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arc21 Residual Waste Management Facility

Appendix 12.2: Health and Waste Management Evidence Base

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Appendix A: Health Evidence Base

1.1 Introduction

1.1.1 The arc21 residual waste management facility (hereafter referred to as the 'proposed development') represents a first for the region in proposing to divert waste from landfill to a technologically advanced integrated waste management facility. It also represents one of, if not the first facility of its kind in Northern Ireland, all-Ireland and the United Kingdom by co-locating energy from waste (EfW) and mechanical biological treatment (MBT) technologies within a single non-hazardous waste treatment facility. That in itself delivers a highly sustainable operation by minimising journey times that would otherwise result in multiple journeys to various sites.

1.1.2 The majority of the waste to be received at the proposed development will be classified as mixed municipal waste under the European Waste Catalogue code 20 03 01. Other third party waste or other non-contract wastes delivered outside the long-term contract will only be non-hazardous wastes as listed in the PPC permit to be secured for the operation.

1.1.3 The remaining sections in this appendix summarise the available health evidence base associated with waste management practices relevant to the proposed development. This document follows the structure as set out below:

- Section 1.2: Material recycling facilities and mechanical biological treatment;
- Section 1.3: Incineration; and
- Section 1.4: Conclusion.

1.2 Material recycling facilities and mechanical biological treatment

Introduction

1.2.1 Materials recycling facilities (MRFs) allow materials to be processed (separated/segregated) or stored temporarily. There are several types of MRFs, but they can generally be divided into those that sort and process construction and demolition waste and those that sort and process source segregated household and commercial waste. A MRF mechanically or manually sorts dry recyclable materials to market specifications for processing into secondary materials (Hester & Harrison, 2002).

1.2.2 MRFs may be attached to, or incorporated within waste transfer stations or other waste facilities, or may be separate dedicated facilities dealing purely with the recyclable fraction of collected municipal waste. Waste material entering a MRF has normally been subject to some pre-segregation by the householder, but further mechanical or manual sorting is also required. MRFs accepting pre-segregated waste are commonly called clean MRFs (as opposed to dirty MRFs which accept unsegregated waste) (Defra, ENVIROS, University of Birmingham, 2004).

1.2.3 Dirty MRF's are facilities which combine a number of screening/sorting techniques to divide residual municipal waste into a recyclable material waste stream and a non-recyclable residual waste stream disposed to landfill. Research states that, due to market acceptability of recyclate and operational experience in the UK, it is unlikely that MRFs processing organic waste (i.e. dirty MRFs), would find any significant future application in the UK (Defra, ENVIROS, University of Birmingham, 2004).

1.2.4 As detailed by the UN Climate Technology Centre and Network mechanical biological treatment (MBT) system is a waste processing facility that combines a MRF with biological treatment methods, such as anaerobic digestion and/or composting (UN CTCN, n.d.).

1.2.5 The MBT processes are usually designed to stabilise the residual waste stream after initial recyclables and compostables are removed or prepare it as a fuel for a thermal treatment process. The process may involve separation of the non-compostable element of the waste stream through a sorting mechanism, for example magnetic separation of residual ferrous metals and the use of a homogenisation drum (including water injection) with screening of the output material into a reject fraction (comprising some textiles, plastics and metals with minor organic contaminants) and the remaining component windrow composted (or also may be fed into an anaerobic digester). The output of the windrow composting will be a stabilised residue which may be subject to further screening or further sorting (e.g. through air classification) dependent on the ultimate application of the residue. This application may be in the form of landfill cover, restoration or for soil conditioning applications if the residue is processed to a sufficient quality or may be fed into another treatment process such as incineration, RDF or gasification (Defra, ENVIROS, University of Birmingham, 2004).

1.2.6 MBT systems can take place prior to or after mechanical treatment (Defra, 2013) and are designed to process mixed municipal waste as well as commercial and industrial waste. The products of the MBT technology are:

- recyclable materials such as metals, paper, plastics, glass etc.;
- unusable materials (inert materials) safely disposed to sanitary landfill;
- biogas (anaerobic digestion);
- organic stabilised end product; and
- refuse derived fuel (RDF) i.e. high calorific fraction.

1.2.7 An evaluation of the progress made by MRF facilities in the UK states that a typical facility would recycle around 92%, whilst 6% would be sent for energy recovery and 2% would go to landfill, meaning that a total of 8% of materials from MRFs are rejected and/or are non-compliant. It is important to ensure that all materials that can be recycled are recycled. However, where materials do not meet the specifications of an MRF for recycling, they are sent to landfill or energy recovery. An integrated approach linking MRFs and energy recovery (i.e. through incineration) would ensure energy recovery is utilised over landfill, which is preferable (Ali & Courtenay, 2014).

Potential health impacts associated with MRF and MBT

Introduction

1.2.8 On the basis that the proposed development includes MBT, all literature relating to MRF and MBT is considered relevant.

1.2.9 Defra outline the key issues that need to be looked at when considering the planning implications of an MBT facility (Defra, 2013). Of most relevance to human health and wellbeing, and which are covered in more detail below, are:

- air emissions (including dust, odour and bio-aerosols); and
- noise.

Air emissions (including dust, odour and bio-aerosols)

1.2.10 It is recognised that the majority of research published on human health effects from changes in air quality associated with MRF and MBT are occupational in nature and have been studied in various countries (Environment Agency, 2005; Defra, ENVIROS, University of Birmingham, 2004).

1.2.11 In an occupational setting, significant associations have been found between exposure to organic dust in handling/sorting facilities and a fall in worker's Forced Expiratory Volume (FEV). Similarly, other studies relating to handling/sorting facilities have indicated occupational asthma as a problem (albeit this has reduced with operational design) and elevated symptoms for chest tightness, toxic alveolitis, gastrointestinal symptoms, skin irritation, flu-like symptoms, itching eyes, itching nose, sore throat, nausea/vomiting and diarrhoea (Environment Agency, 2005).

1.2.12 Regarding MRFs specifically, a study funded by European BIOMED2 and Environment Agency looked at 11 MRFs throughout England and Wales handling a mixture of household and commercial waste materials, with nine also participating in the collection of health data (Hester & Harrison, 2002).

1.2.13 As part of this study, measurements of dust and bioaerosols (including endotoxin and glucan) were conducted. Also measured in this study were VOCs, electromagnetic fields, cadmium and mercury; however, in common with similar studies, no significant amounts were found.

1.2.14 From the nine MRFs providing health data (through self-reported cross-sectional questionnaires), symptoms were compared to exposure grouping (i.e. higher, middle and lower exposure) for dust, endotoxin and glucan. Gradients were clearly seen between those sites classified as higher compared to lower exposed sites and the symptoms reported here are not unusual in workers in the waste industry.

1.2.15 Overall, the results indicate that exposure to dust, endotoxin and glucan in a MRF environment shows a dose-response relationship in terms of exposure and health, particularly for respiratory and gastrointestinal effects. Specifically, total dust exposures are related to diarrhoea and skin problems mainly, although upper respiratory nose and throat irritations are also apparent. The situation with endotoxin is more complex. It appears those in medium-exposed MRFs suffer the least amount of symptoms to a significant level. Workers exposed to higher levels of glucan may be more prone to developing a range of health symptoms.

1.2.16 A large American study was undertaken to understand the effects of MRF operations on occupational health and safety from impacts on ambient air quality (Environmental Protection Agency, 1995). The study assessed worker exposure to total dust, respirable dust, crystalline silica, metals, carbon monoxide, mercury vapor, polychlorinated biphenyls, pesticides, bacteria and fungi. Results indicated that total dust, respirable dust, silica, and metal concentrations were one or more orders of magnitude below the applicable Permissible Exposure Limits (PELs). Carbon monoxide and mercury vapor concentrations were well below the applicable PELs, while PCB and pesticide levels were below the detection limits of the test method. Airborne bacteria and fungi concentrations measured inside the MRFs were roughly one order of magnitude higher than the levels found outside the facility.

1.2.17 As stated in the Defra, ENVIROS, University of Birmingham (2004) review of potential health associated with MRFs, no epidemiological studies were identified for populations living near MRFs. As such, in order to enable the potential health effects in local populations to be assessed, studies were reviewed that assessed adverse health effects associated with plant workers (Defra, ENVIROS, University of Birmingham, 2004).

1.2.18 While this is the case, bio-aerosols are normally found in higher concentrations where large amounts of organic matter are processed. However, available evidence which focusses on composting facilities suggests that communities located beyond 250 m away from such facilities are unlikely to be exposed to harmful levels of bio-aerosols (Defra, 2013). Similar results have been found in relation to transfer or sorting sites, whereby microbial air quality 100 m downwind does not deviate from ambient concentrations (Environment Agency, 2005).

1.2.19 The large American study previously referred to also considered the potential effects of MRF operations on public health from impacts on air quality (Environmental Protection Agency, 1995). The study measured ambient concentrations of total suspended particulates (TSP), PM_{10}, carbon monoxide, volatile organic compounds, lead, and mercury vapor. Generally, TSP, PM_{10}, and lead concentrations were well below the applicable State and National Ambient Air Quality Standards. Carbon monoxide and mercury concentrations were also well below the applicable PELs. Detectable VOC concentrations were several orders of magnitude below applicable state guidelines.

1.2.20 For MBT specifically, there are limited to no studies which assessed the health effects of air emissions. However, the health effects of MBT facilities might be expected to be comparable to those of in-vessel composting facilities (Defra, 2013).

1.2.21 Overall, the health evidence base demonstrates that potential health impacts associated with air emissions from MRFs and MBT are generally occupational in nature and that any diffuse impact on downwind communities is unlikely to be significant.

Noise

1.2.22 The link between community noise and health have been explored by the World Health Organisation (WHO) since 1980. Community noise (also called environmental noise, residential noise or domestic noise) is defined as noise emitted from all sources except noise at the industrial workplace. Main sources of community noise include road, rail and air traffic, industries, construction and public work, and the neighbourhood.

1.2.23 WHOs ‘Guidelines for Community Noise’ (WHO, 1999) had been prepared in response to the need for action on community noise, as well as the need for improved legislation, management and guidance at the national and regional levels. The report consolidated existing knowledge of health impacts from changes in noise exposure and provided guideline figures for the day and night time periods.

1.2.24 Subsequent publications from WHO relate to night specifically to noise (WHO, 2009) and source-specific environmental noise in Europe (WHO, 2018), and are compatible with the noise indicators used in the EU’s Environmental Noise Directive (2002/49/EC).

1.2.25 The main contributors to noise associated with MRFs and MBT are likely to be from traffic on the local road network, vehicle movements/manoeuvring, mechanical processing (e.g. waste preparation, shredders, screens, trommels, air classification, ball mills), air extraction fans/ventilation systems, and operations associated with the preparation, turning and aeration of the biomass (Defra, 2013). However, there is a lack of literature available on potential noise impacts arising specifically from MRFs and MBT specifically.

1.2.26 While this is the case, a large American study was undertaken to understand the effects of MRF operations on public health and the environment, as well as on occupational health and safety (Environmental Protection Agency, 1995). This included consideration of community and occupational noise. Results showed that community noise levels met applicable Federal and state criteria. Worker noise exposure was generally found to exceed limits, but could be mitigated through the implementation of a hearing conservation program.

1.2.27 Overall, it is generally accepted that noise generated by MRFs and MBT is an issue that can be controlled under permitting regulations and by limiting noise levels at nearby receptors by a condition of a planning permission (Defra, 2013). Furthermore, as an occupational health risk, noise generated by MRFs and MBT can be mitigated through appropriate health and safety measures (HSE, n.d.). On this basis, changes in exposure to noise are not considered to be a credible health risk.

1.3 Incineration

Introduction

1.3.1 The role of incineration with energy recovery as a sustainable waste management option should be acknowledged, although the priority must be waste minimisation, reuse and recycling. Incineration is an option for dealing with the residual waste that will still be left after recycling and reuse to help absorb the diversion of municipal waste from landfill. Incineration of MSW is an established technology; in England and Wales, there are 14 operational MSW incinerators, dealing with 9% of MSW generated (Defra, ENVIROS, University of Birmingham, 2004). All municipal waste incinerators in the UK recover energy from waste in the form of electricity and/or heat generation (Defra, 2013).

1.3.2 Incineration involves combustion of waste at high temperatures (above 850ºC) for a sustained period achieving a very substantial reduction in the volume of waste and effectively destroying pathogenic biological organisms. Traditional fuels (e.g. fuel oil or gas) are only used during start-up, and therefore the majority of emissions from the incinerator plant are due to waste combustion (Defra, ENVIROS, University of Birmingham, 2004). To allow the combustion to take place a sufficient quantity of air is required to fully oxidise the fuel, a proportion of which is generally drawn from waste storage areas to reduce odour emissions beyond the facility (National Research Council, 2000). The waste is converted into carbon dioxide and water. Any non-combustible materials (e.g. metals, glass) remain as a solid, known as bottom ash, which contains a small amount of residual carbon (Defra, 2013).

1.3.3 The emissions limits for specific pollutants that are present in the combustion products (flue gases) from the incineration of MSW are defined in the Industrial Emissions Directive (IED) and applied through the Environmental Permitting Regulations. Specific limits for the release to the atmosphere of the following pollutants are outlined in the IED (Defra, 2013):

- sulphur dioxide (SO_2);
- nitrogen oxide and nitrogen dioxide (NO and NO_2);
- hydrogen chloride (HCl);
- hydrogen fluoride (HF);
- gaseous and vaporous organic substances expressed as total organic carbon (TOC);
- carbon monoxide (CO);
- dust;
- heavy metals; and
- dioxins and furans.

1.3.4 To meet these emissions limits, the combustion process must be correctly controlled and the flue gases cleaned prior to their final release. The technology supplier for the incinerator plant will define the exact emissions clean-up processes that will be employed to achieve the required standards and utilising Best Available Techniques (BAT). The clean-up of the flue gases will produce solid residues comprising fly-ash, lime/bicarbonate and carbon. These residues are usually combined (although some systems may separate fly ash and other components), and are often referred to as Air Pollution Control (APCr) residues and classified as hazardous waste (Defra, 2013).

1.3.5 Regulation of MSW incinerators has become increasingly stringent over the years, following the implementation of various European directives (Defra, 2013). The majority of published studies concentrate on the effects of exposure to emissions from the older generation of incinerators which were phased out in the UK after the introduction of stricter emission controls (Defra, ENVIROS, University of Birmingham, 2004). The level of public exposure from the older generation of incinerators was substantially higher than exposure that occurs from modern incinerators, whereby there appear to be stronger links between older incinerator technology and with adverse health effects and infrequent maintenance schedules than more recent incinerators (Tait, et al., 2020; Defra, ENVIROS, University of Birmingham, 2004).

Potential health impacts associated with incineration

Introduction

1.3.6 Modern, well-managed incinerators can be an effective means of reducing and disposing of waste materials so that any potential health risk is minimised. However, the by-products of the combustion process may contain hazardous or toxic pollutants and emissions will add to background pollution levels. As a result, there is often considerable public concern over the possible health effects of living near to incinerators, specifically in relation to cancer, respiratory function and reproductive problems. Despite public concern, in many cases, air monitoring data do not demonstrate that emissions from incinerators are a major contributor to ambient air pollution (Environment Agency, 2005; Defra, ENVIROS, University of Birmingham, 2004).

1.3.7 The former Health Protection Agency (HPA) first issued a statement giving advice on health issues in November 2005 as a result of concerns raised about the air pollution risks posed by municipal incinerators. More research on the possible air pollution risks posed by modern incinerators has been carried out since then, and in 2009 an updated statement was published. The 2009 statement has since been withdrawn; however, the conclusions have been reproduced in the 'Impact on Health of Emissions to Air from Municipal Waste Incinerators - RCE 13' report (Health Protection Agency, 2010), which states that:

"While it is not possible to rule out adverse health effects from modern, well-regulated municipal waste incinerators with complete certainty, any potential damage to the health of those living close-by is likely to be very small, if detectable. This view is based on detailed assessments of the effects of air pollutants on health and on the fact that modern and well managed municipal waste Incinerators make only a very small contribution to local concentrations of air pollutants."

1.3.8 Following the publication of results in two separate papers from a major study on modern municipal waste incinerators by the Small Area Health Statistics Unit (SAHSU) at Imperial College London (Ghosh, et al., 2019; Parkes, et al., 2020), Public Health England (PHE) submitted a statement to confirm the above position from 2009 (Public Health England, 2019).

1.3.9 PHE state that the statement will continue to be reviewed in light of new substantial research on the health effects of incinerators published in peer-reviewed journals.

1.3.10 The following sections summarise the available health evidence base relating to changes in air quality, including source-specific literature relating to incinerators.

Cancer

1.3.11 It has been hypothesised that exposure to dioxins and furans (either directly via inhalation or indirectly via the food-chain) may be major causes of cancer in communities around incinerators. Whilst older incinerators were often significant sources of dioxins and furans in the local environment, modern incinerators are significantly cleaner. A study in Spain by Gonzalez at al. (2004) found no difference in the levels of exposure (based on analysis of substances in blood samples) in residents living near to the incinerator and those living further away (Defra, ENVIROS, University of Birmingham, 2004; Gonzalez, et al., 2000).

1.3.12 Several epidemiological studies have explored the possible association between thermal waste treatment facilities emissions and a variety of cancers including stomach, colorectal and liver cancers; larynx and lung cancers; childhood cancers and soft tissue sarcomas and non-Hodgkin's lymphomas. However, no consistent or convincing evidence of a link between cancer and incineration has been published (Defra, ENVIROS, University of Birmingham, 2004).

Elliott et al. (1996) examined cancer incidence in over 14 million people living within 7.5 km of 72 municipal solid waste incinerators between the mid-1970s and the mid-1980s in the UK. The incinerators studied were the older generation operating prior to the introduction of strict emission controls and were more polluting than modern incinerators. After controlling for a number of potential confounding factors, only liver cancer showed a significant association with distance from the incinerators. However, in this case, it is likely that misclassification of secondary tumours as primary liver cancer may have caused or contributed to the result (Defra, ENVIROS, University of Birmingham, 2004; Elliott, et al., 1996). After considering this study, the Committee on Carcinogenicity (COC) published a statement in 2000 (Committee on Carcinogenicity, 2000), concluding that: "*any potential risk of cancer due to residency (for periods in excess of ten year) near to municipal solid waste incinerators was exceedingly low and probably not measurable by the most modern techniques"*.

1.3.13 An update to this was provided in 2009 (Committee on Carcinogenicity, 2009) on the basis that further relevant epidemiological papers have been published since the 2000 statement. As was the case in 2000, the additional epidemiology studies were carried out on incinerators in operation prior to the imposition of the current strict controls on emissions.

1.3.14 Overall, there were problems interpreting most of these studies due to factors such as failure to control for socio-economic confounding or inclusion of emission sources other than municipal waste incinerators. It was concluded that *"Although the studies indicate some evidence of a positive association between two of the less common cancers i.e. non-Hodgkin's lymphoma and soft tissue sarcoma and residence near to incinerators in the past, the results cannot be extrapolated to current incinerators, which emit lower amounts of pollutants. […] Moreover, they are inconsistent with the results of the larger study [Elliott et al. 1996*]". As such, the COC concluded that there was no need to change the advice given in the previous statement in 2000 (Committee on Carcinogenicity, 2009; Health Protection Agency, 2010).

1.3.15 More recently, a systematic review of English language literature on waste incinerators and health was undertaken by Tait et al. (2020). A total of 15 studies focussed on cancer as a health outcomes. Overall, earlier periods of exposure have a stronger link with cancers such as non-Hodgkin lymphoma and sarcoma. However, results were mixed, which was unsurprising given that many used proximity to the incinerator as the independent variable (despite the limitations of this approach). Furthermore, most papers omitted pertinent details on incinerator design, and several statistically significant results were inconsequential as they approached unity (Tait, et al., 2020).

1.3.16 Another systematic review was conducted by Vinti et al. (2021) of recently published literature to update and expand the epidemiological evidence on the association between MSW management practices and resident populations' health risks. A total of 13 studies were identified, 10 of which were conducted in Europe and three in Asia. Overall, the evidence of increased health risks from residing near an incinerator is mixed. One study reported increased risk of mortality in women for various health outcomes, including cancer. However, other studies, found no evidence of adverse health effects. In particular, Viel et al. (2008) (Viel, et al., 2008) found no evidence of increased invasive breast cancer in women aged 20–59 years, even founding a significant reduction in invasive breast cancer in women aged 60 years and over. Ranzi et al. (2011) (Ranzi, et al., 2011) found no evidence of increased cancer diseases both in men and women. There was also no evidence of increased cancer-related mortality in men (Vinti, et al., 2021).

1.3.17 Overall, epidemiological studies relating to the older generation of incinerators that emitted significantly greater amounts of dioxins than newer facilities have failed to identify an effect on cancer health outcomes. Given that the emissions of dioxins and furans from modern incinerators are orders of magnitude lower than from older incinerators, it can be said with some confidence that any impacts of dioxin and furan on cancer rates in local people are small or non-existent and unlikely to be quantified through epidemiology (Defra, ENVIROS, University of Birmingham, 2004).

Respiratory function and disease

Introduction

1.3.18 Available studies have typically examined respiratory health around the older generation of incinerators. Furthermore, most are based upon self-reported symptoms and therefore may be subject to bias. Overall, there is little evidence to suggest that thermal waste treatment facilities are associated with increased prevalence of respiratory symptoms in the surrounding population (Defra, ENVIROS, University of Birmingham, 2004).

1.3.19 More recently, a systematic review was conducted by Vinti et al. (2021) of recently published literature to update and expand the epidemiological evidence on the association between MSW management practices and resident populations' health risks. A total of 13 studies were identified, 10 of which were conducted in Europe and three in Asia. Only one study Ranzi et al. (2011) looked at mortality and morbidity associated with respiratory diseases, of which no evidence of increased risk was found.

1.3.20 While air monitoring data do not demonstrate that emissions from incinerators are a major contributor to ambient air pollution, the relationship between air quality and respiratory health outcomes is well established (WHO, n.d.; Defra, ENVIROS, University of Birmingham, 2004). As a result, there is a large quantity of good quality epidemiological literature establishing dose response relationships between air pollutants emitted by incinerators, such as particulate matter and nitrogen dioxide, and specific health outcomes.

COPD

1.3.21 As stated by Moore et al. (2016), COPD is a group of progressive lung diseases that causes obstructed airflow from the lungs (ICD-10: J44.1-J44.9). While the effect of environmental exposure is not clear, exacerbations of COPD are a common cause of adult emergency hospital admissions whereby patients may experience more frequent and severe exacerbations as the disease worsens.

1.3.22 Regarding the relationship between COPD-related hospital admissions and exposure to PM_{10}, of the 31 studies analysed by Moore et al. (2016), a positive association was found in 28 where the association was significant in 15. In addition, evidence of a nonlinear relationship where higher effects were reported at higher concentrations. While high heterogeneity was found between studies and there is evidence of a nonlinear relationship, the overall effect of exposure to PM_{10} on COPD-related hospital admissions in the European region is marginal (OR, 1.01 [1.00-1.01] per 10µg/m^3).

1.3.23 Moore et al. (2016) state that heterogeneity remained high when analysing $PM_{2.5}$, due to the lack of available outdoor measurements for this pollutant. Of the 12 studies analysed, a positive association was found in 10; however, the association was only significant in 4. As with PM_{10}, evidence of a nonlinear relationship where higher effects were reported at higher concentrations. Overall, a stronger relationship was found between COPD-related hospital admissions and $PM_{2.5}$ exposure (OR, 1.02 [0.99-1.04] per 10µg/m^3) compared to PM_{10}. However, due to the limited number of included studies, results should be interpreted with caution.

1.3.24 For NO_2, a positive association was reported in 25 of 27 studies analysed by Moore et al. (2016), with a significant association reported in 11. Similar to results for PM_{10} and $PM_{2.5}$, high heterogeneity and evidence of a nonlinear relationship were reported. Overall, the effect of exposure to NO_2 on COPD-related hospital admissions is higher than that for PM (OR, 1.03 [1.02-1.05] per 10µg/m^3).

Asthma

1.3.25 Asthma is the most common chronic disease in children worldwide. While there is a clear relationship between asthma exacerbations and exposure to air pollution, it is still unclear whether long-term exposure to air pollution affects asthma prevalence in children (Mölter, et al., 2015). As a result, Molter et al. (2015) analysed the association between the prevalence of childhood asthma and a range of traffic-related air pollutants (including NO_2, PM_{10} and $PM_{2.5}$).

1.3.26 Molter et al. (2015) found that the relationship between asthma prevalence at age 8–10 years and long-term exposure to air pollution at the birth address was positive for NO_2 (OR, 1.10 [0.81–1.49] per 10 µg/m^3) and $PM_{2.5}$ (OR, 1.23 [0.78–1.95] per 5 µg/m^3), but not for PM_{10} (OR, 0.88 [0.63–1.24] per 10 µg/m^3). However, none of the identified relationships were significant.

1.3.27 Studies show that hospital admissions relating to asthma (IDC10: J45) are higher on days when pollution is higher. Part of a Health Impact Assessment (HIA) looking at the effects of air pollution on asthma in London undertaken Walton et al. (2019), included meta-analyses. The purpose of the meta-analyses was to provide representative concentration-response functions to apply in HIA calculations used to provide a modelled estimate of the impact of air pollution on child asthma admissions (for exposure to $PM_{2.5}$ and NO_2) and adult asthma admissions (for exposure to NO_2) at current levels in London, compared to if air pollution was reduced to the WHO Guideline level.

1.3.28 Results from the meta-analysis undertaken by Walton et al. (2019) state the global summary estimate for child asthma hospital admissions associated with $PM_{2.5}$ exposure as RR, 1.029 [1.016-1.042] per 10µg/m^3. The relationship between child asthma hospital admissions associated with NO_2 is stronger, whereby the global summary estimate is RR, 1.036 [1.018-1.054] per 10µg/m^3.

1.3.29 The global summary estimate for adult asthma hospital admissions associated with NO_2 is RR, 1.012 [1.001-1.023] per 10µg/m^3. No risk ratio is provided for the impact of NO_2 on adult asthma hospital admissions as the 4 studies analysed in the looking at the meta-analyses undertaken by Walton et al. (2019) suggest no association.

1.3.30 The APHEA (Air Pollution and Health: a European Approach) project (Atkinson, et al., 2001) was initiated in 1993 with the aim of investigating whether there was epidemiological evidence for an adverse short-term effect of air pollution on respiratory health by studying eight European cities. Summary results found a positive relationship between exposure to PM_{10} and emergency asthma hospital admissions for children (1.2% [0.2-2.3] per 10µg/m^3) and adults (1.1% [0.3-1.8] per 10µg/m^3).

Adverse birth outcomes (congenital abnormalities and infant mortality)

1.3.31 Animal studies which have demonstrated that high exposure to dioxin is associated with congenital malformations. A few studies have explored this link within humans living in proximity to waste incinerators, however, no conclusive links were found (Defra, ENVIROS, University of Birmingham, 2004).

1.3.32 More recently, a systematic review was conducted by Vinti et al. (2021) of recently published literature to update and expand the epidemiological evidence on the association between MSW management practices and resident populations' health risks. A total of 13 studies were identified, 10 of which were conducted in Europe and three in Asia. Seven studies (ranging from 2006 to 2020) looked at adverse birth outcomes, none of which reported any evidence of a link.

1.3.33 Specific to the UK practice is a 2019 retrospective population-based cohort study, published by the SAHSU at Imperial College London. The study assessed 10 municipal waste incinerators in England and Scotland over the period of 2003 and 2010. No increased risk of congenital anomalies associated with modelled concentrations of PM_{10} was found within 10 km of the incinerators. However, there were small increases in risk (i.e. 2% to 7%) for all congenital anomalies combined, congenital heart defects and genital anomalies, specifically hypospadias, with proximity to the nearest incinerator. The study concluded that the findings related to proximity to the nearest incinerator might be residual confounding, although it is not possible to exclude a potential causal effect even in the absence of associations with modelled PM_{10} emissions (Parkes, et al., 2020).

1.3.34 Another study specific to the UK context was another article published by SAHSU (Ghosh, et al., 2019), which assessed the occurrence of birth and mortality outcomes (e.g. birthweight, premature birth, infant death, or stillbirth) within 10 km of 10 incinerators from 2003 and 2010. No associations were found related to stillbirths, neonatal mortality and post-neonatal mortality and a doubling of ground-level PM_{10}. For birth outcomes, no associations were identified between foetal growth and preterm delivery in relation to waste incinerator emissions.

1.3.35 Both the Ghosh et al. (2019) and Parkes et al. (2020) studies informed the most recent PHE position statement (Public Health England, 2019), which states:

"While it is not possible to rule out adverse health effects from modern, well-regulated municipal waste incinerators with complete certainty, any potential damage to the health of those living close-by is likely to be very small, if detectable. This view is based on detailed assessments of the effects of air pollutants on health and on the fact that modern and well managed municipal waste Incinerators make only a very small contribution to local concentrations of air pollutants."

General mortality and morbidity

1.3.36 The Committee on the Medical Effects of Air Pollutants (COMEAP) advises on all matters concerning the health effects of air pollutants. In 2010, COMEAP published a research and analysis report on the mortality effects of long-term exposure to air pollution in the UK which estimated that anthropogenic $PM_{2.5}$ at 2008 levels (8.97 µg/m^3 in the UK) is associated with an effect on mortality equivalent to almost 29,000 deaths at typical ages of death in the UK in 2008 alongside an associated loss of total population survival of 340,000 years and an average loss of between three to four months of life expectancy in Scotland and Northern Ireland compared to six to seven months in England and Wales (COMEAP, 2010).

1.3.37 Following this, subsequent statements have been published recommending concentration-response functions (CRFs) outlined in Table 1 which represent the relationship between a pollutant and an adverse effect on health, along with advice on how this should be applied. These CRFs are based on a comprehensive analysis of available literature and are continuously updated.

Table 1: Summary of COMEAP general mortality and morbidity CRFs

Pollutant	Health Effect	Population Cohort Studied	CRF (per 10 µg/m³) [95% confidence intervals in brackets]	Comments	Source
NO_2	All-cause mortality	Adults >30 years	1.023 [1.008, 1.037]	Unadjusted* for other pollutants	(COMEAP, 2020)
	Respiratory hospital admissions	All ages	1.0057 [1.0033, 1.0082]	Unadjusted* for other pollutants	(COMEAP, 2022)
$PM_{2.5}$	All-cause mortality	Adults +>30 years	1.08 [1.06, 1.09]	Unadjusted* for other pollutants	(COMEAP, 2022)
	Respiratory hospital admissions	All ages	1.0096 [0.9937, 2.58]	Unadjusted* for other pollutants	(COMEAP, 2022)
	Cardiovascular hospital admissions	All ages	1.009 [1.0026, 1.0153]	Unadjusted* for other pollutants	

*According to COMEAP, it is advised that the pollutant which leads to the greatest increase in a given health outcome should be used to represent the effect of the two pollutants in combination (i.e. either NO_2 or $PM_{2.5}$); as adding them together would represent a considerable overprediction. This is because the health effects of the two pollutants are correlated with each other according to the epidemiological studies which inform the CRFs. As a result, both the '**unadjusted**' NO_2 and $PM_{2.5}$ CRFs may include effects of other pollutants and each other; therefore summing them would represent an overestimate of the effect. For this reason COMEAP advise on calculating the outcome for both pollutants, presenting the pollutant which leads to the greater health impact as the basis for informing scheme effects.

1.4 Conclusion

1.4.1 Overall, the available literature indicates that there is limited evidence to suggest that well managed and regulated MRFs (including those with MBT) and incinerators present a significant risk to community health. This conclusion is consistent with the most recent position statement issued by PHE.

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