hours	6	7	WHO indoor air quality guideline[3]
8 hours	10	10	WHO indoor air quality guideline[3]
	10	10	WHO outdoor air quality guideline[4]
	30	35	Workplace exposure level[5]
1 hour	30	35	WHO indoor air quality guideline[3]
	25	30	WHO outdoor air quality guideline[4]
30 minutes	50	60	WHO outdoor air quality guideline[4]
15 minute	90	100	WHO indoor air quality guideline[3]
	90	100	WHO outdoor air quality guideline[4]
	200	232	Workplace exposure level[5]

Case study 1

A patient presented to hospital at 10:30 hours after working at an indoor karting venue between 18:00 and 23:00 the previous night. Upon presentation the patient had 5.7% carboxyhaemoglobin; though he was a smoker, his last cigarette was at 17:00 the previous day. Assuming a half-life of 4 to 6 hours, this level could have originally been in the range of 22–45% at the end of his shift: a level at which symptoms including throbbing headache, dizziness, nausea, weakness or even collapse could be experienced.

It transpired that due to bad weather the doors at the karting centre had been closed, and the ventilation system was not working correctly, which created high levels of CO indoors. The treating physician contacted the National Poisons Information Service (NPIS) for clinical advice and also expressed his concern about the venue, raising potentially wider public health implications. The NPIS subsequently notified PHE's Centre for Radiation, Chemical and Environmental Hazards (CRCE). Clarification was required on a number of issues including:

- number of people attending the venue (maybe as many 200 people)
- who was responsible for informing the Health and Safety Executive (HSE)
- whether anyone else was experiencing symptoms
- whether there were any ongoing risks

Figure 1 shows the lines of communication during this incident. The local health protection team coordinated the response, with CRCE providing specialist advice on chemical issues such as air quality standards and half-life of carboxyhaemoglobin. As a precaution (no pregnant women were known to be present), the UK Teratology Information Service was asked for advice about possible risks to unborn children and any follow-up and/or interventions that might be required should pregnant women have been exposed. NHS England found that four people, all marshals, attended two different hospital emergency departments. Local authority personnel promptly inspected the venue and working practices were modified to prevent future incidents. Effective multi-agency communication facilitated the prompt collation of relevant information and enabled appropriate action to be taken to ensure future safety at the site.

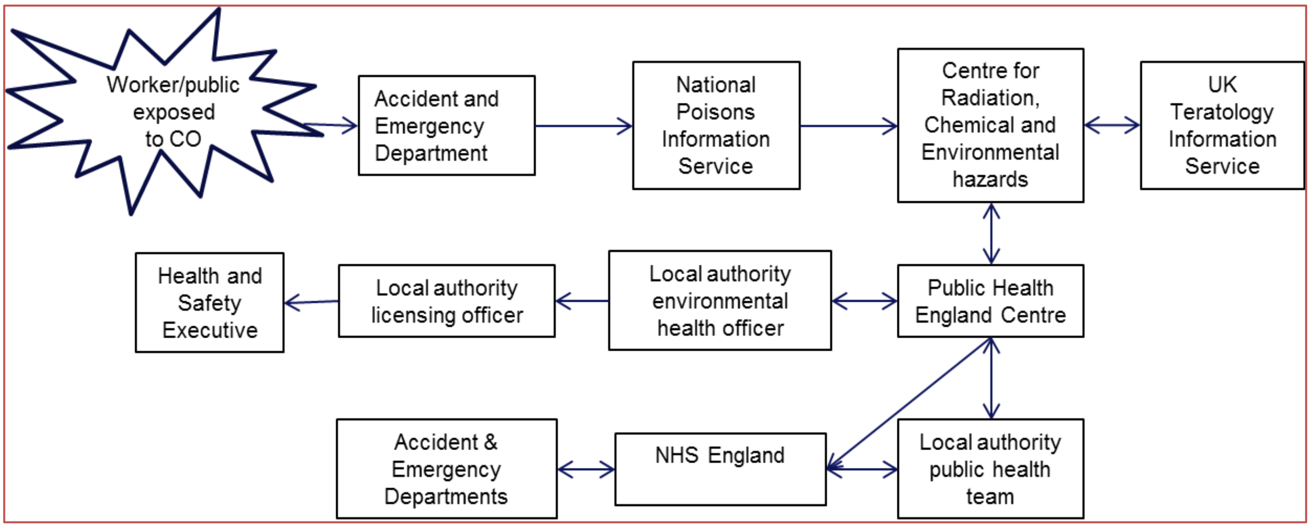

Figure 1: Lines of communication during response

Case study 2

A local authority received two complaints about health effects due to exposure to fumes at an indoor karting facility. The investigation launched by the local authority environmental health officer included measuring levels of CO at head height from within the premises as shown in Figure 2. Levels were consistently above 50 ppm when the track was being used, peaking at approximately 180 ppm. These levels are above all thresholds in the table, except the short-term WEL for 15 minutes (200 ppm). This indicated that further investigation was warranted. CRCE compared these results to a range of standards (WHO outdoor air quality guidelines for 15, 30 and 60 minutes and WHO indoor air quality guidelines for 15 and 60 minutes), all of which were exceeded at some point. Therefore to protect both staff and members of the public it was recommended that levels must not exceed 50 ppm averaged over 60 minutes, and 100 ppm over 10 minutes. The company was committed to ensuring the highest level of safety possible, and installed new ventilation, sensor and alarm systems that would warn if these levels were breached in the future.

Improving standards for karting tracks

The National Karting Association (NKA) was established in 1992 to provide help and assistance to commercial kart circuit operators. However, membership is voluntary, and not all venues belong to the association. NKA, in consultation with the HSE, has produced guidelines for safe operation of karting circuits, which include those related to CO.

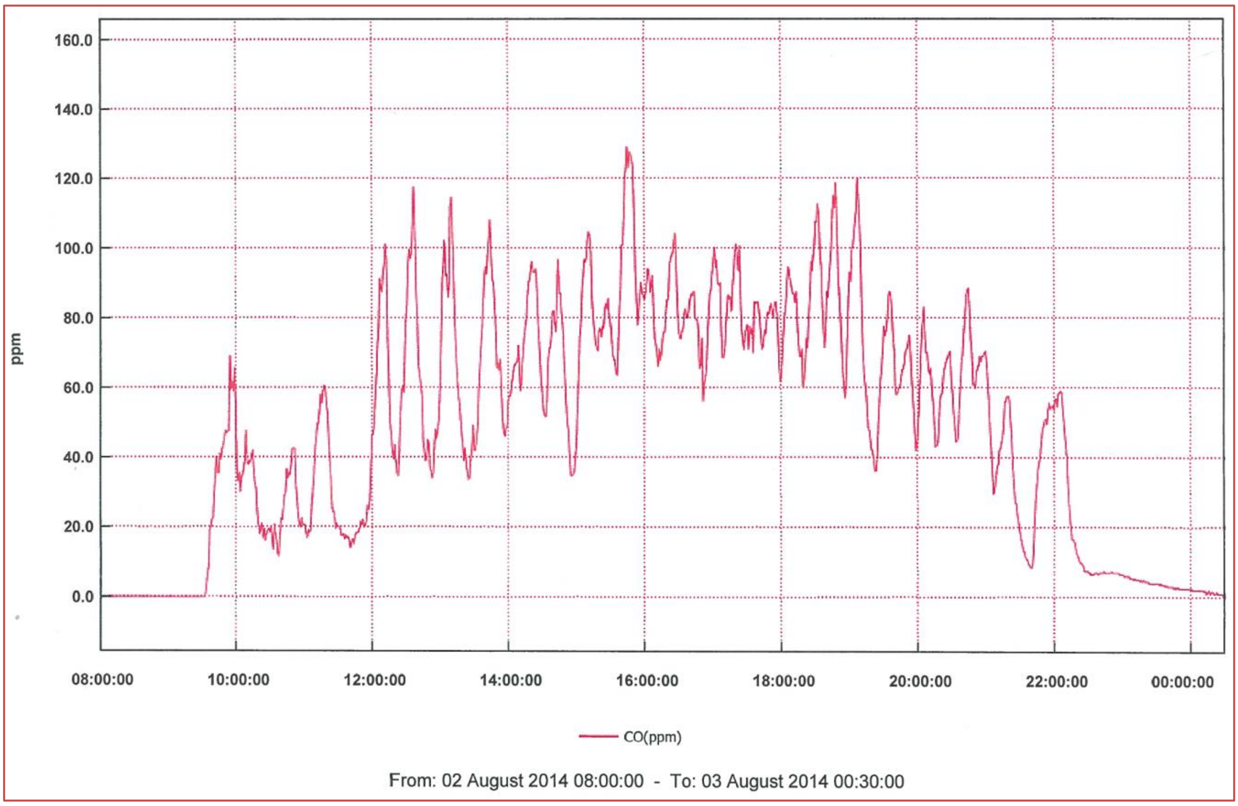

Figure 2: Carbon monoxide monitoring results from within an indoor karting venue

Eastleigh Borough Council in Hampshire is the primary authority for the NKA and in September 2015 entered into a coordinated partnership with them, meaning that the council works on NKA's behalf to assure all its documentation and advice. Members benefit from use of this guidance and are inspected against it, which promotes consistency in standards among member tracks. The primary authority is embarking on training for interested parties. More information can be obtained by contacting pa@eastleigh.gov.uk.

Conclusion

This article briefly presented the ongoing potential risk to people from exposure to CO at indoor karting venues and highlights best practice guidance which should be used to ensure people can continue to have fun without being put at risk. This is especially true for vulnerable users such as pregnant women, or people with pre-existing health conditions such as angina.

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References

1. Health Protection Agency (HPA). Carbon monoxide poisoning at indoor go-karting venue Chemical Hazards and Poisons Report, 2006(8). Available at https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/203521/CHPR_No8_Nov2006.pdf (accessed 21/03/16).
2. Department of the Environment. Expert Panel on Air Quality Standards. Carbon Monoxide, 1994. Available at http://webarchive.nationalarchives.gov.uk/20060715141954/http://www.defra.gov.uk/environment/airquality/aqs/co/index.htm (accessed 21/03/16).
3. World Health Organization (WHO). WHO guidelines for indoor air quality: selected pollutants, 2010. Available at http://www.euro.who.int/__data/assets/pdf_file/0009/128169/e94535.pdf (accessed 21/03/16).
4. World Health Organization (WHO). Air Quality Guidelines for Europe (2nd edition), 2000. Available at http://www.euro.who.int/__data/assets/pdf_file/0005/74732/E71922.pdf?ua=1 (accessed 21/03/16).
5. Health and Safety Executive (HSE). EH40/2005 Workplace Exposure Limits (2nd edition), 2011. Available at http://www.hse.gov.uk/pubns/priced/eh40.pdf (accessed 21/03/16).

Pica – a public health perspective

Ross Thompson, Heba Rabie
Environmental Hazards and Emergencies Department, Centre for Radiation, Chemical and Environmental Hazards, Public Health England
Email: ross.thompson@phe.gov.uk

Background

Pica is generally defined as repeatedly eating objects with no nutritional value; however, the clinical definition put forward by US Diagnostic and Statistical Manual of Mental Disorders (DSM-5) is a form of eating disorder (ICD-10 code: F50.8 in adults and F98.3 in children). The DSM-5 diagnosis is described as follows[1]:

- persistent eating of non-nutritional, non-food substances for a period of at least 1 month
- eating of non-nutritional, non-food substances inappropriate to the developmental level of the individual
- eating behaviour is not part of a culturally supported or socially normal practice
- if occurring with another mental disorder, or during a medical condition, it is severe enough to warrant independent clinical attention

Pica has been seen to occur in both male and females at all ages across the entire IQ range[2]. Examples of substances typically consumed include soil, paint chips, paper, pins, and cloth among other non-nutritional substances. Pica has occurred for centuries, with the earliest documented cases being the ingestion of clay as a treatment for symptoms such as morning sickness and indigestion from around 40 BCE[3]. Australian Aboriginals have been adding soils to their food for generations and woman in Turkey and some countries in Africa were encouraged to ingest clay to enhance fertility. However, with wider dissemination of pharmaceuticals and education these practices are no longer as common[4].

The causes of pica are not fully understood, but are thought to be of two separate streams:

- voluntary ingestion, where an individual enjoys the taste, odour or texture of the material ingested where it is culturally and socially acceptable as described above
- involuntary, either as an impulse due to dietary cravings linked to other underlying physical, mental health or developmental conditions[4]

Health risks associated with pica

The health risks associated with pica can be quite severe[5], hence it is a concern among health practitioners. Non-food substances are inherently less hygienic and subject to fewer controls as they are not intended for human consumption[6]. Adverse health effects include:

- heavy metal toxicity and poisoning
- intestinal obstruction
- internal abrasions from sharp objects
- damage to teeth
- nutritional deprivation
- infectious diseases

Risk factors and prevalence of pica in England

The prevalence of pica in England remains largely unknown. Hospital episode statistics in England show that hospital admissions for pica have increased significantly by approximately 5% a year (95% CI 3.2–6.9%; p-value < 0.001) from 1998–2014, with 51 main diagnoses in 1998, rising to 98 in 2014[7]. However, the number has remained relatively stable in children at under 10 cases a year. The cause for the increase in admissions numbers is unclear but it may be due to changes in reporting practices.

In comparison, data from the US Agency for Healthcare Research and Quality (AHRQ)[5] shows that hospitalisation of patients as a direct result of pica behaviour increased from 964 hospital admissions in the year 1999–2000, up to 1,862 admissions over the period 2008–2009 across the US, an increase of 93% over the decade. Eating disorders are often a secondary diagnosis; the data shows that the top 10 principal diagnoses for patients include schizophrenia and other psychological disorders, and other anaemia and nutritional deficiencies. These associations, however, are not specific to pica, thus caution should be taken when trying to reach conclusions about underlying causes of pica.

Age

Pica behaviours are more commonly observed in young children than in adults due to their innate curiosity and their hand to mouth behaviour; however, there is a negative linear relationship with age and pica behaviours seen[4,6,8]. Typically, a pica behaviour incidence rate of 50% is considered “normal” for children of 18–36 months, falling to about 10% for children over 12 years of age[4,8].

Pregnancy

Pica is also observed among pregnant women, with possible fetal effects such as low birth weight due to a lack of nutrients and exposure to heavy metals such as lead. Research in Saudi Arabia has indicated that around 8.8% of pregnant women engaged in pica behaviour in 2010, whereas studies undertaken in Dar es Salaam, Tanzania, in 2009 and Nairobi, Kenya, in 2008 showed prevalences of 64% and 74%, respectively[9,10].

Socioeconomic and cultural background

It is indicated that, in many countries, the prevalence of pica is often dependent on socioeconomic and cultural backgrounds[3]. The UK population is diverse and pica behaviours have been reported among West African and some Asian communities, in the form of home remedies such as treating morning sickness[11].

In the US, demographic data reveals that pica is observed among individuals of lower socioeconomic status due to the reduced levels of zinc and iron in their diets[12]. Within this group, children from minority backgrounds are particularly affected[13].

Underlying conditions

Where social and cultural acceptability of pica behaviours is not an issue, there tend to be underlying conditions. Pica has been associated with a higher incidence of malnutrition[4,8]. Research shows that there is a strong link between pica and iron and zinc deficiencies, although the causal-effect link is unclear[3,9,14]. There have also been associations with pica and obsessive compulsive disorder[8,15,16,17].

Sickle cell disease and pica are also reported to be associated; however, there are limited evidence-base studies and case reports[18]. Two empirical studies identified within the US[19,20] suggest relationships for pica behaviours in children with sickle cell with incident rates of 33.9% and 62.2%, respectively.

As previously mentioned, there is evidence that individuals with severe developmental conditions such as those within the autism scale, are reported to display pica behaviours more frequently than others[4,6,8,21]. There is an estimated prevalence of 10–20% of pica behaviours by individuals with intellectual disabilities[21]. In the UK, it has been reported that pica is a known cause for hospitalisation for intellectually disabled patients[22]. This implies that the medical risks and concerns described above are significant for the intellectually disabled.

Management of pica

The main approach taken by medical professionals to treat the disease is prevention, through educational outreach in an attempt to alter the pica behaviour and raise awareness of the dangers and risks[4,6]. Preventive steps such as remediation of contaminated source or removal of inedible substances are a common approach. However, where it is required, pharmacological treatment may be warranted. Studies show that some patients with iron deficiency respond positively to iron supplements, while other studies suggest that treatment with selective serotonin re-uptake inhibitors can also aid in positive behaviour modification[8,15].

Public Health England (PHE) has been involved in multi-agency work in producing educational materials to warn expecting mothers of the dangers of using such un-regulated products (sikor – baked clay – and Calabash chalk), as they have been found to contain lead and arsenic[11,23]. PHE has also been involved in the investigation of potential sources of lead poisoning where pica behaviours have been observed, as in the case study below.

Case study of pica leading to lead poisoning

In January 2015, PHE was informed by a clinical haematologist about lead poisoning in a 2 year old child with iron deficiency and a history of pica. The child had a blood lead level of 65 µg/dl. As part of the subsequent public health investigation, PHE visited the property to assist in identifying and controlling the source. Prior to the visit, a questionnaire from the lead action card[24] had been completed, which showed that the child lived in a Victorian property. Despite difficulties in communicating due to a language barrier, the parent was able confirm that the child had been observed eating paint, specifically by the stair bannister. Paint samples were taken from this area and from other locations in the property that appeared to have damaged paint (see the table).

Table: Description of sampling locations and results

Sample area	**Lead concentration mg/kg (%)**
Wooden shelf and bay window sill ground floor front room	1,300 (0.13%)
Newell post and handrail to staircase	8,500 (0.85%)
Architrave to door to ground floor spare room (playroom)	18,000 (1.80%)
Skirting to ground floor rear room (playroom)	6,000 (0.60%)
Paint from tiled sill to first floor front bedroom window	54,000 (5.40%)
Paint from tiled sill to first floor rear bedroom window	1,300 (0.13%)

Up until the 1950s, UK paint may have contained up to 50% lead by weight (500,000 mg/kg). Leaded paint at these concentrations may still be found in non-remediated Victorian properties[25,26].

Monitoring results (see the table) indicated that lead paint was present in multiple places in the property. Given that the child had been observed to eat paint from around the house, this was identified as the most likely cause of the lead poisoning.

Recommendations

The monitoring data indicated that the paint on the windowsill in the front bedroom, architrave to the playroom and the staircase of the property were the most likely sources as they had the highest concentrations of lead. In addition, there were multiple locations that displayed visible evidence of where the child had been gnawing these surfaces. Given that lead was found in all lead samples tested, it was felt likely that untested paint with similar appearance in other areas of the property would also contain lead. Hence, remediation of the majority of the painted areas of the property was recommended by PHE to limit any potential further exposure.

Conclusions

Pica is a complex disorder with a wide variety of potential causes/risk factors among patients. The scientific literature on pica is limited in comparison to other disorders and is restricted to a small number of reviews and case studies, with weak associations observed and little descriptive epidemiology. The dearth of prevalence data is most likely due to under-reporting of the disease, for example:

- patients with pica may be reluctant to seek medical attention
- their behaviour may be considered “normal” for age, cultural or medical reasons
- the patient may be unable to discuss their problem due to underlying psychological issues

In addition, PHE has found that language barriers may sometimes mean parents are less likely to report cases of childhood pica, as was illustrated in the case study.

Work currently underway in the UK suggests that the medical observation of pica behaviour has been the stimulus for testing a child for heavy metal poisoning, which indicates that clinical awareness of pica’s potentially negative consequences is an important public health tool. The identification of heavy metal poisoning and its subsequent treatment can be a significant burden on the UK healthcare system and one that can be prevented if appropriate measures are implemented.

From a public health perspective, education and raising awareness may be the best way to prevent the adverse health consequences of eating non-foodstuffs. Owing to the serious consequences of pica behaviour, it is equally important for health care clinicians to diagnose the disorder as soon as possible as it is for them to impart advice on signs and dangers of the behaviour. Raising awareness should be targeted at the most at risk groups, including parents of young children.

Regulators such as the Food Standards Agency and trading standards teams are integral to ensuring that unregulated products with the potential to harm public health are kept off shop shelves[27]. Local authorities are well placed to provide a coordinated approach to informing and warning the public of the potential dangers these unregulated products may cause, such as the work undertaken by Hertfordshire County Council with the African-Caribbean community and Calabash chalk[28].

It is important for health care professionals to continue researching pica, its causes and effective treatments in conjunction with developing programmes to raise awareness. By ensuring that the public are aware of this condition, family members are more likely to intervene and apply mitigative actions should pica behaviours be observed.

References

1. American Psychiatric A, Force DSMT. Diagnostic and statistical manual of mental disorders : DSM-5. Washington DC: American Psychiatric Association, 2013.
2. Hartmann AS, Becker AE, Hampton C, Bryant-Waugh R. Pica and rumination disorder in DSM-5. Psychiatric Annals 2012;42(11):426-430.
3. Boyle JS, Mackey MC. Pica: Sorting it out. Journal of Transcultural Nursing 1999;10(1):65-68.
4. Blinder BJ. An Update on Pica: Prevalence, Contributing Causes, and Treatment, 2008. Available at http://www.psychiatrictimes.com/eating-disorders/update-pica-prevalence-contributing-causes-and-treatment/page/0/4 (accessed 04/08/2015).
5. Encinosa YZW. An Update on Hospitalizations for Eating Disorders, 1999 to 2009, 2011. Available at http://www.anad.org/wp-content/uploads/2010/06/Update-on-Hospitalizations-for-Eating-Disorders-1999-2009.pdf (accessed 06/08/2015).
6. Williams DE, McAdam D. Assessment, behavioral treatment, and prevention of pica: clinical guidelines and recommendations for practitioners. Research in Developmental Disabilities 2012;33(6):2050-2057.
7. Centre HSCI. Hospital Episode Statistics, Admitted patient care – England: Health and Social Care Information Centre, 1998–2014.
8. Mayton MR, Wheeler JJ, Carter SL. Pica: A review of recent assessment and treatment procedures. Education and Training in Developmental Disabilities 2004;39(4):346-358.
9. Mathee A, Naicker N, Kootbodien T, et al. A cross-sectional analytical study of geophagia practices and blood metal concentrations in pregnant women in Johannesburg, South Africa, 2014.

10. Bartholomew E. Toxic Calabash chalk seized by public health officials in Hackney. The Hackney Gasette, 2013, 15/07/2013.
11. Food Standards Agency. Calabash chalk warning. Secondary Calabash chalk warning. Available at http://www.food.gov.uk/business-industry/imports/banned_restricted/calabashchalk (accessed 15/09/2015).
12. Clay-and cornstarch-eating women. Nutrition Reviews 1960;18(2):35-38.
13. Giudicelli J, Combes JC. Pica and iron deficiency in adolescents [in French]. Archives Francaises de Pediatrie 1992;46(9).
14. López LB, Langini SH, Pita de Portela ML. Maternal iron status and neonatal outcomes in women with pica during pregnancy. International Journal of Gynecology and Obstetrics 2007;98(2):151-152.
15. Hergüner S, Özyıldırım İ, Tanıdır C. Is pica an eating disorder or an obsessive-compulsive spectrum disorder? Progress in Neuro-Psychopharmacology and Biological Psychiatry 2008;32(8):2010-2011.
16. Aksoy I, Kilic OHT, Demir B, Altindag A. Pica ongoing for 36 years comorbid with obsessive-compulsive disorder: a case report. European Neuropsychopharmacology 2014;24, Supplement 2:S620.
17. Stroman D, Young C, Rubano AR, Pinkhasov A. Adult-onset pica leading to acute intestinal obstruction. Psychosomatics 2011;52(4):393-394.
18. Bond S, Conner-Warren R, Sarnaik SA. Prevalence of pica in children with sickle cell disease. 19th Annual Meeting of the National Sickle Cell Disease Program, 1994.
19. Ivascu NS, Sarnaik S, McCrae J, Whitten-Shurney W, Thomas R, Bond S. Characterization of pica prevalence among patients with sickle cell disease. Archives of Pediatrics and Adolescent Medicine 2001;155(11):1243-1247.
20. Lemanek KL, Brown RT, Daniel Armstrong F, Hood C, Pegelow C, Woods G. Dysfunctional eating patterns and symptoms of pica in children and adolescents with sickle cell disease. Clinical Pediatrics 2002;41(7):493-500.
21. Falcomata TS, Roane HS, Pabico RR. Unintentional stimulus control during the treatment of pica displayed by a young man with autism. Research in Autism Spectrum Disorders 2007;1(4):350-359.
22. Glover G, Evison F. Hospital admissions that should not happen, admissions for ambulatory care sensitive conditions for people with learning disabilities in England. The Chartered Scociety of Physiotherapy, 2013.
23. Health Protection Agency (HPA). Health risks of eating chalks and clays, 2013. Available at http://webarchive.nationalarchives.gov.uk/20140722091854/http:/www.hpa.org.uk/webc/HPAwebFile/HPAweb_C/1317139340150 (accessed 24/09/2015).
24. Health Protection Agency (HPA). Lead action card – chronic exposures. Available at http://webarchive.nationalarchives.gov.uk/20140722091854/http://www.hpa.org.uk/webc/HPAwebFile/HPAweb_C/1274092896741 (accessed 11/08/2015).

25. British Standards Institution. Specification for permissible limit of lead in low-lead paints and similar materials. London: BSI, 1968.
26. Secretary of State for the Environment. The Environmental Protection (Controls on Injurious Substances) Regulations 1992.
27. Appleby S. Bangladesh clay food supplement – risk to health of pregnant women and their unborn babies. Food Standards Agency, 2011.
28. Hertfordshire County Counci. Delivering Equality and Diversity in the Community Protection Directorate. Available at http://www.hertsdirect.org/services/commsafe/commprotect/eqdivcpd/#Race&Ethnicity (accessed 13/08/2015).

Unusual cases of lead poisoning in the UK

Elvira Conlon[1], Katie Ferguson[2], Sarah Dack[1], Simon Cathcart[2], Alexander Azizi[3], Alison Keating[4]

1. Environmental Hazards and Emergencies Department, Centre for Radiation, Chemical and Environmental Hazards, Public Health England
2. Health Protection Team, Public Health England
3. Royal Free, London NHS Foundation Trust
4. Alcohol and Drug Team, Public Health England

Email: elvira.conlon@phe.gov.uk

Introduction

Lead poisoning is generally identified in children with conditions such as pica (the persistent consumption of non-food substances, such as paint chippings and soil) or from occupational exposure in adults. Public Health England's (PHE) local health protection teams (HPT) and its Centre for Radiation, Chemical and Environmental Hazards (CRCE) may be notified of a lead incident by health professionals (GP, paediatrician or medical toxicologist) treating the patient, or by the National Poisons Information Service (NPIS). PHE also has arrangements with specialist laboratories to follow up notification of results where the blood lead level (BLL) is greater than 10 µg/dl (0.48 µmol/l) in children under 16 years old[1]. PHE will then support clinicians in identifying the source of lead exposure. Generally a source can be identified either from discussions over the phone with the individual/family or from a site visit. However, in the two cases presented here the source was not readily apparent: case one involved the poisoning of a family from lead contaminated turmeric powder; and case two involved the poisoning of an individual due the use of opium contaminated with lead. Both cases were novel to PHE, hence useful lessons have been learnt.

Lead sources

Lead is a ubiquitous heavy metal with a wide range of historic and current sources including pigments and paint, lead solder, roof flashing, pewter, traditional medicines and soil[2,3,4]. In the UK the use of alkyl lead in petrol and paint has been largely phased out, but its use has left an environmental legacy.

Lead toxicity

Lead can be absorbed into the body by ingestion, inhalation or dermally (through the skin), although the last does not represent a significant pathway for absorption[3]. Once absorbed, the majority of the lead load is distributed to the bone, independent of the route of administration[2,3,4]. Lead is an accumulative, neurological and developmental toxin, which affects multiple systems. Short-term exposure to high levels of lead may cause a metallic taste, abdominal pain, nausea, loss of appetite, low blood pressure, kidney and liver damage. Long-term exposure may cause anaemia, headache, irritability, tiredness, muscle weakness, paralysis, kidney and liver damage, and gastrointestinal changes. Chronic exposure may also adversely affect both the male and female reproductive function. Children are a particularly sensitive group for lead as chronic exposure may lead to cognitive deficit such as decreased IQ; such effects do not exhibit a threshold.

PHE response

PHE's response to lead poisoning incidents is assisted by the lead action card[5] which was developed by the Health Protection Agency (a predecessor body to PHE) in order to guide public health professionals through investigating and managing such incidents. The action card includes a questionnaire that serves to identify or discount potential exposure to common sources of lead, based on the extensive experience of CRCE in managing lead exposure incidents. A multi-agency team may be set up with PHE (HPTs and CRCE), the clinicians involved directly with the patient and local authority (LA) environmental and public health professionals. The source of lead and any vulnerable people (besides the current patient) will be identified and potentially assessed also for lead poisoning. Such vulnerable people may be siblings and other children, especially young children with excessive mouthing or pica behaviours, pregnant women, patients on dialysis and infants fed formula that may be made with drinking water (if it is identified as a potential source).

Case study 1

A 5 year old was admitted to hospital with jaundice and investigated for haemolytic anaemia, after returning from a family visit to Pakistan. The consultant paediatrician contacted PHE after a BLL of 11.6 µg/dl was identified, which had risen to 18.7 µg/dl 3 months later. The patient's house contained seven family members, including two teenage children and grandparents. With the exception of the grandmother, all had elevated BLLs between 11.7 and 25.6 µg/dl.

Given a rising trend, and the approximate half-life of lead in blood (30 days), it could be concluded that there was an ongoing source. Multi-agency investigations, water company analysis and a house visit allowed for the following sources to be discounted: leaded paint from walls or windows in the home, imported saucepans, pewter, pots with earthenware glazes, soil, air and water. Through this, PHE identified inhalation was not a likely source, therefore dermal and ingestion pathways were considered further. However, the dermal pathway was also discounted through investigation by PHE and trading standards officers, to discount products such as face cream, cosmetics and hair dyes.

Therefore an ingestion route was considered likely, especially as the two teenage siblings ate school lunches and had relatively low BLLs in comparison to the rest of the family, and the father, whose BLL was also relatively low (but still above 10 µg/dl), worked in a food outlet. The lowest BLL, however, belonged to the grandmother who ate only at home, confounding the evidence. A multi-agency meeting was called.

Within a further 2 months, the child's blood lead had risen to 20.4 µg/dl. CRCE conducted a literature search of traditional and Ayurvedic (a traditional indian medical system) preparations that may contain lead. Traditional toothpowder, incense and ghee (if kept in pewter, copper or brass containers) were identified as potential sources. A US study found that, of 193 Ayurvedic medications, around 20% contained heavy metals, mostly lead[6]. A study in Karachi, Pakistan, found that all traditional supplements and medicines taken for asthma contained lead. Other studies have found lead present in traditional medicines used for treating diabetes, diarrhoea, indigestion and psoriasis[7,8,9]. Spices were also identified as potential sources of lead as they could be dyed or adulterated with heavy metals[10].

The family was visted again by an LA environmental health officer and a local consultant in health protection (PHE) who asked the family again about cooking pots and imported spices. As a result of this visit, it was discovered that the mother had imported a significant amount of turmeric from Pakistan. This was taken away to be analysed and identifed to contain 23 mg/kg of lead. Mean dietary lead exposures have been estimated for children aged 4–7 years old to be between 0.8 and 2.61 µg/kg bodyweight (bw) per day. However, in this case, assuming a 5 g dose per day (representative of an acute soil ingestion pica-like dose[11] and of the family's daily spice use), the 5 year old could have been consuming 4.6 µg/kg bw per day, approaching double the maximum normal dietary intake. This correlated with exposures being lower for family members who ate outside the family home. The grandmother's low BLL was further explained when she noted that she often ate separately from the family due to having diabetes.

The key finding from this case was the identification of spices imported from outside the EU as being potential sources of lead exposure which, as a foodstuff, has the potential to affect an entire family. In future, consideration will be given to this potential exposure source in cases of lead poisoning, particularly where patients have returned to the UK.

Case study 2

An adult patient presented to a hospital with a 4 day history of migratory colicky (cramping) abdominal pain, absolute constipation, nausea, vomiting and anorexia. The patient had no past medical, surgical or family history of disease that explained the symptoms. The patient had smoked 10 g of opium a week for around a year and a half, prior to admission. Initial investigations showed anaemia; however, the clinical team could not find an underlying cause of the symptoms and despite successfully treating the patient's constipation, the abdominal pain persisted. Heavy metal toxicity was then investigated as this can be associated with colicky abdominal pain[12]. This revealed an elevated BLL of 114 µg/dl. As a result, the patient was treated with chelation therapy to reduce their BLL and has since made a good recovery.

The local HPT was contacted and, with information from the lead questionnaire and the detailed assessment carried out by the HPT, CRCE was able to exclude the patient's hobbies, diet and other possible sources of lead exposure. The patient's occupation was not typically linked to lead sources; however, prior to 2010 they had been employed as a painter and decorator. Sanding or stripping of leaded paint surfaces is a known route of lead exposure, but it was thought that the concentration of lead in the patient's blood reflected a more recent exposure.

As the patient regularly smoked opium it was considered as the next potential source, although CRCE had not encountered such a case before. A review of the published literature[13] indicated contaminated opium as a potential source of lead exposure, with various case reports[14] and cross-sectional studies[15,16], mainly from Iran, demonstrating lead contaminated opium use resulting in lead poisoning. Case reports of lead poisoning from contaminated marijuana and heroin were also identified[17,18]. Once a probable source had been established, it was necessary to identify if others were at risk of lead exposure through inhalation of contaminated smoke. After discussion with the patient, the HPT established that they lived in a house of multiple occupants, but smoked alone; hence the risk to others was deemed to be minimal.

The HPT discussed the case with PHE's regional alcohol and drug team, who liaised with the national team. As this was an individual case – there had been relatively few published cases, none of which had been in the UK – and the source of lead poisoning was as yet unconfirmed by analysis, the decision was made not to send out a regional alert. However, the case was raised at London-wide forums of substance misuse service commissioners, providers and service users, as well as the network of alcohol liaison nurses with representatives across local hospitals. Local substance misuse services in the patient's area of residence ensured alerts were posted in that area and the risk was raised with individual clients, as relevant.

The key finding from this case was that the use of recreational drugs such as opium can be a cause of lead poisoning. Furthermore, there is the potential that smoking opium may present a risk to non-users through passive inhalation of lead vapour; however, as with all chemical exposures, the risk would depend on the concentration and duration of exposure. Although the concentration of lead in opium was not established in this case, reports suggest that it can be considerable[13]. Recreational drugs will be added as a potential source for consideration on the next revision of the lead action card.

Conclusions

The first case study highlighted lead contaminated spices as a potential source of lead poisoning, which should be considered in risk assessments for other cases. This case also emphasises the need to raise awareness that food purchased outside the EU may not have been subject to the same controls as are in place within the EU. The second case study highlighted opium and other recreational drugs as a potential source of lead poisoning; as far as is known, lead poisoning associated with lead contaminated opium has not yet been reported in the UK. There is also little data on the use or popularity of opium in the UK.

Recommendations

It is important that clinicians and public health professionals are aware of cases such as these when patients present with symptoms potentially associated with lead exposure; to aid this, opium and recreational drugs will now be added to the lead action card as a potential factor when investigating lead poisonings.

References

1. The British Paediatric Surveillance Unit (BPSU), Royal College of Paediatrics and Child Health. Raised blood lead levels in children. Available at http://www.rcpch.ac.uk/bpsu-raised-blood-lead-levels-children (accessed 09/02/16).
2. Health Protection Agency (HPA). Lead. Health effects, incident management and toxicology. Available at https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/317531/HPA_Compendium_of_Chemical_Hazards_LEAD__v4.pdf (accessed 10/01/16).
3. Fewtrell L, Kaufmann R, Prüss-Üstün A. Lead: assessing the environmental burden of disease at national and local level. World Health Organization Environmental Burden of Disease Series, 2003; No. 2. Available at http://www.who.int/quantifying_ehimpacts/publications/en/leadebd2.pdf (accessed 29/02/16).
4. Agency for Toxic Substances and Disease Registry (ATSDR). Toxicological Profile for Lead, 2007. Available at http://www.atsdr.cdc.gov/toxprofiles/tp13.pdf (accessed 09/01/16).
5. Health Protection Agency (HPA). Lead action card – chronic exposures. Available at

http://webarchive.nationalarchives.gov.uk/20140714084352/http://www.hpa.org.uk/webc/HPAwebFile/HPAweb_C/1274092896741 (accessed 02/03/16).

6. Saper RB, Kales SN, Paquin J, Burns MJ, Eisenberg DM, Davis RB, Phillips RS. Heavy metal content of Ayurvedic herbal medicine products. Journal of the American Medical Association 2004;292(23):2868-2873.
7. Nagarajan S, Kalaiarasi S, Krishnaswamy S, Pemiah B, Rajan KS, Krishnan UM, Sethuraman S. Safety and Toxicity issues associated with lead-based traditional herbo-metallic preparations. Journal of Ethnopharmacology 2013;151:1-11.
8. Breeher L, Gerr F, Fuortes L. A case report of adult lead toxicity following use of Ayurvedic herbal medication. Journal of Occupational Medicine and Toxicology. 2013;8(1):26.
9. Saeed M, Muhammad N, Khan H, Zakiullah. Assessment of heavy metal content of branded Pakistani herbal products. Tropical Journal of Pharmaceutical Research 2011;10(4):499-506.
10. Lin CG, Schaider LA, Brabander DJ, Woolf AD. Pediatric lead exposure from imported Indian spices and cultural powders. Pediatrics 2010;125(4):828-835.
11. US Environmental Protection Agency (USEPA). Chapter 5 – Soil and Dust ingestion. Exposure Factors Handbook 2011 Edition (Final). Washington DC: EPA/600/R-09/052F. Available at https://cfpub.epa.gov/ncea/risk/recordisplay.cfm?deid=236252 (accessed 29/02/16).
12. Chang SH, Yoon SB, Lee JW, Lee DJ. What caused hemolytic anemia and colicky abdominal pain? Lead! Korean J Intern Med 2013;28(4):504–506.
13. Ferguson K. Literature review of opium use and lead poisoning. Unpublished, internal PHE literature review, 2015.
14. Karimi G, Moshiri M, Etemad L. Review of cases of lead poisoning from opium abuse in Iran. Pharmacologyonline. 2009; 3:897-905. Available at http://pharmacologyonline.silae.it/files/newsletter/2009/vol3/90.Karimi.pdf (accessed 10/12/15).
15. Aghaee-Afshar M, Khazaeli P, Behnam B, Rezazadehkermani M, Ashraf-Ganjooei N. Presence of lead in opium. Archives of Iranian Medicine 2008;11(5):1029-2977.
16. Meybodi FA, Eslick GD, Sasani S, Abdolhoseyni M, Sazegar S, Ebrahimi F. Oral opium: an unusual cause of lead poisoning. Singapore Medical Journal 2012;53(6):395-397.
17. Busse F, Omidi L, Leichtle A, Windgassen M, Kluge E, Stumvoll M. Lead poisoning due to adulterated marijuana. New England Journal of Medicine 2008;358(15):1641-1642.
18. Parras F, Patier JL, Ezpeleta C. Lead-contaminated heroin as a source of inorganic-lead intoxication. New England Journal of Medicine 1987;316(12):755.