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Aims and scope

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The Journal of Environmental Health Research is a peer reviewed journal published in three formats: Printed Full Journal, Printed Abstracts and On-Line Journal.

The Journal publishes original research papers, review articles, technical notes, professional evaluations and workshop/conference reports and short communications covering the diverse range of topics that impinge on public and environmental health including: occupational health and safety, environmental protection, health promotion, housing and health, public health and epidemiology, environmental health education, food safety, environmental health management and policy, environmental health law and practice, sustainability and methodological issues arising from the design and conduct of studies.

A special category of paper – the 'first-author, first-paper' – is designed to help build capacity in environmental health publications by encouraging and assisting new authors to publish their work in peer-reviewed journals. Here the author will be given active assistance by the editors in making amendments to his or her manuscript before submission for peer review.

The Journal provides a communications link between the diverse research communities, practitioners and managers in the field of public and environmental health and aims to promote research and knowledge awareness of practice-based issues and to highlight the importance of continuing research in environmental health issues.

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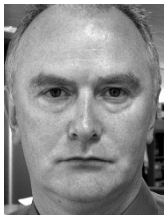
Miss Julie Barratt is Director of the Chartered Institute of Environmental Health, Wales. She graduated in environmental health in 1981 and has a wide range of practice experience in environmental health. She graduated in law in 1992 and qualified as a barrister in 1993. She is legal columnist for Environmental Health News.



Mr Martin Fitzpatrick is a practising environmental health professional with Dublin City Council currently specialising in environmental protection. He is an advisor, consultant and author to the World Health Organisation and the United Nations Development Programme and has advised on, and managed, environmental health projects in Europe, Indonesia, Latvia, Kazakhstan and Thailand. He was an advisor to the WHO preparatory meeting on the Third Ministerial Conference on Environment and Health, advisor to the Department of Health and Children in the Republic of Ireland and environmental health advisor to Concern International in Banda Aceh following the tsunami disaster. He has been associate editor of JEHR for the past seven years and is a member of the Environmental Health Officers Association of Ireland.

Dr Gai Murphy is Associate Dean of the Faculty of Science, Engineering and Environment at the University of Salford, with responsibility for improving learning, teaching and enhancement within the faculty. She studied Zoology at Queens University, Belfast and holds a doctorate in zoology from Manchester University. She is a member of the Biomedical Research Centre at Salford. Her research interests focus on the impact of pests in the urban environment and the application of integrated pest management in urban areas.

Mr David Statham was formerly Director of Enforcement and Standards at the Food Standards Agency. He graduated in environmental health in 1974 and also holds a Master of Business Administration. He is Past Chairman of Council of the Chartered Institute of Environmental Health and has chaired the Food and General Health and the Resources Committees of the CIEH and led the European Food Law Enforcement Practitioners Group (FLEP).

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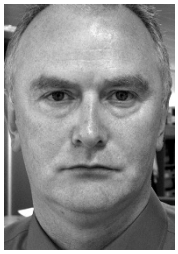

Martin Fitzpatrick

According to the Belgium-based Centre for Research on the Epidemiology of Disasters (CRED), 2010 was one of the worst years on record for natural disasters over the past two decades, leaving nearly 297,000 people dead. The 2010 earthquake in Haiti accounted for about two thirds of the toll, killing more than 222,500 people, while the summer heatwave in Russia was the second deadliest disaster of the year, leaving 55,736 people dead.

The economic cost of the 373 major disasters recorded in 2010 reached US$109 billion, headed by an estimated US$30 billion in damage caused by the powerful earthquake that struck Chile. This earthquake unleashed a tsunami that swept away villages and claimed most of the 521 dead. Summer floods and landslides in China caused an estimated US$18 billion in damage, while floods in Pakistan cost US$9.5 billion. In total, Asians accounted for 89% of the 207 million people affected by disasters worldwide last year. As 2011 unfolds, we have seen Brisbane subjected to severe flooding, and Christchurch and large parts of Japan hit by earthquakes.

For many communities, particularly in developing countries, diasters and emergencies add untold hardship to what can already be a challenging and precarious existence. What we don't see once the news crews have packed up and moved onto the next big story, is the slow, grinding recovery process that such communities face.

So what has this got to do with environmental health and the research agenda?

There are clear environmental health issues to be considered in the immediate wake of a natural disaster or emergency. Clean water, sanitation, shelter, disease prevention, food and the means to cook it are obvious concerns for environmental health practitioners in such situations.

In the middle to longer term, environmental health practitioners also have a role in the reopening of schools, restoring the means to earn a livelihood, the reconstruction of housing and working with the movement of communities from emergency shelter back to their own homes or alternatives.

In some countries a considerable and increasing number of environmental health practitioners are engaged in emergency preparedness. There is a depth of skill being developed and experience gained, but there is a question as to how effectively we share those skills and experiences with the wider audience of fellow professionals. This is a space we should try to occupy, in part at least, through published research and information sharing.

At the international level the International Federation of Environmental Health (IFEH) is promoting an initiative to support international relief and development aid agencies: EHiDE – Environmental Health in Disasters & Emergencies. The challenge faced is twofold.

First, to work with the humanitarian aid agencies in developing a cadre of suitably prepared environmental health professionals who can respond at short notice to fulfil identified needs in (natural or man made) disaster situations. It is envisaged that are those aid agencies with a track record in this field that have identified gaps in their environmental health expertise.

Second, to making the major aid and development agencies aware that there is a valuable human resource

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available to them. In many cases, these environmental professionals are living and working in countries where these organisations have already developed.

What many of us now appreciate is that disasters and emergencies are not something that just happens in far-off, exotic places. They can all too easily occur in our own communities.

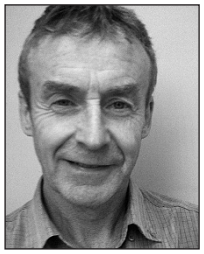
It is also a facet of our global village that the call for help in such situations can be made far beyond our local borders. A case in point is the global call earlier this year by the State of Queensland looking for suitably Qualified Environmental Health Officers (EHOs) with experience in disaster response, following the flooding there.

So there is a need to do more to gather and disseminate our shared experience in this field.

With that in mind it is perhaps timely to remind readers that this Journal, as well as publishing original research papers, also welcomes technical notes, professional evaluations, review articles, workshop/conference reports and short communications covering the diverse range of topics that impact on public and environmental health.

Sharing your experience and knowledge through the Journal on how we prepare for, and face, disasters and emergencies would be a valuable resource for all as we simply do no not know where they will strike next.

Guest editorial



Professor George Morris
BSc(Hons) PhD FREHIS FFPH
Independent Science Policy Adviser

Reconfiguring environmental public health for an ecological era

Among the component specialisms of modern public health, environmental health has one of the longest traditions. Viewed in the round, it is a good news story. Environmental health has delivered time and again for population health and the prosperity of many nations. Success has been built on flexibility, with priorities and emphases differing over time and according to location and, always, driven by advances in scientific and epidemiological understanding.

However, a new 'era of ecological public health' and changing perspectives on the relationship between health and physical environment create fresh challenges for both policy and practice in environmental public health and across the field of public health generally. The environmental health profession has many of the skills and operates at a spatial and administrative level where it can be a key part of an effective environmental public health response to the challenges of the ecological era. However, different approaches supported by new skills and competencies are undoubtedly indicated.

Over time I have contributed to a literature which, in essence, contends that that those professionally concerned with environment and human health have lost traction in some politically high profile public health policy issues through an over-rigid adherence to a narrow, compartmentalised and hazard-focused health protection agenda. See, for example Burke *et al.,* (2002), Morris *et al.,* (2006). As a consequence, the contribution of physical environment, and especially the physical aspects of the local or neighbourhood environment, has been under-represented in issues such as the obesity epidemic, mental health and wellbeing, child health and health inequalities between socio-economic groups. This failure to adequately link policy and action on environment and place to the health improvement agenda has been professionally damaging but arguably also a significant impediment to the success of public health policy. Underpinning the problem has been an inability to embrace, in a policy-relevant way, the complex interaction of environmental factors with socio-demographic, behavioural and other variables. However, this is only symptomatic of a wider failure to translate rhetoric around complexity into policy across the field of public health.

The obesity epidemic might be credited with moving the debate around complexity into sharper focus. Here is a massive policy and societal challenge defined by complexity and the interaction of many influences also but also accepted as having a significant environmental dimension. The term 'ecological public health' is gaining currency in public health circles to describe an era in public health wherein health and disease in populations (and inequalities in health between different socio-demographic groups) are viewed not only as products of a very complex interaction of factors but, critically, in which the pursuit of the public health solutions must be co-ordinated with the pursuit of planetary economic and societal sustainability. In evidence to the Foresight Obesity Project, Lang and Rayner (2007) offered an elegant, if somewhat sobering, distillation of what is likely to be required in taking an 'ecological approach' on obesity but, by extension other complex challenges of the ecological era. They concluded that the ecological approach would necessitate:

Guest editorial

> *"Comprehension of the composite interactions between the physical, physiological, social and cognitive worlds that determine health outcomes in order to intervene, alter and ameliorate the population's health by shaping society and framing public and private choices to deliver sustainable planetary, economic, societal and human health."*

Source: Lang and Rayner – Expert submission to Foresight Obesity Project (published in obesity reviews, January 2007)

No-one will underestimate the challenge involved in conceiving and implementing the truly ecological approach envisaged by Lang and Rayner. It will require entirely new ways of thinking, working and networking and an unprecedented degree of orchestration. This will profoundly challenge not just public health but governments and wider society. However, it is not fanciful to suggest that the environmental public health constituency might take some important initial practical steps to better equip themselves to participate in the challenge. They might usefully start by scoping the prerequisites and principles of an ecological approach for them and, by extension, begin to shape a new research, information, professional and policy agenda for environmental public health.

Driven by a concern to revitalise policy and practice on environmental health to better address contemporary public health challenges (but especially the country's stubborn and significant health inequalities challenge), work began in Scotland in 2004 to develop a new environment and health approach. Early thinking informed the launch (in December 2008) of *Good Places, Better Health*, Scottish Government's key policy initiative on environment and human health (Scottish Government, 2008). Conceived independently of the debate around ecological public health, it may be however, that the work in Scotland offers some initial pointers for an environmental public health response to the ecological era.

The prototype phase of *Good Places, Better Health* took as its focus, four distinct health outcomes in children eight years and under – obesity, asthma, mental health and wellbeing and unintentional injury. It has been recognised that the new approach has been built on five generic pillars, which may offer some pointers to environmental public health as it begins to shape an effective response for the era of ecological public health.

Five key pillars of a modern environmental public health approach

1 Holistic problem framing

Complex issues in environmental public health require to be considered with reference to all the factors that bear upon them and in a way that links to policy. This demands a robust, flexible, but above all holistic, problem-framing approach. To this end, Good Places, Better Health employs a 'purpose built' problem framing tool. The Modified DPSEEA model (1) is an amended version of a model originally developed by the World Health Organisation to conjure a European environmental health information system. The modified DPSEEA model is an example of a 'full chain' approach to problem framing and may be populated for any issue in environmental health. Its key benefits are its capacity to:

a) map the spectrum of influences (social, economic, cultural etc.) which create both positive and negative environmental characteristics in any locality.
b) represent the socio-demographic and other factors that influence the exposure and the exposure-response function in the individual
c) to map existing points of intervention
d) provide a framework for quantification of health impact

2 Wide stakeholder engagement

Implicit in the analysis, which calls for new approaches on environmental public health, is a need for wide stakeholder engagement. Good Places Better Health uses a variety of techniques to engage a spectrum of national and local experts, practitioners, NGOs etc. in the problem-framing approach. Though this, it is possible to map existing policies and interventions that bear upon the issue and to identify gaps in policy, information (often in the form of data) in knowledge and in policy.

3 Exploitation of a 'mixed economy' of evidence

A key challenge for modern environmental public health in moving beyond its health protection roots concerns the need to draw upon a much wider range of qualitative and quantitative evidence. This requires a number of quite different approaches to evidence gathering to be adopted in parallel. Borrowing terminology first coined by Petticrew *et al.,* (2004), the term a 'mixed economy of evidence' is used in Good Places, Better Health to reflect the breadth and diversity

of both qualitative and quantitative evidence that requires to be gathered. Good Places, Better Health has created structures to assemble and exploit this mixed economy in reaching its conclusions and making its recommendations. The mixed economy includes evidence ranging from the product of classical randomised control trials and the views of national topic experts though to local practitioner insights and opinions gained in workshop situations

4. Evidence must be the subject to 'qualitative synthesis'

While the assembly of a 'mixed economy of evidence' is consistent with a modern holistic approach to environmental public health, ways must be found to synthesise evidence of very different types to produce clear recommendations for policy. This demands a distinct 'process stage', which might be termed 'qualitative synthesis'. Good Places, Better Health has sought to provide this synthesis through bringing together a carefully selected independent expert group, which draws upon its individual and collective experience and expertise to a) further augment the evidential pool b) provide additional synthesis and, critically, c) take the necessary helicopter view across the evidential and policy landscape to distil recommendations that speak to the many different areas of policy across government whose interests bear upon the concept of healthy better places and the many benefits that can flow from these. Implicitly, the group is required not only look 'downwards' to the evidence but also 'upwards' to the ongoing policies and the programmes of government.

5. Structures created to deliver a new approach must challenge professional, institutional and policy silos

If the vision of a modern crosscutting environmental public health approach is to be realised, it must challenge silo working. For example, when holistic problem framing and analysis is applied to an environmental health issue, it may be revealed that the important levers of change lie, say, with policy leads whose primary concern is education, regeneration or social policy. This requires close attention to the evidence/policy interface and wide policy engagement. It also implies the need to exploit e.g. community planning structures to drive crosscutting approaches at local level. Good Places, Better Health is overseen at government level by a steering group of senior policy leads representing a spectrum of policy constituencies and seeks to address silo working at local level through multi-agency topic workshops.

Acknowledgements

While the views expressed here are my own and have not been otherwise endorsed, I wish to acknowledge the excellent work of the Good Places, Better Health team (past and present). I have also drawn upon the insights of Good Places, Better Health Intelligence Partnership, NHS Health Scotland (*http://www.healthscotland.com*, Health Protection (*http://www.hps.scot.nhs.uk*) and the Environmental Determinants of Health in Scotland (EDPHiS) research consortium (*http://www.edphis.org/node/15*)

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Food poverty: Living in hotels and guesthouses without access to adequate kitchen facilities

Richard John Hopkins MSc

Housing Regeneration Team Leader, Thanet District Council

Correspondence: Housing Regeneration, Community Services, Thanet District Council, PO Box 9, Cecil Street, Margate, Kent, CT9 1XZ. Telephone: 01843 577402. Email: richard.hopkins@thanet.gov.uk

Abstract

The English town of Margate suffers from high levels of unemployment and benefit dependency, and contains some of the South East's most deprived areas. It was once a prosperous seaside resort, but following the demise of the traditional seaside holiday, many of its hotels and guesthouses began catering for otherwise homeless and vulnerable persons. Many of these establishments offer residents meals rather than access to adequate kitchen facilities. Without reliable information about meal take-up and the true nature and length of stay, it was unclear how such arrangements impacted upon the ability of residents to maintain a healthy diet. To consider whether the otherwise homeless residents of these hotels and guesthouses suffered from food poverty, a cross-sectional survey was undertaken, targeting 13 establishments. Sixty-two hotel residents who were offered meals instead of kitchen facilities were asked about their food choices. The majority avoided buying hotel food, with less than 7% purchasing evening meals. Most residents said they preferred to make their own food choices and usually relied on a microwave for their hot meals. Eighty-two percent were either unemployed, long term sick/disabled or retired and almost 70% had been in occupation for more than three months. Thirty-nine percent of respondents had been resident for more than a year. A dietary assessment tool was used to assess the diet of residents. The results were compared to a control group comprised of 54 local residents who were living in similar socio-economic circumstances with access to adequate kitchen facilities. The hotel residents appeared to consume a diet that was on average less healthy than the control group. Hotel residents skipped breakfast more often and consumed less fruit and fewer vegetables, carbohydrates, meat and dairy products. The research suggests that hotel residents face food poverty because of their inability to access adequate kitchen facilities.

Key words: *Food poverty, diet, HMO, temporary accommodation, health inequalities*

Introduction

The English town of Margate, on the Isle of Thanet in Kent, was once a popular and prosperous seaside resort. However, the decline of the traditional English seaside holiday in recent decades has had a profound impact on the town (Stewart and Meerabeau, 2009). Having lost much of its tourism, Margate now suffers from high levels of unemployment and benefit dependency, and contains some of the South East's most deprived areas (Office of the Deputy Prime Minister, 2006a). A ready supply of cheap rented accommodation has driven an inward migration of benefit households (Beatty and Fothergill, 2003). Margate's fortunes are not unique and many other English seaside resorts face the challenge of a built environment created by a bygone era when foreign travel was generally reserved for the privileged minority.

In its heyday Margate had numerous hotels and guesthouses, but despite many closures there remains an oversupply of accommodation originally intended to cater for holidaymakers. To maintain viability, a significant proportion of those continuing to operate have diversified by reducing services and investment and letting rooms on a longer term basis to otherwise homeless persons (Thanet District Council, 2006). These premises are often dilapidated and occupied by vulnerable individuals on state benefits (Communities and Local Government Committee, 2007).

As hotels and guesthouses rarely provide cooking facilities, residents are often unable to prepare and cook meals for themselves (Shelter, 2008). Consequently, they are faced with the choice of eating in the restaurant provided by the hotel or guesthouse, or obtaining their food from elsewhere. Whereas this arrangement is typical for tourists and other short stay guests, it raises questions about the longer term residents and how they can access a healthy diet, particularly if they are on limited means. Whether such residents were in food poverty as a consequence of their accommodation was unclear. People who consume a poor diet because they face difficulties accessing and affording the foods they need to make up a healthy diet are said to be in food poverty (Friel and Conlon, 2004). A poor diet increases the risk of cancer, coronary heart disease, stroke and diabetes, and is linked to almost a third of life years lost due to early death (Press and Mwatsama, 2004).

The local housing authority for Margate, Thanet District Council, deems these hotels and guesthouses to be houses in multiple occupation (HMOs). As such they are residential premises and are subject to English housing law. The current English housing law definition of an HMO is lengthy, but in simple terms, these hotels and guesthouses are HMOs because they are occupied by unrelated persons who share basic facilities and reside in the accommodation as their only or main residence (Government of England and Wales, 2004).

HMOs are often associated with poor management and poor physical conditions. As such, mandatory HMO licensing was introduced in England in April 2006 to improve standards in this type of accommodation. Hotels and guesthouses considered to be HMOs by a local housing authority would normally be licensed if they comprise three or more storeys and are occupied by five or more persons (Local Authorities Co-ordinators of Regulatory Services, 2007). In Margate, Thanet District Council had licensed 13 hotels and guesthouses as of April 2009, all of which were in the Cliftonville area. The HMOs so licensed contained a total of 242 bedsit-type rooms, which could house up to 328 residents at maximum capacity (Thanet District Council, 2009). Every licence granted contained conditions requiring the owner to offer meals on a daily basis in a communal dining room. A further licence condition required the provision of one small snack kitchenette containing a sink and a microwave so residents could make their own light snacks outside restaurant opening hours.

Research has been carried out to investigate the relationship between HMO occupation and diet (Cade, 1992); while Shaw *et al*. (1999) and Evans and Dowler (1999) considered the relationship between homelessness and health. On a wider scale, health inequalities (Department of Health, 2003; Marmot, 2010) and low income diets (Nelson *et al.,* 2007; Dowler, 2008) have been extensively researched. However, there does not appear to be any substantive published research that considers the relationship between dietary health and residency of hotels and guesthouses that do not provide access to adequate kitchen facilities. This appears to be a little studied area of public health.

Cade (1992) undertook a study to compare the diets of 73 adult HMO residents to that of 34 council tenants. Although the study included people living in bed and breakfast hotels, the HMO group also comprised residents from other types of HMO, including those living in bedsits with access to kitchen facilities. The research used food frequency questionnaires to compare the two groups, and overall, concluded that the differing housing conditions did not have a major impact on nutrient intake. In 2006, the Food Standards Agency carried out a study relating to food poverty and homelessness in Northern Ireland (Food Standards Agency, 2006). In their report, the term 'homeless person' was applied to both rough sleepers and to residents of temporary accommodation. The study interviewed 72 people who were staying in temporary accommodation and concluded that the quality of their diet was poor, although they generally had enough to eat. However, many of the respondents had good access to kitchen facilities. Therefore, while relevant, little can be inferred from either of these studies as their subject groups included a mixture of residents, some of whom had access to adequate kitchen facilities, and some that did not.

Bines (1994) considered a wide range of health issues in a study of single homeless people, which included residents of bed and breakfast and hostel accommodation. The study concluded that residents were more likely than the general population to suffer from a range of ailments, such as digestive problems and frequent headaches; however, it did not consider whether accessibility to kitchen facilities was a contributing factor. Therefore, it is difficult to establish a link between the poor health outcomes identified in the study and the provision, or otherwise, of kitchen facilities, particularly as there are many confounding factors to be taken into account. Residents of this type of accommodation are prone to behaviour injurious to health, drink and drug problems, and mental health disorders (Victor, 1997; Food Standards Agency, 2006). These factors contribute to the statistic that, using standardised mortality ratios,

> *"bed and breakfast residents have death rates four or five times that of the general population"*
> (Shaw *et al.,* 1999).

The aim of this study was to consider whether the residents of Margate's hotels and guesthouses were in food poverty as a consequence of their housing situation.

Methodology

Residents of HMOs, particularly those living in areas of high deprivation such as Cliftonville, are often hard to reach and prone to leading chaotic lifestyles (Department for Communities and Local Government, 2007). Nevertheless, the only way to obtain the data necessary to achieve the stated aim was to contact residents directly. A structured interview was considered to be the most effective survey methodology, as experience has shown that this is the only practical method for obtaining adequate dietary information from HMO residents (Cade, 1992). However, such an approach has its limitations and access rates were anticipated to be low. Accordingly, a questionnaire was designed for use as an interview schedule and as a questionnaire that could be completed by residents in their own time.

Owing to their socio-economic circumstances, the residents of Margate's hotels and guesthouses are likely to be prone to eating a poor diet; yet, so are most of the less wealthy sections of society (Nelson *et al.,* 2007). Therefore, any analysis of the diets consumed by the hotel and guesthouse residents in isolation would be of limited value. Whether their diet was any different to that of other people living in similar socio-economic circumstances who had access to adequate kitchen facilities was the key issue. Consequently, a comparative survey was needed to ascertain whether there was any significant difference between the diets of these two population subgroups.

Sample selection

The residents of the 13 hotels and guesthouses licensed as HMOs in the Cliftonville area of Margate became the target subjects and were collectively named the 'HMO Group'. No sampling techniques were used for the HMO Group as a census type survey was attempted. To obtain meaningful results, the chosen 'Control Group' had to reflect as closely as possible the socio-economic character of the HMO Group. The hotels and guesthouses of the HMO Group were located in seven roads, containing 1,221 other dwellings within the Cliftonville area. The Control Group included the residents of those other dwellings who were privately renting and had full access to adequate kitchen facilities. Random sampling was used to select target homes.

Questionnaire design and administration

The questionnaire designed for the survey comprised 36 questions divided into four parts. Part A related to residency status and length of stay. Part B concerned food sourcing, restaurant meal take-up and reasons for food choices, and Part C comprised a dietary assessment tool. Part D collected demographic information. The Control Group were only asked the questions set out in Parts C and D.

The means of dietary assessment used for Part C was a questionnaire and results calculator collectively known as the *Healthy Eating Assessment Tool* (HEAT) (Beesley, 2008). Developed by Tonbridge and Malling Borough Council, it uses 17 questions to gauge diet quality. Each question is based on a food type and asks how often it is consumed. Respondents have the following nine options to choose from: every day, most days, every week, most weeks, every month, most months, less often, never and not sure. The answers from each questionnaire are entered into a computer program and a dietary score is calculated, based on a scale of 1 to 5, where 1 indicates a 'very unhealthy' diet, and 5 indicates a 'very healthy' diet. The tool also asks respondents to rate their own diets using the same scoring technique. The system was designed to evaluate diet quality based on the Food Standards Agency's *Eatwell Plate* (Food Standards Agency, 2011) which recommends in what proportions the five main food groups should be consumed in order to maintain a healthy and well-balanced diet.

The HEAT methodology was suitable for the study as it allowed comparisons to be made between the HMO and Control Groups that could be easily interpreted, and did not require extensive questioning. The answers to the 17 questions could also be individually collated to allow comparisons to be made in respect of each food type. A survey using a food frequency questionnaire was thought to be impractical owing to the anticipated difficulties of engaging with the HMO Group. HMO residents were not expected to tolerate a survey lasting more than five minutes, whereas food frequency questionnaires usually contain a large number of questions based on 150 or more food types (Wrieden *et al.,* 2003). However, no dietary survey based on a questionnaire can be entirely accurate as they only measure what respondents say they have consumed, and not necessarily what they have (Drewnowski, 2001).

Up to three visits were made to each room in all 13 HMOs. After the third unsuccessful visit to a room, an envelope containing a questionnaire, a pre-paid return envelope and a covering letter was pushed under the door. Before being placed in the envelope, each questionnaire was coded for identification purposes. The randomly selected homes in the Control Group were visited at least twice, but no questionnaires were left behind because of uncertainty over tenure and therefore eligibility for inclusion in the survey.

Restaurant provision

To consider whether HMO residents faced any unique barriers to achieving a healthy diet, it was necessary to determine how factors outside their control affected their food choices. Accordingly, the managers of the hotels and guesthouses accessed were, where willing, questioned about their restaurant service during the HMO Group survey. Enquiries were made regarding meal options and pricing.

Table 1.0
Length of stay of HMO Group respondents

	<1 month	1 – 3 months	3 – 6 months	6 – 12 months	>12 months	Total
HMO Group	9 (14.5 %)	10 (16 %)	9 (14.5 %)	10 (16 %)	24 (39 %)	62 (100 %)

Table 2.0
Work status of HMO and Control Group respondents

	Un-employed	Long term sick/disabled	Retired	Part-time work	Full-time work	Other	Totals
Control Group	15 (28 %)	10 (18 %)	7 (13 %)	6 (11 %)	8 (15 %)	8 (15 %)	54 (100 %)
HMO Group	34 (55 %)	7 (11 %)	10 (16 %)	6 (10 %)	4 (6 %)	1 (2 %)	62 (100 %)

Table 3.0
Number of HMO Group respondents using their hotel/guesthouse restaurant

	Number (% of HMO Group)
Respondents using restaurant service (breakfast and evening meals)	4 (6.5 %)
Respondents using restaurant service (breakfast only)	5 (8 %)
Respondents not using restaurant service	53 (85.5 %)
TOTAL	**62 (100%)**

Statistical analysis

To ascertain whether there were significant differences between the HMO and Control Groups results, the self-assessed and calculated scores generated by the HEAT system were subjected to statistical analysis. The data sets were first compared using the Kolmogorov-Smirnov test to establish whether they were distributed normally. The self-assessed scores were then compared using the non-parametric Mann-Whitney test, while the calculated scores were compared using the independent samples t-test.

Results

The fieldwork for both the HMO and Control Group surveys was undertaken during the months of March, April and May 2009.

Access rates

Because of changes in circumstances and the reluctance of some hotel/guesthouse managers to participate in the study, only 145 rooms were accessible during the HMO Group survey. Forty of the 145 rooms were found to be empty and two residents refused to take part. Fifty-nine residents were interviewed and 44 questionnaires were pushed under the door after three unsuccessful visits. Only three questionnaires were returned. The HMO Group therefore comprised 62 participants. The access rate for the Control Group was low; however, 54 interviews were completed. All Control Group respondents were living in either bedsits or self-contained flats.

Length of stay of HMO Group residents

All 62 respondents claimed that their hotel/guesthouse room was their only home, with almost 70 % having been in occupation for more than three months. Although the questionnaire did not require respondents to state exactly how long they had been occupation, some claimed that they had been resident for a number of years. Table 1 shows the length of stay of HMO Group respondents.

Most common food choice of respondent	Number (% of population subgroup)
Use a microwave to prepare meals	30 (57%)
Eat meals in a restaurant or cafe elsewhere	8 (15%)
Eat meals at a friend's or relative's home	6 (11%)
Eat fast and takeaway foods	6 (11%)
Eat foods from shops/supermarkets that need no further cooking	3 (6%)
TOTAL	**53 (100%)**

Table 4.0 Food choices of HMO Group respondents not using their hotel/guesthouse restaurant

Work status

Eighty-two percent of HMO Group residents were either unemployed, long term sick/disabled or retired. The comparative figure for the Control Group was 59%. Table 2 shows the work status of all HMO and Control Group respondents.

Meal choices of HMO Group residents

The majority of respondents did not purchase the meals offered by their hotel/guesthouse restaurant. The survey results relating to meal take-up are shown in Table 3.

The 53 respondents who did not purchase meals were asked why they avoided using their hotel/guesthouse restaurant. Sixty-six percent of this population subgroup, n=35, said they simply preferred to make their own food choices. Other reasons were also given for not purchasing meals, but only 17% of this population subgroup, n=9, said they did not buy meals because they were dissatisfied with the food service offered. The same 53 respondents were asked what they did most often to obtain their food. The results are shown in Table 4.

A significant proportion of respondents had food supplies in their rooms, with tinned soups and instant noodles being particularly popular. A common complaint related to the inability to keep refrigerated and frozen foods, in particular dairy products and ready meals. Although a fridge was usually available in the snack kitchenette of all hotels and guesthouses, they were usually empty. When asked, many respondents said they did not use the communal fridge as any food or drink stored in them was likely to be stolen.

Meal options and pricing

Six managers of the targeted hotels and guesthouses answered questions about their meal service. Overall, meal pricing appeared to be reasonable. Generally, residents could purchase a breakfast for around £1.50 and an evening meal for about £3.50. Becuse of low demand, most kitchens maintained a limited stock of food supplies and all managers questioned required residents to book their meals in advance. Three establishments were only offering meals on a weekly paid-in-advance basis, with no credit being given for missed meals. The managers questioned only offered one meal choice each evening. None of the hotels or guesthouses visited offered a restaurant service to the general public.

Dietary assessment

The *Healthy Eating Assessment Tool* (HEAT) survey form was completed in full by all respondents of both the HMO and Control Groups. The self-assessment HEAT question asked:

> *"How healthily do you eat on a scale of 1 to 5 where 1 is 'Very unhealthily' and 5 is 'Very healthily?'"*

The results are shown in Table 5. There was a significant difference in the way the two groups viewed the quality of their diets (u=1053.5, p=.000); on average, the Control Group believed that their diet was healthier.

Table 5.0
Frequency of self-assessed diet ratings and average group scores

	Score given by respondent						Average (Mean)	Standard Deviation
	1	2	3	4	5	Totals		
Control Group	1 (2%)	6 (11%)	23 (43%)	13 (24%)	11 (20%)	54 (100%)	3.50	1.00
HMO Group	11 (18%)	11 (18%)	28 (45%)	8 (13%)	4 (6%)	62 (100%)	2.73	1.10

Table 6.0
Calculated HEAT scores – Summary results

	Average Score (Mean)	Standard Deviation	Lowest calculated score	Highest calculated score
Control Group	3.43	0.48	2.04	4.49
HMO Group	2.99	0.38	2.04	3.82

For each questionnaire, the answers to the 17 HEAT questions were entered into the HEAT computer program. The summary results are shown in Table 6. In comparing the calculated scores for both groups it was found that there was a significant difference between them (t=-5.54, df=114, p=.000). The results suggest that the Control Group's diet was healthier than the HMO Group's.

The answers to each of the HEAT questions were also collated. Some of the questions produced results which revealed significant differences between the HMO and Control Groups. The number of respondents giving the key answers of every day, most days, every week, and never for those questions are shown in Table 7.

Discussion

The survey revealed that HMO residents were staying for prolonged periods; consequently, their exposure to accommodation lacking in adequate cooking facilities was significant. Although the provision of a meal service was compulsory for the hotels and guesthouses surveyed, very few meals were being served. This was primarily owing to low demand. For the most part, residents simply wanted to make their own arrangements for food. This raises the question of the economic viability of a meal service. A viable meal service relies on economies of scale; therefore, the provision of a good quality low-cost food service is rendered difficult when only a few residents use it. The meal services on offer were therefore, almost inevitably, very limited. Despite this, only few residents quoted problems with their meal service as a reason for making alternative food choices.

All of the hotels and guesthouses surveyed only offered one choice of evening meal. Therefore, if the dish on offer was not to their taste, residents would need to make alternative meal arrangements or go without. This could lead to meals being skipped, particularly where vulnerable persons are concerned. The policy of some hotels and guesthouses to require block payments for whole weeks also appears to be a barrier to meal take-up, as it is unlikely that every resident would want to take meals every day. Without credit for missed meals, low income residents may resent paying for meals they do not need. In which case, the weekly system is likely to dissuade residents from using the meal service. The weekly system could also commit residents to paying for meals that were not to their liking.

Many residents said that although the meals were not expensive they could eat much cheaper by purchasing their own food. One respondent said he could eat for about a £1.00 a day. Seemingly, for some there was a cost saving in not using the meal service. This did not necessarily mean residents were eating off premises; a significant proportion were using a shared or private microwave to cook some or most of their meals. Many had installed one in their room. Although microwaves are versatile, the lack of other kitchen facilities such as hobs and ovens may limit meal options. The lack of kitchen facilities in rooms, such as adequate

	Every day	Most days (4 to 6 days a week)	Every week (1 to 3 days a week)	Never
How often do you eat breakfast?				
Control Group	28 (51.9%)	6 (11.1%)	4 (7.4%)	11 (20.4%)
HMO Group	20 (32.3%)	6 (9.7%)	8 (12.9%)	22 (35.5%)
How often do you eat bread (two slices or equivalent)?				
Control Group	35 (64.8%)	13 (24.1%)	4 (7.4%)	0 (0.0%)
HMO Group	29 (46.8%)	13 (21.0%)	11 (17.7%)	4 (6.5%)
How often do you eat potatoes, rice, pasta or noodles?				
Control Group	28 (51.9%)	17 (31.5%)	9 (16.7%)	0 (0.0%)
HMO Group	14 (22.6%)	14 (22.6%)	25 (40.3%)	6 (9.7%)
How often do you eat dairy produce?				
Control Group	27 (68.5%)	7 (13.0%)	5 (9.3%)	4 (7.4%)
HMO Group	23 (37.1%)	15 (24.2%)	14 (22.6%)	4 (6.5%)
How often do you eat vegetables (at least two portions a day)?				
Control Group	26 (48.1%)	15 (27.8%)	12 (22.2%)	0 (0.0%)
HMO Group	13 (21.0%)	9 (14.5%)	21 (33.9%)	9 (14.5%)
How often do you eat fruit or drink fruit juice or smoothies (at least three portions/glasses a day)?				
Control Group	22 (40.7%)	6 (11.1%)	10 (18.5%)	3 (5.6%)
HMO Group	2 (3.2%)	.3 (4.8%)	15 (24.2%)	22 (35.5%)
How often do you eat salad?				
Control Group	7 (13.0%)	15 (27.8%)	18 (33.3%)	6 (11.1%)
HMO Group	3 (4.8%)	2 (3.2%)	19 (30.6%)	19 (30.6%)
How often do you eat chicken or turkey or vegetarian equivalents?				
Control Group	8 (14.8%)	6 (11.1%)	29 (53.7%)	0 (0.0%)
HMO Group	1 (1.6%)	1 (1.6%)	25 (40.3%)	14 (22.6%)
How often do you eat red meat (such as beef, lamb, pork, bacon and sausages)?				
Control Group	1 (1.9%)	11 (20.4%)	28 (51.9%)	3 (5.6%)
HMO Group	4 (6.5%)	6 (9.7%)	18 (29.0%)	13 (21.0%)
How often do you eat take-aways (including Chinese, Indian, kebabs and pizza)?				
Control Group	0 (0.0%)	0 (0.0%)	12 (22.2%)	16 (29.6%)
HMO Group	3 (4.8%)	7 (11.3%)	18 (29.0%)	13 (21.0%)

Table 7.0
Significant results of food specific HEAT questions

work surfaces and a sink with hot and cold water, is likely to make safe food preparation more difficult than normal. In an ordinary dwelling the lack of adequate facilities for the storage, preparation and cooking of food would normally be considered a health and safety hazard because of the increased risk of infection (Office of the Deputy Prime Minister, 2006b).

Many HMO and Control Group respondents acknowledged that their diet could be healthier. However, the self-assessment element of the HEAT revealed that the HMO Group were less optimistic about the quality of their diet. This may indicate that diet perceptions are affected by a person's ability to access adequate kitchen facilities. During the HMO Group survey, the answers to the self-assessment question were sometimes qualified by comments such as: *"Well, I can't cook for myself, can I?"* The calculated results generated by the HEAT computer program revealed that the HMO Group's diet was less healthy than the Control Group's. This may suggest that people living in hotels and guesthouses without access to adequate kitchen facilities are more likely to consume a diet which is less healthy than that consumed by similar socio-economic groups.

The HEAT performed well and the individual scores appeared to reflect diet adequacy with some consistency. However, the algorithms used by the calculator did not cope especially well with low-intake diets. There were several HMO Group respondents who would arguably be expected, from the answers given, to be suffering from some form of undernutrition. For example, one HMO Group respondent said that he had just been released from hospital after experiencing ill-health associated with malnutrition, and had large quantities of food supplements in his room which he claimed had been prescribed by his doctor. The surveys, which suggested that all food types were being consumed in very small quantities, did not score as low as perhaps would be expected. To some extent this inadequacy may mask some of the differences being experienced by the two population subgroups. It should be noted here that the HEAT calculator was designed primarily to assess how well-balanced, and thus how healthy, a respondent's diet is likely to be, and was not intended to assess the extremes of dietary behaviour encountered during the survey. Realistically, no dietary assessment technique can measure nutrient intake without some degree of error (Margetts and Nelson, 1997).

The individually collated results of the questions used by the HEAT were also revealing. As HMO Group residents were less likely to have a daily breakfast and more inclined to skip it altogether, they were at a disadvantage when compared to the Control Group as breakfast skipping has been linked to poor dietary health outcomes (Giovannini *et al.,* 2008). The HMO Group ate fewer amounts of potatoes, rice, pasta and noodles; with nearly twice as many respondents from the Control Group eating these starchy foods every or most days. In a healthy diet, the main source of energy should come from such carbohydrates (Press and Mwatsama, 2004). The HMO Group also consumed less dairy produce. Although milk and dairy foods should be consumed in moderation, some foods from this group should be eaten every day, as an adequate intake of calcium is needed to maintain healthy bones (Press and Mwatsama, 2004). The HMO Group were understandably at a disadvantage due to their general lack of refrigerated storage. Significantly, the HMO Group ate less fruit and fewer vegetables. It is well recognised that an inadequate consumption of fruit and vegetables is linked to an increased risk of many chronic diseases (Department of Health, 2005). Approximately three-quarters of the Control Group respondents ate chicken or turkey (or vegetarian equivalents) at least once a week, whereas less than half of the HMO Group did likewise. The results for red meat products were very similar. The fewer cooking options available to the HMO Group may contribute to the differences in meat consumption. While meat products should be consumed in moderation, they are a good source of protein, vitamin B12, zinc, magnesium, and easily absorbable iron (Press and Mwatsama, 2004). The use of a microwave as the sole means of cooking may lead to an increased consumption of processed meat products, which by their nature are prone to a high salt content. In general, the HMO Group respondents appeared to consume most foods less frequently. Poverty and social isolation are risk factors for undernutrition (Press and Mwatsama, 2004).

An unhealthy diet does not only have physiological consequences. Poor nutritional intake is associated with poor emotional and mental health outcomes (Kayani, 2009). As HMO accommodation is often associated with anti-social behaviour and chaotic lifestyles, it seems apparent that tackling the barriers to healthy eating, such as access to adequate kitchen facilities, may have wider benefits than simply improved physiological outcomes.

In the context of public health, living without adequate kitchen facilities in a hotel or guesthouse might not be unreasonable if stays are of limited duration; indeed,

there is a clear need for temporary accommodation of some description to cope with the changes that occur in people's lives. However, many of the respondents did not appear to be 'temporary' in nature, and there seems to be a culture of permanency throughout this type of accommodation in Margate. For how long should people be exposed to a home life that lacks adequate kitchen facilities? From a practical viewpoint, challenging this situation is not without difficulty; nevertheless, if housing of this nature contributes to the array of avoidable health inequalities present in modern day England, then efforts to tackle it must be a priority. With 70,000 people living in temporary accommodation (Capie, 2009), this situation may not be uncommon. Coastal towns are most likely to be affected.

Conclusions

The residents of the hotels and guesthouses surveyed generally stayed on a long-term basis, quite often for periods in excess of a year, and did not have any other home. Although the meals on offer were not expensive, residents were faced with very limited food choices and restricted payment methods. Most residents did not purchase restaurant meals.

The comparisons made between the HMO and Control Groups suggest that there was a significant difference between the adequacies of the diets consumed. The hotel and guesthouse residents appeared to consume a diet that was, on average, less healthy than that consumed by similar socio-economic groups who had access to adequate kitchen facilities.

In the knowledge that diet and health are inextricably linked, it may be argued that this form of housing increases the risk of poor health outcomes and perpetuates health inequalities. Ultimately, this research concludes that such accommodation promotes food poverty among some of the most deprived and vulnerable groups in society.

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Contamination of surface waters by polycyclic aromatic hydrocarbons in two Nigerian coastal communities

G R E E Ana, M K C.Sridhar[1] and G O Emerole[2]

[1] Division of Environmental Health Sciences, Faculty of Public Health, College of Medicine, University of Ibadan, Ibadan, Nigeria
[2] Department of Biochemistry, Faculty of Basic Medical Sciences, College of Medicine, University of Ibadan, Ibadan, Nigeria

Correspondence: Dr Godson Ana, Faculty of Public Health, College of Medicine, University of Ibadan, Ibadan, Nigeria.
Email: anagrow@yahoo.com

Abstract

Polycyclic aromatic hydrocarbons (PAHs) are among nature's most widespread compounds. They originate from both natural and anthropogenic sources following incomplete combustion processes. In view of their ubiquitous and toxic nature they pose serious threat to the health of populations and cause tumours, especially in experimental animals. Currently, studies on the disparities in PAH levels in different surface water ecosystems are scanty and herein lies the objective of this investigation. Eighteen surface water samples from two communities, one highly industrialised and another less industrialised, in Nigeria's Niger Delta Area were collected systematically and analysed for pH value using the probe method and polycyclic aromatic hydrocarbons (PAHs) using high performance liquid chromatography with fluorescence and UV detectors. Results indicated that the highest number (7) of individual PAH components were recorded at the highly industrialised site and the concentrations of total PAHs were three times higher ($2.21x10^{4}$ng/l) as compared to the less industrialised site ($8.39x10^{3}$ng/l) and also higher than the WHO guideline limits of 50ng/l($p<0.05$). Seven of the surface water sources at the highly industrialised site as against three from the less industrialised site were in the high risk category based on the PAH risk map prepared for the area. This study reveals that surface waters from the highly industrialised site are polluted with PAHs and may present greater health risks to populations.

Key words: Polycyclic aromatic hydrocarbons, surface waters, industrial pollution, health risks, Niger Delta communities.

Introduction

Polycyclic aromatic hydrocarbons (PAHs) are multi-ringed organic compounds which are ubiquitous in nature and are being derived from both natural processes of biogenic precursors (Young and Cerniglia 1995) and anthropogenic processes of incomplete combustion of organic matter and emissions of non combustion-related petrogenic processes (Harvey, 1996).

Contamination of aquatic ecosystems by PAHs has been recognised as a major public health risk (Okafor and Opuene, 2007). Exposure to PAHs has been found to be harmful to health under some circumstances. Epidemiological studies on air pollution have shown that individuals exposed to mixtures of PAHs via different routes, including GIT and dermal contact, for long periods can develop cancer. Also several of the PAHs, including benz[a]anthracene, benzo[a]pyrene, benzo[b]fluoranthene, benzo[j]fluoranthene, benzo[k]fluoranthene, chrysene, dibenz[a,h]anthracene and indeno [1,2,3-c,d]pyrene, have caused tumours in laboratory animals when they are exposed to these substances via several exposure pathways (WHO,1998) .

The point sources of emissions of reportable size of polycyclic aromatic hydrocarbons include petroleum refineries; sites dealing with the production of coal tar, coke, bitumen and asphalt, paper, wood products, and aluminum; industrial machinery manufacture and power production from fossil fuels (NPI, 2001). Non point sources may include aerial fallout, inadvertent oil spills, and marine oil spillage (Eddy and Cherrie, 1994). Once formed, PAHs can be transported into an aquatic environment by a number of pathways including fossil fuel distribution, petroleum spillage, storm water and surface runoff, sewage and waste water effluent (Brooks, 1997).

The occurrence of PAHs in the aquatic ecosystem has been the subject of significant investigation across many industrialised countries (Countway *et al.,* 2003; Zhou and Maskaoui, 2003; Witt 1995; Xiao-Jun *et al.,* 2006; Opuene, 2005). In a related study, the highest concentrations of PAHs in water in Canada were reported for water samples from ditches next to utility and railway lines near Vancouver. The highest mean concentrations were measured near utility points treated with creosote, with values estimated at 2000ng/litre for fluoranthene, 1800ng/litre for phenanthrene, and 490ng/litre for naphthalene (Environment Canada, 1994).

Similar studies have been carried out in countries with industrial growth like Nigeria. For instance Okoro (2008) found that concentrations of PAHs in Ekpan Creek in the Niger Delta were from pyrogenic origin and include phenanthrene, anthracene, fluoranthene, pyrene, chrysene and benzo(a)anthracene. The concentrations (mg/l) of these PAH components ranged between 0.02439-0.2836 compared to 0.00017-0.00186 recorded for the control creek at Abraka (Okoro, 2008). In another study by Olajire *et al.,* (2007) 10 PAHs were analysed from surface water samples from South Western Nigeria and the total concentration found to be 11.2 to 341.5µg/l in water. Opuene *et al.,* (2009) analysed total PAHs and found that levels varied from 720.46 to 857.65µg/l in surface waters, indicating that the aquatic ecosystem is polluted by PAHs. The most abundant PAHs in the surface waters and sediments

were fluorene and acenaphthylene. Ogunfowokan *et al.,* (2003) showed that at Osogbo and Ile-Ife areas, the mean levels of PAHs in surface runoff ranged between 0.1-15.81mg/l while in the more industrialised Lagos area the levels were between 0.1-73.72mg/l.

With more industries springing up in the Niger Delta Area (NDA) in Nigeria, it is expected that the burden of PAHs from anthropogenic sources would be on the increase. So far no studies have tried to assess the disparities in the pollution load of surface water sources in comparison with guideline limits. This study compares the levels of PAHs determined (using HPLC with uv/fluorescence detector) in highly polluted and less polluted aquatic ecosystems found in two non-contiguous communities of the NDA with WHO guideline limits and used that in developing a risk map for the area.

Materials and methods

Study area

The study was conducted in two communities in the Rivers state in the NDA. An area that accounts for over 80% of Nigeria's oil mineral reserves, Eleme, which hosts most of the petroleum related industries including refineries and petrochemicals was chosen as the study area and Ahoada East, where there is absence of such industries, was chosen as the comparison area.

NDA, located in the Southern part of Nigeria, is an intricate, interconnected body of rivers, which drain from central and northern Nigeria through a landmass into the Atlantic Ocean. NDA is a vast deltaic wetland of about 70,000 square kilometers, consisting essentially of Bayelsa, Delta, Akwa Ibom, Ondo, Imo, Edo, Cross River, Abia and Rivers states. It is made up of four distinct ecological zones: coastal ridge barriers, mangroves, freshwater swamp forests, and lowland rain forests, each of which offers diversity of settings for ecological resources and human activities. The area, which extends from the coast to about 150km inland, shares similar climatic characteristics as the equatorial climate.

The people of the area, located in different settlements, are of multiethnic origin and of diverse culture. The natives are engaged primarily in traditional occupations such as farming and fishing, which constitute their dependable source of income and livelihood. As such they are hugely reliant upon the quality of surface waters and are disproportionally affected by pollution of the aquatic ecosystem.

Surface water samples and sampling procedure

A comparative cross-sectional study design was adopted, involving collection of surface water samples from both Eleme and Ahoada East. A total of 18 grab surface-water samples with nine each from Eleme and Ahoada East communities respectively were deliberately collected because they were the most prominent receiving surface water bodies in the area. A GPS was used to capture the coordinates of each of the sample locations that were eventually used for the GIS risk map. In each case samples were collected at a depth of 20cm below the surface of the water using amber-coloured 1 litre capacity glass bottles. Samples obtained in this form were then transferred to the laboratory for further processing.

Determination of pH in surface waters

The pH of surface water samples was determined by probe method according to standard procedures (APHA,1992). The determination of pH even though not the analyte of interest is usually regarded as part of the preliminary physicochemical assessment of water quality. Fifty mililitres of water sample was introduced into a conical flask and the probe introduced after calibration of the instrument. An Orion research Digital pH meter model 407A was used.

Determination of phenol in surface waters

Phenol in water was determined according to ASTM method No 1783 (ASTM, 1980). This method was limited to only soluble phenols. The determination of phenols was also regarded as a preliminary measure of the byproducts of single aromatic compounds in the water samples. To 100ml of the water sample 5ml of NH_4Cl was added and pH adjusted to 9.8-10.2 using NH_4OH. After this, 2ml of 4-amino antipyrine plus 2ml of $K_5Fe(CN)_6$ was added and then mixed immediately. After 15 minutes a reading was taken at an absorbance of 510nm. This analysis was done in duplicate and the procedure repeated for blank. The concentration of phenol in water is expressed in mg/l.

Determination of PAHs in surface waters

The determination of PAH followed methods described by ASTM D 4657-92 (ASTM, 1998) with few modifications. It involved the extraction, purification, concentration, solvent exchange and analysis using HPLC (ASTM,1998).

Sample ID/location Components	SWE1 Alesa ***	SWE2 Aleto *	SWE3 Akpajo ***	SWE4 Agbonjia ***	SWE5 Ogale ***	SWE6 Ebubu ***	SWE7 Eteo ***	SWE8 Ekporo *	SWE9 Onne ***	Range
Naphthalene	–	–	–	–	–	–	–	–	–	–
Acenaphthylene	–	–	–	–	–	–	–	–	–	–
Acenaphthene	–	–	–	–	–	–	–	–	$3.02x10^{4}$	0 - $3.02x10^{4}$
Fluorene	–	–	–	–	–	–	–	–	–	–
Anthracene	–	–	–	–	–	–	–	–	–	–
Phenanthrene	–	$9.28x10^{-5}$	–	–	–	–	–	–	–	0 - $9.28x10^{-5}$
Fluoranthene	–	$3.23x10^{-4}$	–	–	–	–	–	–	–	0 - $3.23x10^{3}$
Pyrene	–	$1.41x10^{-3}$	–	–	–	–	–	–	–	0 - $1.41x10^{-3}$
Benzo (a) anthracene	–	$7.53x10^{-4}$	–	–	–	–	–	–	–	0 - $7.53x10^{-4}$
Chrysene	–	$5.05x10^{-4}$	–	–	–	–	–	–	–	0 - $5.05x10^{-4}$
Benzo (b) fluoranthene	–	–	–	–	$5.53x10^{3}$	–	$5.07x10^{3}$	–	–	0 - $5.53x10^{3}$
Benzo (k) fluoranthene	$2.54x10^{4}$-	2.50x 10^{-3}	$1.49x10^{4}$	$1.63x10^{3}$	–	$9.19x10^{3}$	–	$2.16x10^{-3}$	–	0 - $2.54x10^{4}$
Benzo (a) pyrene	–	–	–	–	$1.46x10^{4}$	–	$1.47x10^{4}$	–	–	0 - $1.47x10^{4}$
Indeno (1,2,3 –cd) pyrene	–	$7.00x10^{-4}$	$1.22x10^{3}$	$1.41x10^{3}$	–	–	–	$4.05x10^{-4}$	$5.87x10^{4}$	0 - $5.87x10^{4}$
Dibenzo (a,h) anthracene	$1.04x10^{4}$	–	–	–	–	$6.41x10^{2}$	–	–	–	0 - $1.04x10^{4}$
Benzo (g,h,i) perylene	–	–	–	–	–	–	–	–	–	–
Range	0 - $2.54x10^{4}$	0 - $2.5x10^{-3}$	0 - 1.49x104	0 - $1.63x10^{3}$	0 - $1.46x10^{4}$	0 - $5.42x10^{3}$	-$1.47x10^{4}$	0 - $2.16x10^{-3}$	0 - $5.87x10^{4}$	

*** High Risk; ** Medium Risk; * Low Risk

Table 1.0 Concentration of PAH in surface waters at Eleme.

(i) Extraction

In the extraction procedure, a liquid-liquid extractor model 6-4770 Supelco INC, made in England was used with dichloromethane as the extracting solvent.

In this method, one litre of the samples and 60ml of the solvent was used for extraction, which lasted 3 hours. This step was repeated twice and the combined extract collected and used for the pre-concentration stage prior to clean up.

(ii) Purification

The purification of the sample extract involved use of a glass column embedded with activated silica gel, which

Sample ID/location Components	SWA1 Ahoada ***	SWA2 Ulapata **	SWA3 Ula Ehuda ***	SWA4 Ihuogbogu *	SWA5 Odiamerenyi *	SWA6 Odiabidi *	SWA7 Ihuoho *	SWA8 Edoha *	SWA9 Ikata ***	Range
Naphthalene	–	–	–	–	–	–	–	–	–	–
Acenaphthylene	–	–	–	–	–	–	–	–	–	–
Acenaphthene	–	–	–	–	–	–	–	–	–	–
Fluorene	–	–	–	–	–	–	–	–	–	–
Anthracene	–	–	–	–	–	–	–	–	–	–
Pyrene	–	–	–	–	–	–	–	–	–	–
Benzo (a) anthracene	–	–	–	–	–	–	–	–	–	–
Benzo (b) fluoranthene	–	–	–	–	–	–	–	–	–	–
Benzo (k) fluoranthene	$1.93x10^{-4}$	–	–	$1.81x10^{-3}$	–	–	–	–	$1.26x10^{-4}$	0 - $1.93x10^{-4}$
Benzo (a) pyrene	–	$2.07x10^{-1}$	2.13x104	–	–	–	–	–	–	0 - $2.13x10^{-4}$
Indeno (1,2,3 – cd) pyrene	$2.22x10^{-4}$	–	–	$7.38x10^{-4}$	$7.24x10^{-4}$	$7.86x10^{-4}$	$4.03x10^{-4}$	$1.09x10^{-3}$	$5.87x10^{-1}$	0 - $2.22x10^{-4}$
Dibenzo (a,h) anthracene	–	–	–	–	–	–	–	–	–	–
Fluoranthene	–	–	–	–	–	–	–	–	–	–
Benzo (g,h,I) perylene	–	–	–	–	–	–	–	–	–	–
Range	0 - $2.22x10^{-4}$	0 - $2.07x10^{-1}$	0 - $2.13x10^{-4}$	0 - $1.81x10^{-3}$	0 - $7.24x10^{-4}$	0 - $7.86x10^{-4}$	0 - $4.03x10^{-4}$	0 - $1.09x10^{-3}$	0 - $1.26x10^{-4}$	

*** High Risk; ** Medium Risk; * Low Risk

Table 2.0 Concentration of PAH in surface waters at Ahoada East. (Results expressed in (ng/l)

was oven dried, at 120°C for 12 hours. This silica gel was placed in 50ml dichloromethane and poured into the 10mm internal diameter glass column. The column was gently stirred to settle the silica gel and eluted with dichloromethane before adding a 2cm layer of anhydrous sodium sulphate to the top of the silica gel bed. The column was pre-eluted with 40ml of pentane and eluate discarded. Additional 5ml of cyclohexane was used to complete the transfer and the eluate collected in a 500ml KD flask equipped with a 10ml concentrator.

(iii) Concentration

The pre-concentration stage involved placing the combined extract in the 500ml K-D flask equipped with a

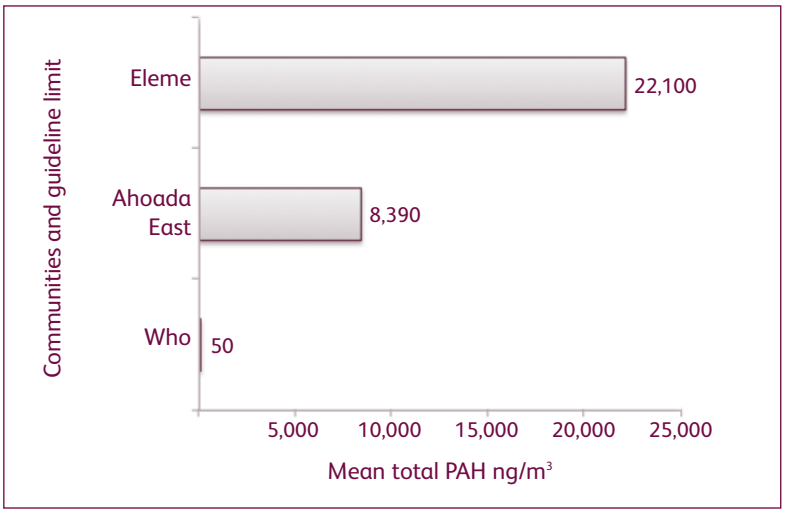

Figure 1.0
Mean total PAH concentration in surface waters at Eleme and Ahoada East in comparison with WHO limits

10ml concentrator tube on a steaming hot water bath of a rotor evaporator and allowing the concentration to be completed in 30min. The concentrated extract of volume less than 20ml was then solvent exchanged with 5ml cyclohexane inside the K-D apparatus and an extract volume of 5ml was obtained.

(iv) HPLC analysis
The final extract (5ml) was then analysed using HPLC. The HPLC used is made up of an auto sampler (Waters 717), pump (Waters 610) for both the fluid unit and valve station and Waters 6.00E for the pump system controller; photodiode detector (Waters IM 996); fluorescence detector (Waters 470). The software Millennium 32 was used and the method of operation was of the isocratic/gradient type with a combination of acetonitrile and deionised filtered water as the mobile phase and a stationary phase made up of silica gel loaded in 5µm HPLC column, SUPELCOSIL™ LC-PAH col: 12435-007of dimensions 15cm x 4.6mm.

Analysis of unknown samples followed a method set created using a collection of standards for the 16 WHO prioritised PAH components. The test samples were run against these calibrated standards, integrated and the concentration of the PAH components based on the size of the peaks quantitated. Results are expressed in ng/l.

PAH risk analysis for surface waters in selected study locations

A risk map with the model below was developed based on a comparison of the observed PAH concentrations in the study communities and the WHO guideline limits of 50ng/l in surface and coastal surface waters (WHO 1998):

- Surface water with total PAH concentration >50 ng/l: High risk (+++ or red triangle)
- Surface water with total PAH concentration 1-50 ng/l: Medium risk (++ or purple square)
- Surface water with total PAH concentration <1.0 ng/l: Low risk (+ or blue circle)

Results

Concentration of PAHs in surface waters

Table 1 shows that at Eleme the highest number(seven) of PAH components, namely phenanthrene, fluoranthene, pyrene, benzo(a)anthracene, chrysene, benzo(k)fluoranthene, and indeno (I,2,3-cd pyrene), with concentrations ranging between 0-2.5 x 10^{-3}ng/l were recorded. Similarly, the highest individual PAH concentrations of 2.54 x 10^{4} and 5.87 x 10^{4}ng/l. Benzo(a)pyrene (an indicator for PAH toxicity) was only observed at concentration levels of 2.01 x 10^{4}ng/l and 1.98 x 10^{4}ng/l in surface waters in the area.

Table 2 indicates that two PAH components, namely benzo(k)fluoranthene, and indeno(1,2,3-cd)pyrene, were recorded in surface water samples at Ahoada with values ranging between 0-2.22 x 10^{4}ng/l. The most likely causation would be a result of runoff containing

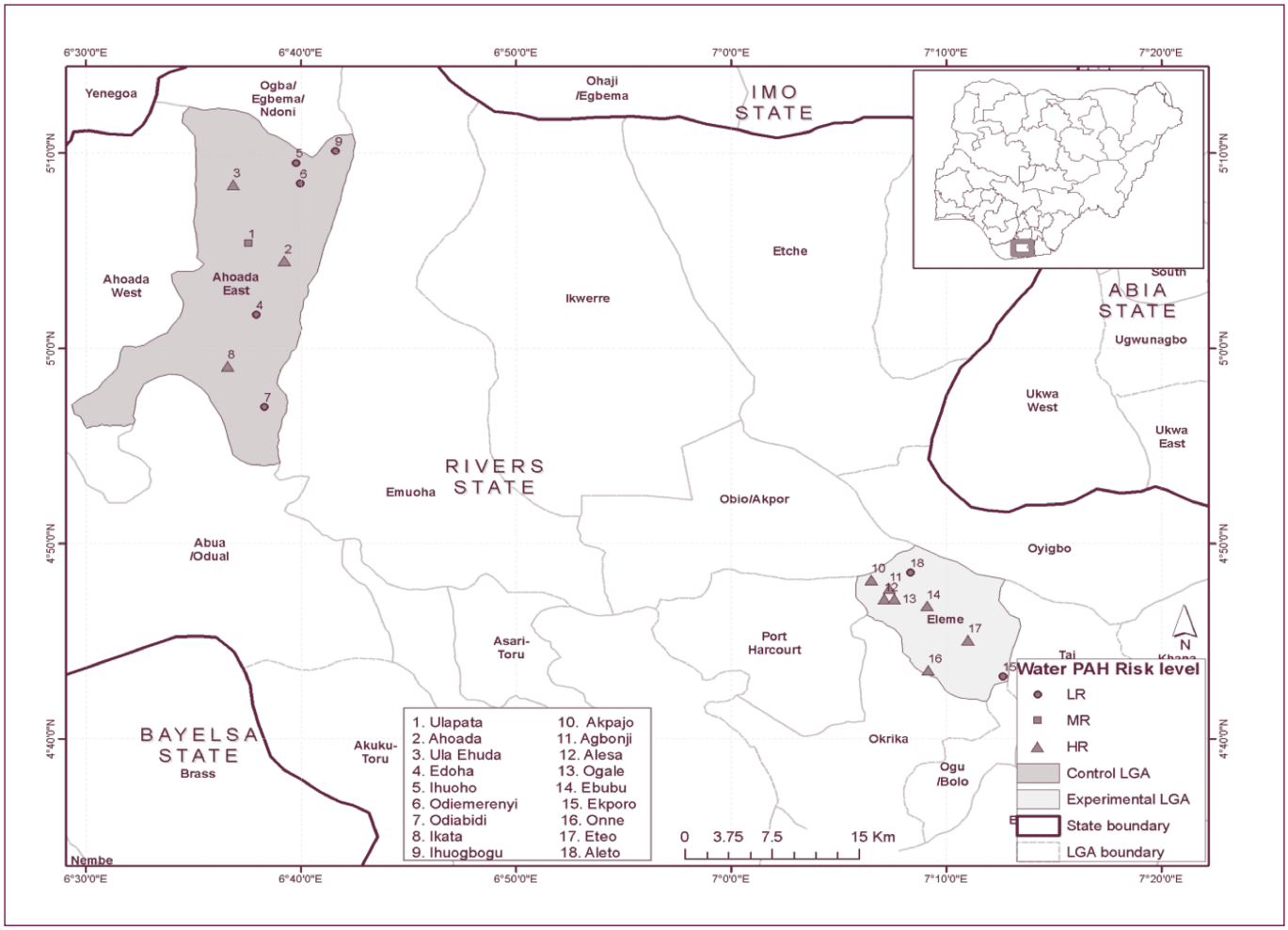

Figure 2.0
Risk map of PAHs in surface waters at Eleme and Ahoada East

petroleum by-products from filling stations within the vicinity. The highest concentrations of benzo(a)pyrene recorded in the area was $2.07x10^{1}$ng/l and $2.13x10^{4}$ ng/l. Fig 2 shows the pattern of the PAH components.

Overall, numerically, the burden of PAH was three times higher in surface waters at Eleme compared to those found in Ahoada-East (See Fig 1).

Risk map based on surface water PAH concentrations

The risk map derivable from Tables 1 and 2 shows that at Eleme, seven surface water samples were categorised as high risk while two surface water samples were categorised as low risk. There were no surface water samples in the medium risk category (see Fig 2).

At Ahoada East only three surface water samples at Ahoada, were categorised as high risk, one surface water sample was of medium risk while the five surface water samples were classified as low risk(see Fig 2).

Discussion

Surface water pollution is unequivocally one of the major environmental problems confronting urban communities in Nigeria (Ana *et al.*, 2005). In the Niger Delta Area this

situation is further accentuated by inputs from industries within the region. The present study looked at the risks in terms of the levels of PAHs in surface waters present in a highly industrialised community (Eleme) compared to a less industrialised community (Ahoada East).

The preliminary physico-chemical characteristics of surface water indicated that at Eleme, both the pH value and phenol determined were within NGL for surface waters. A similar trend was observed at Ahoada East.

For PAH levels, the highest number of components (7) and the highest total PAH level of 8.89 x 10^4ng/l were recorded at one of the tributaries close to the seaport at Eleme. This latter result is substantially higher than the guideline value of 50ng/l (WHO, 1998). It is suggested that the levels are a result of the presence of shipyards where coal tars are used to periodically treat ships and boats for inland navigation. The resultant leaching/abrasion of this coating become a source of PAHs (Berbee, 1992). It is also suggested that refinery waste water may also have contributed to the higher PAH levels of 3.5 x10^4ng/l into the receiving creek. This determination is based upon the presence of the effluent containing trace organics. Incidentally, benzo(a)pyrene, the principal PAH toxic indicator, was recorded only in two of the surface waters in the area.

The concentrations of other PAH components such as benzo(b)fluoranthene, benzo(k)fluoranthene and benzo(a)pyrene recorded in some nearby streams and creeks at Eleme were higher than the range of 1-50ng/l recorded for rivers in Germany (Krober and Hackl, 1989). Also the levels <100ng/l for fluoranthene, pyrene, chrysene, benzo(a)pyrene documented by Krober and Hackl (1989) were still lower than the levels for some surface waters at Eleme. Their occurrence must have been caused by inputs from domestic origin and from industrial discharges that are minimally or seldom treated.

At Eleme, which is the most industrialised community in the NDA and where the receiving water body receives effluents from Port Harcourt Refining Company, the prevalent PAH components were benzo(k)fluoranthene and dibenzo(a,h)anthracene with concentrations greater than a thousand fold compared to the guideline limit. Berglind (1982) found similar results in Oslo, Norway when he reported that Bislet Creek, which is contiguous to an industrial location, contained fluoranthene, pyrene, phenanthrene, methyl phenanthrene, naphthalene, acenaphthene, acenaphthalene and fluorene at concentrations >1000ng/litre.

At Ahoada East, which was taken as the comparison area, the only PAH components recorded were benzo(k) fluoranthene, benzo(a)pyrene and indeno(1,2,3-cd) pyrene. The highest total PAH concentration recorded was 8.39 x 10^3 ± 1.46 x 10^4ng/l and was less than 2.21 x 10^4 ± 2.76 x 10^4ng/l found in Eleme surface waters. The water body at Ahoada that recorded the highest total PAH level of 4.15x10^4ng/l could have possibly been inundated with higher PAH inputs from domestic urban runoff, judging from its status as the administrative capital of the LGA.

The levels of PAH recorded in these surface waters, though not as high as that recorded in the industrial area like Eleme, were in some cases higher than those reported by Grimmer *et al.* (1981) in their studies on PAH levels in the rivers Thames and Trent. With seven surface water samples as compared with two from Ahoada East recording the highest number of PAH components, and a total PAH burden that is three times higher in the former and the fact that seven surface water sources at Eleme as compared with three from Ahoada East were classified as high risk, it is obvious that surface waters in Eleme are more contaminated with PAHs, which may be predominantly from industrial origin.

The high levels of PAHs recorded in surface waters in Eleme portend increased health risks for populations in those affected communities as compared to Ahoada East. According to WHO (1998), exposure to water containing PAHs, especially naphthalene via the oral route, could predispose the populations to symptoms such as nausea, vomiting, and convulsions after one to several days, and often followed by diarrhoea. Other symptoms include disturbances of consciousness, lethargy, ataxia, and in severe cases hemiplegia and coma. Also, exposure to PAHs via the dermal route for sensitive individuals could result in symptoms ranging from irritation to severe dermatitis (WHO, 1998).

Conclusions

The levels of PAH in surface waters at Eleme were three times higher than that recorded at Ahoada East indicating that there were possible contaminations from the industrial sources. Levels were higher than WHO guideline limits of 50ng/l.

The highest number (seven) of PAH components and the highest total PAH levels (8.89 x 10^4ng/l) were recorded in surface waters at Eleme.

Since more of surface waters at Eleme (seven) as compared to Ahoada East (three) fell under the high risk category as depicted in the risk map it is obvious that highly industrialised communities are at greater risk of surface water pollution than the less industrialised ones.

The outcome of this pilot study suggests that industries within the Niger Delta area, especially those at Eleme, must ensure that their wastes containing PAH compounds are carefully managed to minimise the pollution of environmental media particularly surface water sources in the region.

Policy measures must be put in place to ensure that anthropogenic activities that lead to the release of PAHs are checked and there should be a regular monitoring regime to assess PAH levels in aquatic ecosystems in the communities.

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Exposure of children to second-hand smoke in cars

Araceli Sánchez-Jiménez[1], Karen S Galea[1], Martie Van Tongeren[1], Nina Gotz [2], Hilary Wareing[2]

[1] Institute of Occupational Medicine, Edinburgh EH14 4AP, UK
[2] Tobacco Control Collaborating Centre, Warwick CV34 4RA, UK

Correspondence: Araceli Sánchez-Jiménez ,Telephone 0131 449 8031. Email: Araceli.Sanchez@iom-world.org

Abstract

Objective: To investigate exposure of children to second hand smoke (SHS) in cars under real life smoking and realistic driving conditions.

Methods: $PM_{2.5}$ concentrations (particulate matter with an aerodynamic diameter below 2.5µm) were monitored as a marker for SHS in 21 car journeys using the TSI portable photometer SidePak™. Five participants (including one non-smoker) volunteered to drive their own cars and were asked to make no changes to their normal smoking behaviour. A child-sized doll was positioned in a child car seat on the back seat of each car. Monitoring took place under different traffic conditions and different ventilation conditions.

Results: Geometric mean (GM) $PM_{2.5}$ concentrations during smoking journeys (65µgm^{-3}) exceeded the proposed WHO 24-hour guideline concentration for outdoor air pollution (25µgm^{-3}) and were 10 times higher than those found during non-smoking journeys (6.8µgm^{-3}). GM $PM_{2.5}$ concentrations on journeys with low ventilation were 139µgm^{-3}, whereas for journeys with high ventilation the GM $PM_{2.5}$ concentration was 32.5µgm^{-3}.

Conclusions: Smoking in cars produces concentrations of $PM_{2.5}$ that could be classified as unhealthy, even when windows are open or ventilation is on. Based on these findings, measures to prevent smoking in cars, particularly when children are present, should be explored.

Key words: Second-hand smoke, $PM_{2.5}$, passive smoking, car

Introduction

Second-hand smoke (SHS) from cigarettes is associated with respiratory symptoms, reduced lung function, asthma, lung cancer and coronary heart disease in non-smokers, often resulting in premature death (USEPA, 1992; NIH, 1999). In children, exposure to SHS increases the risk of sudden infant death syndrome (SIDS), acute respiratory infections, ear infections and asthma (DoH, 2007). Kabir *et al.,* (2009) reported a significant increase in wheeze and instances of high fever in Irish children aged 13-14 exposed to SHS in cars. In the UK smoking in private homes and vehicles is not regulated and individuals can choose whether or not to allow smoking within the privacy of their own car or home. $PM_{2.5}$ (particulate matter with an aerodynamic diameter below 2.5µm) is of particular concern because particles of this size can travel deep into the lungs and therefore pose a health hazard (Donaldson and Borm, 2007). There is no threshold value below which $PM_{2.5}$ does not pose a health risk (WHO, 2005). The WHO has proposed a 24-hour guideline concentration for $PM_{2.5}$ in outdoor air of 25µg.m^{-3} to protect population from health effects from outdoor air pollution (WHO, 2005).

Exposure to SHS levels in private cars under real driving conditions is not well documented. We identified only one study, Rees and Connolly (2006), that reported $PM_{2.5}$ concentrations in smoking cars under real driving conditions. The authors measured $PM_{2.5}$ concentrations in 43 car journeys in the US, and found a mean $PM_{2.5}$ concentration of 272µgm^{-3} when windows were closed and 51µg.m^{-3} when windows were open. Other studies have been carried out in simulated environments: Sendzik *et al.,* (2009) observed in a controlled study where a single cigarette was smoked in each car journey, a mean $PM_{2.5}$ of 844µgm^{-3} during journeys when air conditioning was on and 223µgm^{-3} when the smoker was holding the cigarette close to an open window. Another study in a controlled environment in New Zealand reported $PM_{2.5}$ concentrations of 143µgm^{-3} when two cigarettes were smoked with the windows half down during a period of approximately 15 minutes (Edwards and Wilson, 2006). Jones *et al.,* (2009) found median air nicotine concentrations in smokers' vehicles of 9.6µgm^{-3} compared to non-detectable concentrations in non-smokers' vehicles. The large range of concentrations found in the different studies may be a consequence of the different experimental conditions (including ventilation rate and number and type of cigarettes smoked) and possibly differences in the smoking regimes, experimental investigations where a controlled number of cigarettes are smoked may not represent the real smoking behaviour.

Methods

Participants who gave their consent were asked to behave as they normally do in relation to driving and smoking. $PM_{2.5}$ was measured using a TSI photometer SidePak™ AM510 Personal Monitor. A child-sized doll was placed on the left side of the rear seat of the volunteers' private vehicles (passenger's seat), as it would have been unethical to expose a child. All cars were right-handed. The inlet of the monitoring device was placed at the nose height of the doll. Participants completed a questionnaire on traffic characteristics (low, medium and high traffic density), number of cigarettes smoked during each journey, journey duration and ventilation condition and windows position.

Table 1.0
Descriptive statistics of the arithmetic mean (AM), geometric mean (GM) and range of $PM_{2.5}$ concentrations found during journeys in cars of smokers and cars of non-smokers.

	Journeys	n	AM (μgm^{-3})	GM (μgm^{-3})	Range (μgm^{-3})
Mean	Smoking	15	88	65	13 – 242
	Non-smoking	6	7.0	6.8	4.4 – 9.2
Peak levels	Smoking	15	438	232	54.3 – 1,550
	Non-smoking	6	12	12	8.6 – 15

The SidePak™ uses a laser photometer to detect particles in real time. The device was fitted with a selective inlet to collect particles with a median aerodynamic diameter corresponding to the definition of $PM_{2.5}$ aerosol. Airflow rates were set up to $1.7lmin^{-1}$. Measurements were recorded every 1 minute and the average concentration was calculated for the duration of the journey. A calibration factor of 0.295 was applied to the results generated by the SidePak™ to correct for the properties of SHS particles (Kabir *et al.*, 2009; Jones *et al.*, 2009).

$PM_{2.5}$ measurements generally follow a log-normal distribution and therefore the GM was used to describe the results. Differences in the log-transformed concentrations between smoking and non-smoking journeys were tested by t-tests (assuming unequal variances). The increase in $PM_{2.5}$ concentrations with increasing smoking rate (cigarettes per hour) was evaluated by least squared linear regression of the log-transformed data vs. cigarettes smoked per hour using Excel 2003. Differences in the concentrations for different variables (ventilation conditions) were evaluated using t-test and one-way repeated measures analysis of variance (ANOVA).

Results

In total, $PM_{2.5}$ measurements were carried out during 21 journeys. The number of cigarettes smoked per journey ranged from 0 to 3; during 15 of the 21 journeys smoking occurred in the car. The duration of the journeys ranged from 10 to 80 minutes with an average of 46 minutes. During six smoking journeys, the ventilation was high (windows were open and the ventilation system on during at least part of the journey) although it is not known the degree to which these were open (fully or partially). During four smoking journeys the ventilation was medium (windows closed and ventilation on during most of the journey) and in four smoking journeys the ventilation was poor (windows closed and the ventilation system off during most of the journey). There was no information on the window positioning and ventilation system for one of the smoking journeys, and therefore this data was excluded from the dataset in the analysis of the effect of the ventilation on the $PM_{2.5}$ concentrations.

Table 1 shows the arithmetic mean (AM), GM and range of the $PM_{2.5}$ concentrations found in the smoking and non-smoking journeys.

Observed $PM_{2.5}$ levels were an order of magnitude higher during smoking journeys ($GM=65\mu gm^{-3}$) than during non-smoking surveys ($GM=6.8\mu gm^{-3}$); this difference was statistically significant ($p<0.001$).

Figure 1 shows the $PM_{2.5}$ concentrations found in each smoking journey according to the different window positioning and ventilation settings: low ventilation refers to windows shut during most or the entire journey and ventilation system off during most or entire journey: medium ventilation refers to windows closed during most of the journey and ventilation system on during most of journey; and high ventilation refers to windows open during most or the entire journey and any ventilation condition.

$PM_{2.5}$ concentrations in smoking journeys appeared to be higher when the ventilation was poor ($GM=139\ \mu gm^{-3}$, $n=6$), compared to journeys where the ventilation was medium ($GM=57.2\mu gm^{-3}$, $n=4$) or high ($GM=32.5\mu gm^{-3}$, $n=4$); despite the smoking rate, were similar for journeys with high and medium ventilation (2.0 and 1.75 cigarettes/hour respectively). These differences were statistically significant at the 0.01 level (ANOVA test).

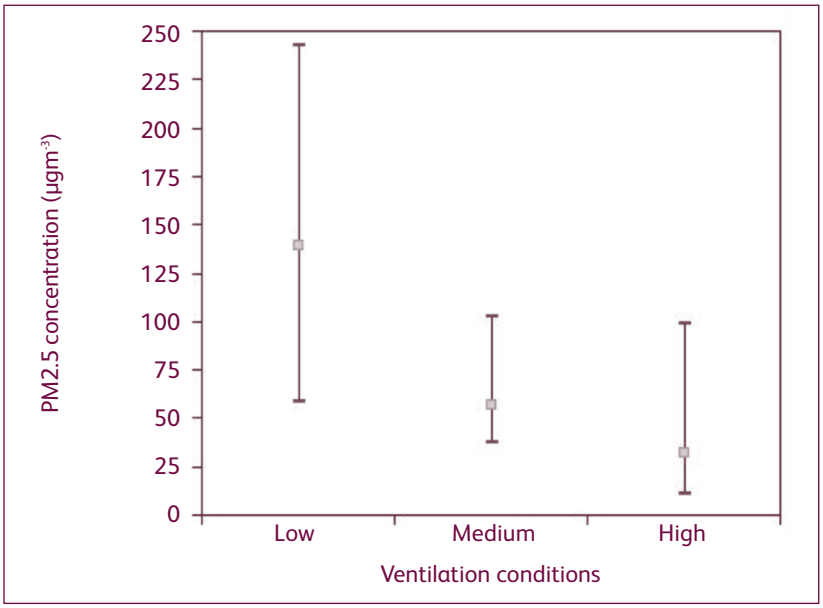

Figure 1.0
$PM_{2.5}$ concentration in smoking journeys according to ventilation conditions.

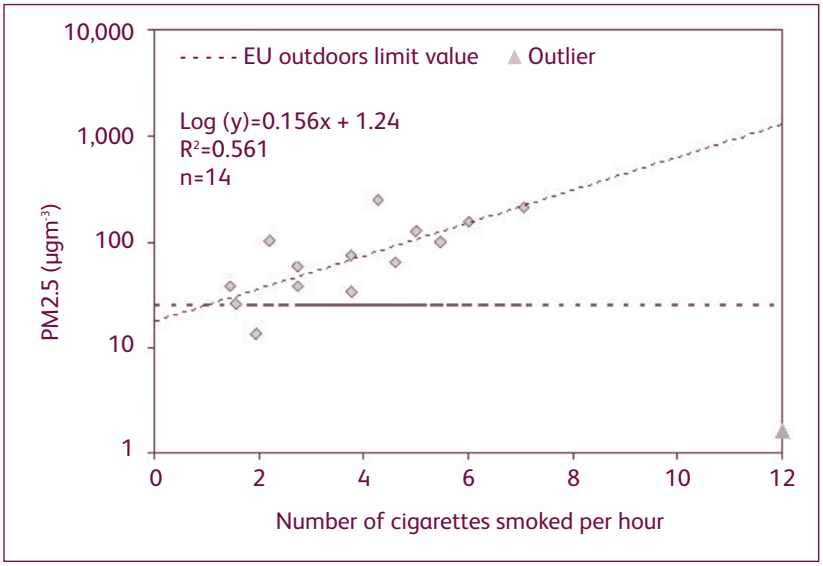

Figure 2.0

Scatter plot of $PM_{2.5}$ concentration against number of cigarettes smoked per hour.

There was no statistically significant difference in $PM_{2.5}$ concentrations between light, medium and high traffic conditions ($p>0.05$) for non-smoking and smoking journeys.

Figure 2 shows a scatter plot and relationship between the logarithm transformed $PM_{2.5}$ concentrations and the rate of cigarettes smoked during the survey (number of cigarettes smoked per hour).

There was a clear trend for higher $PM_{2.5}$ concentrations with increasing smoking rate. After removing an outlier, which deviated from the linear trend, 56% of the variance in the log-transformed $PM_{2.5}$ concentrations

was explained by the rate of cigarettes smoked in the car (Figure 2). Smoking one cigarette per hour resulted in $PM_{2.5}$ concentrations of 25µgm^{-3}.

Opening windows and switching on the ventilation system resulted in lower concentrations (GM=32.5µgm^{-3}, n=4) than having the windows closed or ventilation system off (GM=139µgm^{-3}, n=6).

Discussion

Main findings of the study

This study examined the levels of $PM_{2.5}$ as a marker for SHS during car journeys. The $PM_{2.5}$ concentrations found during smoking journeys greatly exceeded the WHO recommended daily exposure limit of 25µgm^{-3} for outdoors air (WHO, 2005). Although $PM_{2.5}$ levels were reduced when windows were opened or ventilation switched on, these levels still generally exceeded the proposed EU limit value. $PM_{2.5}$ levels increased with increasing smoking rate. Although we compared the $PM_{2.5}$ concentrations with outdoor standards (since there is no current standard for indoor environments) it should be considered that these may underestimate the actual hazard of $PM_{2.5}$ from SHS. As SHS contains high concentrations of carcinogenic compounds, is likely to be more hazardous than outdoor particles (Klepeis *et al.,* 2007). On the other hand, the duration of exposure to SHS in cars will be much less than 24 hours per day.

Limitations of this study

There are some limitations that should be considered when interpreting the results reported in the current study. Results were available only from a limited number of journeys and more data are required to confirm these results and investigate the impact of different smoking behaviours and window and ventilation settings on the SHS levels in the car. In addition, it is considered that the main scenario for children exposure to SHS is at home (Rees and Connolly, 2006). Therefore, the SHS exposure experienced in cars is likely to represent only a fraction of their total personal exposure.

Possible policy implications

$PM_{2.5}$ concentrations in journeys where smoking occurred exceeded the WHO guideline value for 24-hour for outdoor air pollution (25µgm^{-3}), even in journeys with windows open or ventilation system switched on (32.5 µgm^{-3}). Taking into account that there is no threshold value below which $PM_{2.5}$ does not pose a health risk and that $PM_{2.5}$ from SHS is likely to be more hazardous than outdoor exposures, measures to prevent smoking in cars, particularly when children are present, should be explored. The public should be informed about the potential risk that smoking in cars has for children.

Conclusion

Real life smoking in cars under real driving conditions produce concentrations of $PM_{2.5}$, that could be classified as unhealthy, even when windows are open or ventilation is on.

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Assessment of polycyclic aromatic hydrocarbons, carbon monoxide, nicotine, metal contents and particle size distribution of mainstream Shisha smoke

Andrew Apsley[1], Karen S Galea[2], Araceli Sánchez-Jiménez[2], Sean Semple[1], Hilary Wareing[3], Martie van Tongeren[2]

[1] Scottish Centre for Indoor Air, University of Aberdeen, Aberdeen, UK
[2] Scottish Centre for Indoor Air, Institute of Occupational Medicine, Edinburgh, UK
[3] Tobacco Control Collaborating Centre, Warwick, UK

Correspondence: Dr. Karen Galea, Institute of Occupational Medicine, Research Avenue North, Riccarton, Edinburgh, EH14 4AP. Telephone: 0131 449 8034. Email: karen.galea@iom-world.org.

Abstract

There is a widespread but unsubstantiated belief that the practice of smoking shisha products is relatively safe, which has led to resurgence in its use. This study aimed to characterise the mainstream smoke composition of three popular smoking products for shisha:, two that contain tobacco and one herbal, a tobacco-free product. A smoking machine was used to generate mainstream smoke from shisha in a series of controlled experiments using the three shisha smoking products. Each smoking session lasted 30 minutes and used 10g shisha product. The mainstream smoke was sampled and analysed for selected metals, nicotine, carbon monoxide (CO) and selected polycyclic aromatic hydrocarbons (PAHs). The particle size distribution of the shisha smoke was also determined. Levels for most metals in the mainstream smoke were found to be lower, or close to, the limit of detection (LOD) for all three smoking products. The main exceptions were copper (total yield of 1.3 and 2.3µg for the two tobacco-containing mixtures and 1.7µg for the herbal tobacco-free product) and zinc (yield ranged from 1.1µg for a tobacco-containing mixture to 2.1µg for the herbal product). Nicotine yields for the two tobacco-containing mixtures averaged 316 and 339µg per smoking session. PAHs were detected for all three shisha products, although yields for PAHs were generally less than the LOD of <0.02µg; the highest levels were observed for acenaphthene with the herbal tobacco-free product (total yield 17.3µg). CO levels in the mainstream smoke ranged from 800 to 1000ppm, suggesting a typical CO yield of 30mg per smoking session. The mass median aerodynamic diameter of the mainstream smoke ranged from 100-150nm. Results from this study appear to be different compared to other published studies, which could be owing to a number of factors such as shisha product type, smoking behaviour and measurement methods.

Key words: Shisha, hookah, mainstream smoke, polycyclic aromatic hydrocarbons, metals, nicotine.

Introduction

Research into health effects of mainstream smoke and environmental tobacco smoke (ETS) have generally focussed on cigarettes. However, shisha, hookah or narghile waterpipes have been used to smoke tobacco products for centuries and relatively little is known about the content of mainstream and sidestream smoke from these products and the associated health risks.

The shisha has its roots in the sub-continent of India in the 1400s, with its use then spreading to the Middle East. In recent years, the use of shisha is becoming increasingly prevalent in Western countries and use is reportedly often social, engaged in by peer groups or families (Knishkowy and Amitai, 2005). Shisha use appears to be evenly distributed between both sexes (Knishkowy and Amitai, 2005; WHO, 2005) and it has also been reported that there is a "widespread but unsubstantiated belief that the practice is relatively safe" (WHO, 2005). The latter could perhaps partly explain the recent resurgence in its use as it may be seen as a relatively healthy alternative to cigarette smoking.

The composition of shisha tobaccos is variable and not well standardised (Knishkowy and Amitai, 2005). The smoking mixture can be typically made up of a variety of ingredients including tobacco, honey, molasses or treacle, spices and dried fruits (Knishkowy and Amitai, 2005; Chaouachi, 2007) as well as glycerine as a moisture preserver (Chaouachi, 2007).

The shisha pipe consists of a clay head, metal body, glass bottle with water, and a flexible connecting hose with a mouthpiece. The tobacco (usually 10-20 grams per session) is placed in the head, which consists of a bowl over the metal body. The tobacco is covered usually by perforated aluminium foil. On the top of the foil a briquette of charcoal is placed. The tobacco is heated by the charcoal. When a smoker inhales through the hose, a vacuum in the headspace of the water is created causing the tobacco smoke from the heating tobacco to bubble through the water in the bowl (Shihadeh, 2003).

The composition of the mainstream smoke depends on a wide range of factors, including the type of tobacco-molasses mixture, temperature of coal in the shisha head, type of charcoal used, the perforation pattern of the aluminium foil and the smoking regimes (number of puffs per session and depth of inhalation) (Shihadeh, 2003; Hadidi and Mohammed, 2004; Shihadeh and Saleh, 2005; Chaouachi, 2006).

The aim of this study was to characterise the mainstream smoke composition from a shisha using three commercially available smoking products.

Methodology

Two sets of experiments were carried out to characterise the mainstream smoke. The first was a series of nine smoking sessions using three shisha products with

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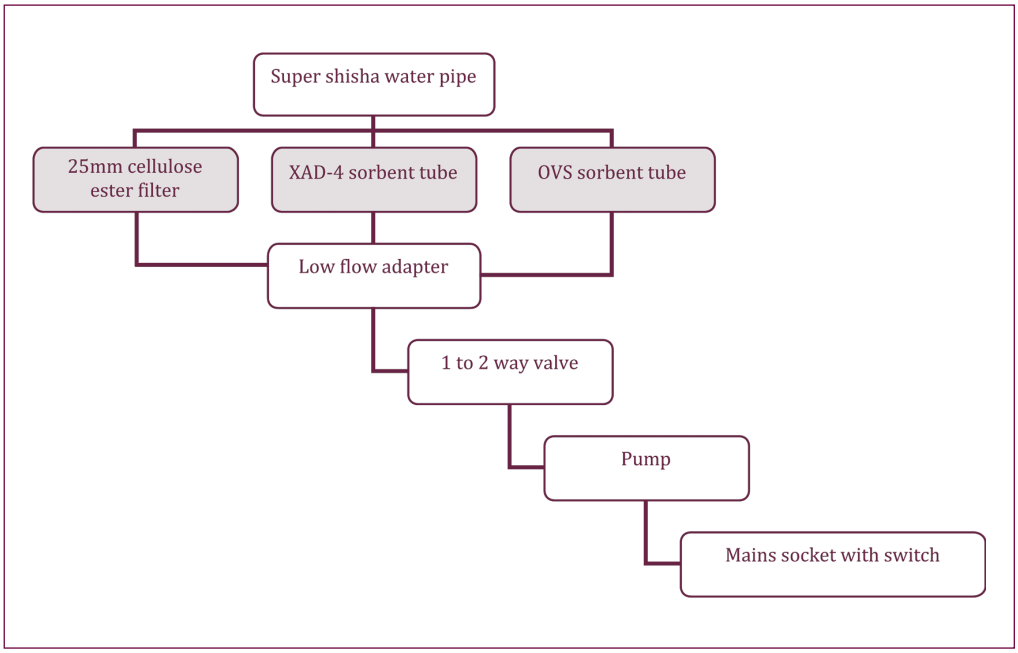

Figure 1.0 Sampling arrangement used in mainstream smoke characterisation experiments.

samples collected from the mainstream smoke, which were analysed for selected metals, nicotine and 16 priority PAHs. Three smoking sessions were completed for the banana flavoured tobacco, three for the herbal tobacco-free product (mango flavoured) and three for the strawberry flavoured tobacco, purchased from a UK high street shisha product supplier. The second set of experiments consisted of a series of three runs using the most commonly used strawberry flavoured tobacco product to provide data on CO concentrations and mainstream smoke particle size distribution (PSD).

In addition, the variability of metal content in the bulk tobacco was assessed for six shisha products including the three used in the mainstream smoke characterisation part of this study.

Experimental set-up for determining metal content, nicotine and PAHs

The sampling arrangement used for the first series of experiments is illustrated in Figure 1. A smoking machine was designed to mimic that used by Shihadeh (2003). A vacuum pump was attached, via a valve and sampling media, to the end of the inhalation pipe of the water pipe. The pump was set to operate at a rate of 6 l/min and with a low flow adapter manifold this allowed 2l/min to be pulled through each of the following (parallel) collection media:

- 25mm cellulose ester filters positioned in a 25mm in-series filter holder (for particle mass collection and subsequent extraction of metals);
- XAD-4 sorbent tube (SKC 226-93) (for analysis of vapour-phase nicotine); and
- OVS sorbent tube (SKC 226-30-16) (for analysis of PAHs).

The procedure developed by Shihadeh (2003) was utilised in this study. A sampling cycle consisted of a puff and a rest period. The 'puff' duration was three seconds, with rest period of 15 seconds in between puffs to simulate a typical smoking pattern. This was achieved by switching the valve on (allowing the air to pass through the filter media) and then switching the valve off (the pump would then pull through the ambient air bypassing the filter media). Each of the experiments was designed to last 30 minutes, resulting in a sampling duration of mainstream smoking of five minutes in total (100 puffs with duration of three seconds). Therefore, each of the parallel sampling medium sampled a total of 10 litres of mainstream smoke.

Ten grams of shisha product were used for each of the

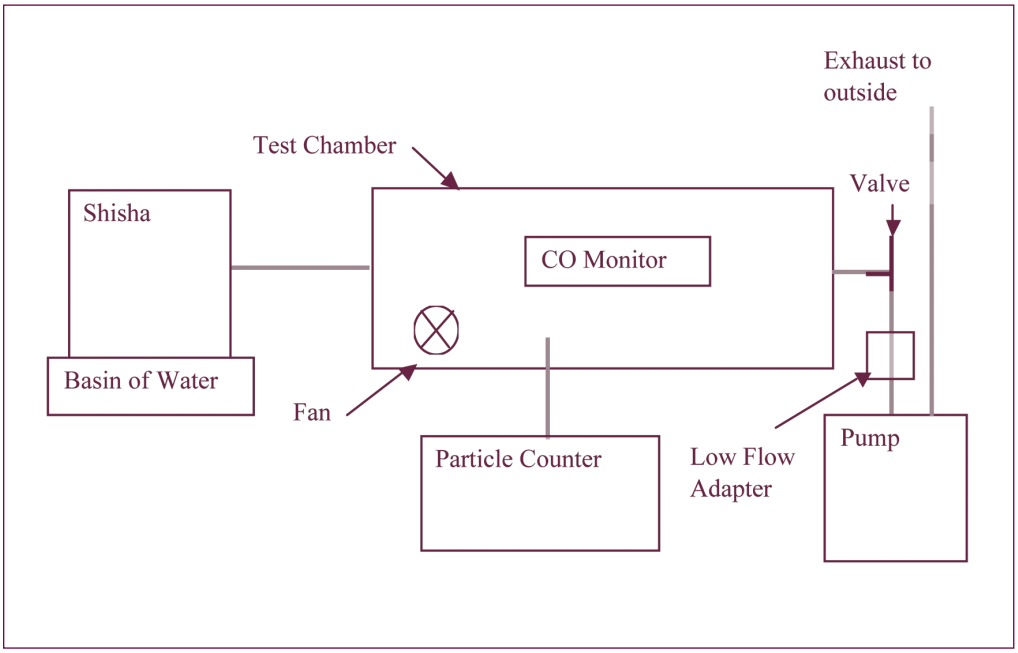

Figure 2.0 Sampling arrangement for CO and particle concentration measurements.

experiments. An aluminium foil sheet perforated with 19 holes was placed over the bowl containing the tobacco. The foil was pressed down so that there was a 2mm depression that the charcoal (brand name Swift-Lite) would sit in directly above the tobacco. The foil was then compressed around the neck of the bowl.

Upon completion of each smoking session the absorption sampling media (XAD-4 and OVS tubes) were capped. The cellulose filters were removed from the sampling head, transferred to a Sterlin tube. All samples were refrigerated at 4°C before analysis.

Chemical analysis of collected samples

The cellulose ester filters were analysed for 12 key metals (cobalt, arsenic, boron, cadmium, chromium, copper, mercury, nickel, lead, selenium, vanadium, zinc). Selection of the metals was based on the review of Shihadeh (2003). Metal extraction was performed using a modification of OSHA ID121 and metals were analysed by Inductively Coupled Plasma/Atomic Emission Spectrometry (ICP/AES) (OSHA, 1991). The limit of detection (LOD) by this method is 0.1µg.

The OVS tube samples were extracted in dichloromethane. Aliquots of the extracts were analysed for PAHs by gas chromatography/mass spectrometry (GC/MS). The GC was fitted with a 30 metre DB5-MS capillary column and programmed to heat from 60 to 310°C. The MS was set in selected ion monitoring (SIM) mode for the specific ions corresponding to a series of the 16 priority PAHs (ATSDR, 2005): napthalene, acenapthalene, acenaphthene, fluorene, phenanthrene, anthracene, fluoranthene, pyrene, benzo(a)anthracene, chrysene, benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(a)pyrene, dibenzo(ah)anthracene, indeno (1,2,3) pyrene and benzo(ghi)perylene (NIOSH, 1994). The LOD for PAHs by this method is 0.02 µg. The ion chromatograms generated were examined for these specific ions. Calibration standards were prepared from a 2000µg/ml stock solution, purchased from Supelco, of the 16 priority PAHs.

The XAD-4 tubes were analysed for nicotine using a method based on NIOSH 2551: Nicotine (NIOSH, 1998). The tube was extracted in ethyl acetate containing 0.01% triethylamine. Aliquots of the extracts were analysed by GC/MS, fitted with a 30 metre DB5-MS capillary column and programmed to heat from 60 to 200°C. The MS was set in SIM mode for the specific ions corresponding to nicotine. The ion chromatograms generated were examined for these specific ions. Calibration standards were prepared from known

weights of Analar grade chemicals in the desorption solution. The LOD of nicotine by this method is 0.1µg.

For all experiments the total yield for each analyte in the mainstream smoke concentration was obtained by multiplying the total mass of the analyte collected on the sampling media during the smoking session by three, to take account for the three parallel sampling trains. The arithmetic mean (AM) yield and mainstream smoke concentrations were produced for the three tobacco types.

Experimental set-up to determine CO and PSD of shisha smoke

To measure the concentration of CO in and the PSD of the mainstream smoke, a 16.3 litre cylindrical chamber (diameter 0.17m, length 0.72m) was placed between the breathing machine and the shisha (Figure 2). A small DC fan was placed inside the cylindrical chamber to ensure good mixing within it.

CO concentration was monitored by a HOBO H11 (MicroDAQ, New Hampshire) data logger, which was placed in the chamber and set to record CO levels every 10 seconds. This method of measuring the mainstream smoke CO concentrations only provides information regarding CO concentrations and not the pattern of CO levels exiting the shisha.

The mainstream smoke CO concentration exiting the shisha is diluted as it entered the cylindrical chamber. The CO concentration in air exiting the chamber is equal to that in the chamber (which is less than that entering the chamber) thereby increasing the CO concentration in the chamber over time. Eventually, the chamber concentration reaches a steady state at a concentration equal to that of the shisha mainstream smoke. The steady state concentration is presented in this paper.

The PSD was measured using a Wide-range Particle Spectrometer (1000 XP, MSP Corporation, Minneapolis) which was attached via Tygon tubing to the chamber and set to produce a scan of the PSD between 10 and 500nm in 16 distributions, 48 channels, with a 2 second sample time per channel and a wait time of 15 seconds (MSP Corporation, 2004).

The smoking sessions were performed as described before and a total of three smoking sessions were carried out using the strawberry flavoured tobacco.

Bulk Sample analysis of shisha tobacco products

To assess the variability of metal content in different products, bulk analyses were carried out on six shisha products including the three used in the mainstream smoke characterisation part of this study. All shisha smoking products were obtained from a high street shisha product supplier. The six products consisted of two products containing no tobacco (mixed fruit and mango products) and four fruit flavoured tobaccos (banana, strawberry, apple and grape). A bulk sample was collected for each of the shisha products, which was selected from a number of locations within the specific products storage packet/tub to ensure a representative sample.

The bulk samples of each product were analysed to determine their content for 12 metals (cobalt, arsenic, boron, cadmium, chromium, copper, mercury, nickel, lead, selenium, vanadium, zinc) using a modification of OSHA ID121 and analysed by ICP/AES (OSHA, 1991). The LOD for metals by this method is 0.1 mg/kg.

Table 1.0
Nicotine mainstream smoke arithmetic mean (AM) and range for the three tested shisha products.

Shisha product		Nicotine	
		AM	Range
Banana Flavoured	Yield (µg)	339	177.7 – 520
	Conc. (mgm^{-3})	11.3	5.9 – 17.4
Herbal Hukka, Mango Flavoured	Yield (µg)	<0.3	<0.3
	Conc. (mgm^{-3})	<0.01	<0.01
Strawberry Flavoured	Yield (µg)	316	182.0 – 567
	Conc. (mgm^{-3})	10.5	6.1 – 18.9

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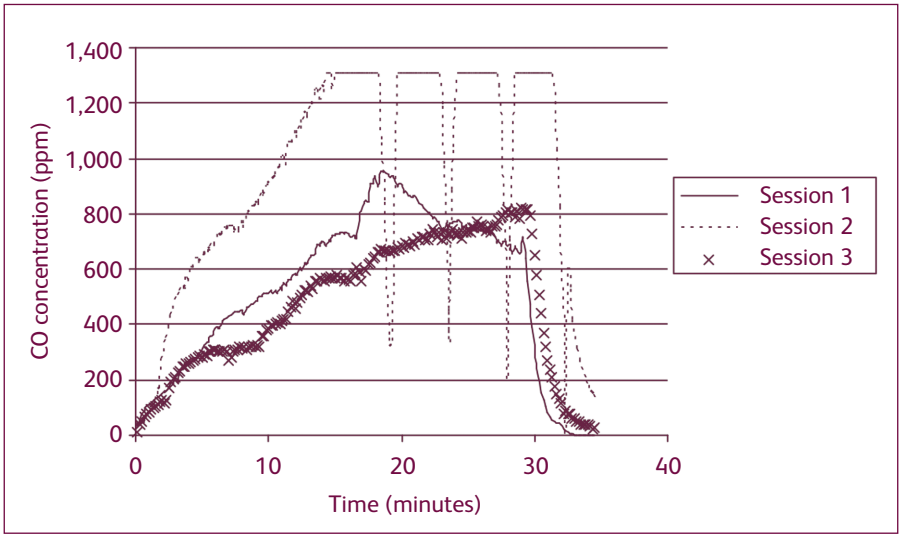

Figure 3.0
Carbon monoxide concentrations measured in the cylindrical chamber during a 30 minute smoking session.

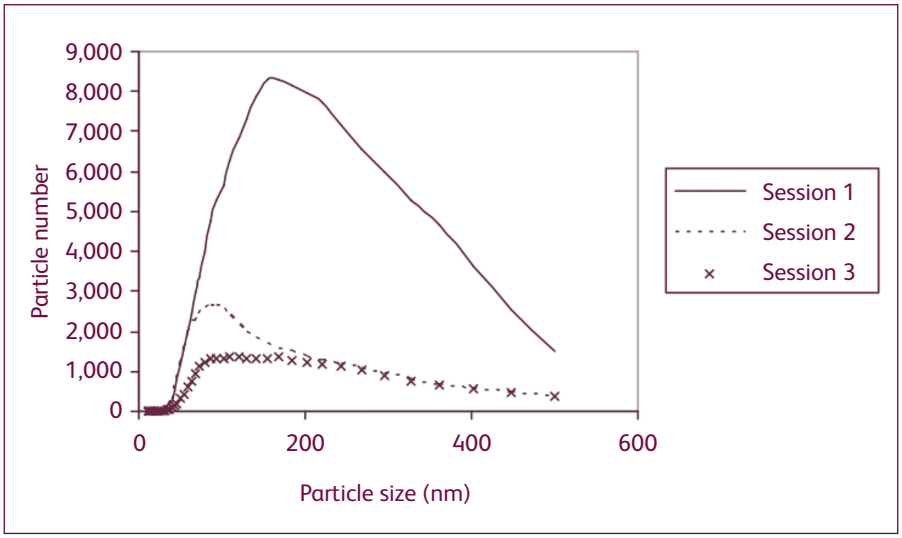

Figure 4.0
Median particle number across the 10-500nm range measured during the three 30 minute smoking sessions.

Results

The sample results were blank corrected. A number of the samples were found to be below the LOD and therefore half the LOD were assigned as the result for these samples.

Nicotine

Table 1 presents the mean nicotine yield and concentrations (and corresponding range) for the three shisha products. Nicotine yields for the two tobacco containing mixtures was very similar and averaged 316 and 339µg, respectively, per smoking session; for the herbal tobacco-free mixture the nicotine yield was less than the LOD. However, the nicotine yield varied between smoking sessions, ranging from approximately 180 to 570µg per smoking session. This equated to a mean mainstream smoke concentration of approximately 11 mgm^{3} (range 5.9 – 18.9) for both tobacco-containing products.

Table 2.0
PAH mainstream smoke content for the three tested shisha products.

Shisha product		PAH AM (Range) Naphthalene	Acenapthalene	Acenaphthene	Fluorene	Anthracene	Pyrene	Benzo(a)-anthracene
Banana Flavoured	Yield (µg)	3.86 (2.3-6.5)	<0.25 (<0.1-0.6)	1.47 (0.3-3.5)	<0.06 (<0.1-1.2)	0.86 (<0.1-2.3)	<0.03 (<0.1)	<0.03 (<0.1)
	Conc. (μgm^{-3})	128.67 (75-216)	<8.33 (<2-20)	49.00 (11-118)	<2.00 (<2-4)	28.67 (<2-77)	<1 (<2)	<1 (<2)
Herbal Hukka Mango Flavoured	Yield (µg)	<0.03 (<0.1)	0.70 (0.48-0.96)	17.26 (16.0-18.3)	<0.35 (<0.1-0.6)	6.28 (4.9-9.0)	12.95 (8.4-19.8)	15.19 (9.8-23.6)
	Conc. (μgm^{-3})	<1 (<2)	23.33 (16-32)	575.33 (534-610)	<11.67 (<2-19)	209.33 (162-301)	431.67 (280-661)	506.33 (327-785)
Strawberry Flavoured	Yield (µg)	0.8 (0.5-1.0)	<0.17 (<0.1-0.24)	<7.67 (<0.1-21.8)	<0.06 (<0.1-0.1	1.32 (1.0-1.7)	<0.03 (<0.1)	<0.03 (<0.1)
	Conc. (μgm^{-3})	26.67 (16-34)	<4.00 (<2-8)	<255.67 (<2-728)	<2.00 (<2-4)	44.00 (33-58)	<1 (<2)	<1 (<2)

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Shisha product		Metals AM (Range)						
		Boron	Chromium	Cobalt	Copper	Lead	Nickel	Zinc
Banana Flavoured	Yield (µg)	1.31 (<0.3-3.6)	<0.25 (<0.3-0.3)	<0.3 (<0.3)	2.30 (1.8-3.3)	<0.25 (<0.3-0.3)	0.40 (0.3-0.6)	1.40 (1.2-1.8)
	Conc. (μgm^{-3})	43.7 (10-120)	<8.33 (<10-10)	<5.00 (<10)	76.67 (60-110)	<8.33 (<10-10)	13.33 (10-20)	46.67 (40-60)
Herbal Hukka Mango Flavoured	Yield (µg)	0.55 (<0.3-1.2)	<0.25 (<0.3-0.3)	<0.3 (<0.3)	1.70 (0.6-2.4)	<0.15 (<0.3)	<0.20 (<0.3-0.3)	2.10 (0.9-4.5)
	Conc. (μgm^{-3})	18.33 (<10-40)	8.33 (<10-10)	<5.00 (<10)	56.67 (20-80)	<5.00 (<10)	<6.67 (<10-10)	70.00 (30-150)
Strawberry Flavoured	Yield (µg)	0.35 (<0.3-0.6)	0.30 (0.3)	<0.3 (<0.3-0.3)	1.30 (0.9-1.5)	<0.20 (<0.3-0.3)	<0.30 (<0.3-0.6)	1.10 (0.9-1.2)
	Conc. (μgm^{-3})	11.67 (<10-20)	10.00 (10)	<6.67 (<10-10)	43.33 (30-50)	<6.67 (<10-10)	<10.00 (<10-20)	36.67 (30-40)

Table 3.0
Metal mainstream smoke content for the three tested shisha products .

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Sample	Run	Metal Concentration (mg/kg) As	B	Cd	Co	Cr	Cu	Hg	Ni	Pb	Se	V	Zn
Banana Flavoured	1-4	<0.1	8.7	0.6	0.1	0.2	4.0	<0.1	<0.1	0.8	0.1	4.7	15.9
Herbal Hukka Mango Flavoured	5-7	1.4	2.5	<0.1	0.4	0.5	2.9	<0.1	0.1	0.7	0.6	<0.1	15.0
Strawberry Flavoured	8-10	<0.1	10.9	0.4	0.4	<0.1	9.3	<0.1	0.7	<0.1	0.1	0.7	14
Apple Flavoured	–	<0.1	5.6	0.2	0.1	0.1	3.6	<0.1	1.0	<0.1	0.4	0.5	20.4
Grape Flavoured	–	<0.1	8.0	0.5	<0.1	<0.1	3.3	<0.1	0.4	<0.1	0.2	1.5	11.2
Herbal Hukka Mixed Fruit Flavoured	–	<0.1	1.3	<0.1	1.4	0.2	4.2	<0.1	0.1	<0.1	0.1	<0.1	8.5

Table 4.0 Metal concentrations of each of the shisha products from bulk samples.

Note: As – arsenic; B – boron; Cd – cadmium; Cr – chromium; Co – cobalt; Cu – copper; Hg – mercury; Ni – nickel; Pb – lead; Se – selenium; V – vanadium; Zn – zinc

PAHs

The concentrations of chrysene, benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(a)pyrene, indeno(123-cd)pyrene, dibenzo(ah)anthracene, benzo(ghi)perylene, fluoranthene and phenanthrene were below the LOD for all tobacco products.

Presented in Table 2 are the mean (and range) yield and concentrations for the remaining PAHs. Acenphthalene, acenaphthene and anthracene were detected in the three shisha products analysed. Pyrene was only found in the smoke product by the herbal product Naphthalene was detected in all the smoking sessions except when the herbal tobacco-free product was used.

There was a great deal of variation between smoking sessions using the same product, for example, naphthalene in the tobacco-containing banana flavoured product varied between 75 and 216 μgm^{-3}.

Metals

The mass for the metals arsenic, cadmium, mercury, selenium, and vanadium were less than the LOD for all the samples collected. For the remaining seven metals, the yields and concentrations are provided in Table 3. Copper and zinc were detected in all samples. Boron and chromium, nickel and lead were detected in all tobacco products although concentrations were below the LOD for some of the runs. The maximum total yield for a metal in a single sample was 4.5µg for zinc.

The yield of copper per smoking session was 1.3 and 2.3µg for the two tobacco-containing mixtures and 1.7µg for the herbal tobacco-free product, whereas the average yield of zinc per smoking session ranged from 1.1µg for a tobacco-containing mixture to 2.1µg for the herbal product.

Carbon monoxide and particle size distribution

Three smoking sessions were carried out to determine the concentration levels of the CO in the mainstream smoke. Figure 3 shows the concentration levels over time. Smoking sessions 1 and 3 are quite similar but it is unclear if the concentrations have reached steady state conditions over the 30 minute periods. This makes it difficult to ascertain the actual CO concentrations but a very conservative estimate would be 900-1,000ppm.

During smoking session 2 the CO concentrations were above the range of the measuring instrument (Figure 3) and accounts for the flatness and sudden dips in concentration levels. The reason for the much higher concentration during this smoking session is unknown.

Over three, 30 minute smoking sessions, 45 PSD measurements were obtained. Typically a mass median

aerodynamic diameter (MMAD) for smoking sessions 1, 2 and 3 was found to be around 98, 128 and 150nm. Figure 4 shows the median particle number concentrations across the particle size range measured by the instrument for each of the three smoking sessions. Median particle number concentrations of approximately 34,000, 13,000 and 9,000 particles/cc for smoking sessions 1, 2 and 3 were found.

Bulk sample analysis for metals

Metal content varied between the bulk tobacco samples (Table 4). For example, although boron, copper, selenium and zinc were detected in each of the bulk samples, the concentrations ranged from 1.3 – 10.9mg/kg for boron; 2.9 – 9.3mg/kg for copper; 0.1-0.6 mg/kg for selenium and 8.5 – 20.4mg/kg for zinc. The mercury concentration was less than the LOD for all the bulk samples and arsenic was only detected in one product. Zinc was the metal found in highest concentrations.

Discussion

A series of laboratory experiments was carried out to simulate smoking sessions using a shisha and three different types of shisha products (including a herbal tobacco-free product). The study investigated the chemical composition of a variety of shisha smoking products for nicotine, metal and PAH content. Measurements of the PSD of the shisha mainstream smoke and the CO levels were also carried out under simulated smoking conditions in the laboratory.

Nicotine yields for the two tobacco-containing mixtures averaged around 320 – 340µg per smoking session (30 minutes, using a 10g tobacco, smoking pattern 3 second puffs with 15 second rest), with the herbal tobacco-free mixture producing nicotine yields less than the LOD. PAHs were detected in all three varieties although yields were generally low (<LOD), with the herbal tobacco-free product producing the highest yield of 17.3µg for acenaphthene. Other studies using a higher sampling volume than that used in this study found concentrations of benzo[a]pyrene, benzo[b þ k]fluoranthenes, dibenz[a,h]anthracene, benzo[g,h,i]perylene and ideno[1,2,3-cd]pyrene in the range of 155-322ng per session (Daher *et al.,* 2010).

Metal content was low for all three shisha products, with levels being less than or around the LOD for most, with the exception of copper and zinc. Copper and zinc were also consistently detected in the bulk samples of shisha smoking products. The yields of both copper and zinc were approximately 1-2µg per smoking session. Low levels (< 0.6mg/kg) of mercury, selenium and cadmium were observed in the bulk samples of the smoking products. Elevated arsenic and vanadium contents were observed in separate shisha smoking products, but these metals were not detected in the mainstream smoke.

CO concentrations of mainstream smoke were very high, with concentrations of 900-1000ppm in the mainstream smoke (in two of the smoking sessions) suggesting a typical CO yield of 30mg per smoking session, almost double that of the Kentucky Reference Cigarette type 1R3F (17.2mg/cigarette) (Chambers, 2009). In a recent published study, Daher *et al.,* (2010) report average CO yields of 2269 +/-108mg/waterpipe for 13 replicate smoking sessions where sidestream smoke was assessed. Clearly, the amount of tobacco used differs between shisha and cigarette smoking and a shisha smoking session is often shared between different users, thereby reducing the exposure for each user. Furthermore, it should be noted that the smoking behaviours of shisha smokers will be very different to that of cigarette smokers. While a cigarette smoker will smoke a number of cigarettes over a 24 hour period, shisha smoking is likely to be irregular, normally during social settings and is engaged by peer groups or families (Knishkowy and Amitai, 2005). Nevertheless, the high observed CO levels in mainstream shisha are of concern when considering potential health risks from shisha smoking.

A comparison with the levels of PAHs found in our present study with those reported in mainstream cigarette smoke (Gmeiner *et al.,* 1997) indicate that shisha levels for some PAHs can be up to three orders of magnitude greater. Mainstream smoke levels of metals such as chromium found in this current study were greater than that reported in mainstream cigarette smoke (Hoffman *et al.,* 2001) although for metals such as nickel the opposite was true. It should, however, be noted that cigarettes will tend to be used throughout a 24 hour period and that it is likely that shisha use may be more infrequent.

There are some differences in the results from the laboratory study and those reported in the peer reviewed literature. For example, where we found the MMAD to peak around the 150nm size range (range 100-150nm), others have quoted particle sizes of 40 (Monn *et al.,* 2007; Daher *et al.,* 2010) and 270nm Becquemin *et al.,* 2008). Spetdjian *et al.,* (2008) reported 0.49µg/session for acenaphthene whereas we recorded a highest yield of

17.3µg for a herbal tobacco-free product. While the laboratory study reported nicotine yields of approximately 0.3mg per smoking session, others have reported higher values of 3.0 to 25mg per session (Mutairi *et al.,* 2006). The laboratory study also found heavy metal concentrations to be lower in comparison with the literature, for example Shihadeh (2003) reported 6.87µg of lead per smoking session, whereas we reported 0.2-0.3µg.

Several factors may lead to variability in the experimental findings and comparisons with other studies including tobacco type, burn conditions, smoking behaviour and differences in measurement methods. The type of shisha product used can vary greatly between batches and countries introducing considerable uncertainties. The source of the product and its subsequent treatment will affect levels of trace metals (from soil or pesticides), pesticides, nicotine and other substances present. In addition, there are numerous different additives to shisha including honey, dried fruits and spices which affect the composition of shisha smoke. The amount of shisha, the type of charcoal and the temperature at which it is burned as well as the shisha pipe characteristics could all affect the smoke composition.

Different studies have used varying definitions of what constitutes a 'typical smoking session'. In this study we used a smoking pattern similar to that reported by Shihadeh (2003). However, this may be judged as being low in comparison to other studies, for example, Shihadeh *et al.,* (2004). Different smoking patterns have been observed in the Middle East and Europe, suggesting smoking patterns observed in one place can not be generalised to cover all situations. The large variety in smoking patterns further hampers the comparison between studies and their application to real world situations.

All studies used machines with regular puffs intervals, which may not to represent real smoking conditions and therefore the real combustion of the shisha. Shihadeh and Sima Azar (2006) found that the widely used periodic puffing regime (fixed intervals of puffs or a fixed duration) yielded 20% less CO than the played-back smoking session (i.e. with a machine able to store information on real smoking behaviour and replicate it).

It is likely that different studies have used different sampling kit and analytical procedures. This is likely to have contributed to the observed variability in reported findings, although the impact of these sources of uncertainty is likely to have been smaller than for the factors discussed above.

Few studies have investigated shisha smoking and with the prevalence of shisha smoking reportedly increasing, it is an area requiring further investigation. Many people view shisha use as the safer option when compared to cigarettes; therefore it is important that health education regarding shisha smoking is based upon sound scientific evidence.

Conclusions

This study aimed to characterise the mainstream smoke composition of three popular smoking products for shisha in a controlled laboratory setting. The results from this laboratory study and those from other published literature show that shisha smoking may result in exposure to harmful levels of hazardous substances. Even nicotine-free tobaccos are likely to be harmful because of the exposure to carbon monoxide, particles and PAHs that arise during shisha smoking activity. Appropriate health education is therefore needed to inform shisha users of the potential health risks.

Acknowledgements

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A preliminary investigation into the efficacies of different adsorbents for neutralising formaldehyde from graveyards

Dr Paul Joseph[1], Dr Svetlana Tretsiakova-McNally[1], Mr David Spiers[2] and Miss Ruth Polley[1]

[1] School of the Built Environment and the Built Environment Research Institute, University of Ulster, Newtownabbey, BT37 0QB, Northern Ireland, UK.
[2] Greenacre Innovations Limited, 52c Forest Hill, BT23 7FL, County Down, Northern Ireland, UK

Correspondence: Dr Paul Joseph, School of the Built Environment and the Built Environment Research Institute, University of Ulster, Newtownabbey, BT37 0QB, Northern Ireland, UK. Telephone: 0044 (0)28 9036 8755. Email: p.joseph@ulster.ac.uk.

Abstract

Recent evidence suggests that the United Kingdom is facing a shortage of burial space, particularly, in densely populated areas such as major capital cities. A new system of burial, created by a local company, based in Northern Ireland, has been suggested as a solution to this burial crisis. Owing to its salient features, land previously deemed unsuitable may be utilised, and through its modular form, the system can maximise all available cemetery space within each site, potentially, more than doubling capacity in comparison to a traditional cemetery. While this system's ability to increase cemetery capacity provides significant advantages in terms of land usage, it will also increase the risk of soil and ground water contamination, as cemeteries have the potential to release hazardous chemicals, such as formaldehyde, from embalming fluids into the surrounding environment. The full environmental and health implications of this effect are far from clear as fluid retention within the structures of the synthetic polymeric resins employed and the potential life of such materials are largely unknown.

The current study focuses on developing a method for the treatment of embalming chemicals in decomposition fluids so as to minimise contamination of the surrounding environment, especially, by formaldehyde. Six adsorbents such as clay, sawdust, chicken litter, ash and alumina (both neutral and basic) were selected to determine their ability to hold and neutralise formaldehyde contained within the cavity and arterial embalming fluids. Holding capacity was assessed through small scale mixing and through larger scale experiments, under gravity, in which the pH values of eluates produced were also assessed. From the results obtained, it can be concluded that clay was most effective in neutralising formaldehyde, and was recommended for inclusion within this new system despite its comparatively low holding capacity. These findings ought to reduce contamination risk in relation to cemeteries.

Key words: Cemeteries; formaldehyde; adsorbents; holding capacity; neutralisation

Introduction

Historically, death has been followed by burial. However, since the 1960s cremation has become increasingly popular, rising from 34.7% of funerals in 1960 to 73.3% in 2009 (Rugg, 2000). This statistic, however, is not representative of Northern Ireland where only 20% of funerals take the form of cremation. For those unwilling or unable to practice cremation, owing to religious beliefs or cultural norms, the need for burial space still exists (Francis *et al.,* 2000). Furthermore, the United Kingdom is facing a shortage of burial space, particularly, in densely populated areas. For example, in England this is recognised as a major problem, particularly within the London Boroughs (London Planning Advisory Committee, 1997).

The need for a more sustainable system of burial is clear, as it is inevitable that the amount of land devoted to cemeteries will become disproportionate, particularly as population increases (Dunk and Rugg, 1994). However, action must be taken with consideration to social, cultural and religious factors (Tumagole, 2009) to ensure a "sustainable, acceptable and sensitive approach"; therefore, alternative solutions to the re-use of graves should be considered.

A burial firm, based in Northern Ireland, sought to address the issues faced regarding the shortage of burial land while remaining sympathetic to traditional burial needs. The system design is that of modular interlocking, comprising of recycled polymer and composite materials. In standard configuration each unit would allow four interments and a lid section capable of holding up to twenty-seven urns; thus, allowing for the creation of a family grave. Owing to its structure, land previously deemed unsuitable for use as a burial site may be utilised (Greenacre Innovations Ltd., 2011; see, *http://www.greenacreinnovations.com*, for details). Through its modular form, this burial system seeks to maximise all available cemetery space within each site. This provisionally allows for 1,800 plots per acre, in comparison to the 750 plots per acre provided by a traditional cemetery.

There are several potential risks from cemeteries that could lead to acute environmental and health implications. Recent studies suggest that an incorrectly sited cemetery can pose a threat to ground water deemed "at least equal in magnitude to that posed by a conventional waste disposal site" (Spongberg and Becks, 2000a; Spongberg and Becks, 2000b). Apart from natural decomposition products, cemeteries have the potential to release hazardous chemicals from coffin sealers and varnishes, formaldehyde from embalming, and metals such as lead or zinc into the surrounding environment (Environment Agency, 2004). This leads to concern not only for soil quality but also for the condition of ground and surface waters.

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While the new burial system's ability to increase cemetery capacity provides significant advantages in terms of land usage, it will also increase the associated risk of soil and ground water contamination owing to the significant increase in the number of bodies and subsequent pollutants (Tumagole, 2009). As such, it is clear there is a need to alter how these activities are managed with a view to reducing the impacts on the environment. The overall aim of the present work was to develop a method for treating embalming chemicals present in decomposition fluids so as to minimise the contamination of the environment, particularly by formaldehyde.

Modern embalming uses approximately 0.57l of embalming fluid for every 6.4kg of body weight plus an additional 0.57l in the ratio of 60% arterial embalming fluid to 40% cavity embalming fluid (Havering London Borough, 2007). This inhibits the growth of micro-organisms and delays decomposition of the body. The process of embalming begins by spraying the body with disinfectant, then cleansing it with a germicidal soap; after this begins the treatment of the vascular system through arterial injection of embalming fluids. Blood is drained via the right jugular vein, while the embalming fluid is injected into the right carotid artery (Bryant and Peck, 2009). This results in a build up of pressure throughout the vascular system, enabling the chemical to permeate through the body. A tint is included within arterial embalming fluid to simulate the presence of blood, thereby adding a natural colour to the body. After this process, the body cavity is preserved; cavity embalming fluids replace liquid or gaseous build up within the abdominal and thoracic cavities (O'Sullivan and Mitchell, 1993). Embalming is not a legal requirement and is not permitted in the case of death from a communicable disease (Bryant and Peck, 2009).

At room temperature and pressure, formaldehyde is a colourless gas with a pungent odour, and for its use in the embalming process it is dissolved in water (Brown *et al.,* 2011). Concerns have been raised regarding the levels of formaldehyde in dissection and embalming rooms (O'Sullivan and Mitchell, 1993). These concerns have been emphasised by studies such as Hayes *et al.,* (1990) which found a greater than average incidence of cancer affecting blood, bone marrow and the lymphatic system among anatomists and embalmers in the United States. A study conducted by the World Health Organisation also showed a link between inhalation and increased risk of sino-nasal cancer, lymphoid leukaemia and lung cancer (World Health Organisation, 2005).

While no studies on cemeteries could be found in the available literature with regards to levels of formaldehyde, concerns have been raised that this chemical may leach in sufficient quantities to adversely affect health and the environment (Spongberg and Becks, 2000b). There is debate regarding this concern, as formaldehyde is said to degrade quickly under most environmental conditions. However, caution should be exercised whenever a new burial site is under consideration as concentrations of formaldehyde above acceptable levels might compromise the quality of water in the area.

The effects of formaldehyde in water and its health implications are far from clear; the weight of evidence would suggest that formaldehyde is not carcinogenic via the oral route. However, ingestion of formaldehyde in drinking water over a two-year period was shown to result in stomach irritation in rats (World Health Organisation, 2005). Regardless of this uncertainty, it is accepted that a greater concentration of bodies will increase any risk posed (Tumagole, 2009). It would therefore be advisable to reduce the total amount of formaldehyde before it is given the opportunity to leach into its surroundings and potential water sources (Moyce and Hanna, 2009). It is also proposed that this could be facilitated through effective absorption and neutralisation of fluids resulting from the decomposition of bodies.

Graveyards have largely remained outside of environmental critique (Tumagole, 2009), and as such no specific studies could be found in the available literature with regards to neutralising formaldehyde in decomposition fluids. However, research has been done with a view to removing formaldehyde from industrial wastewater through interaction with composite silica particles (Lee *et al.,* 2008). Activated carbons have been shown effective in removing low levels of formaldehyde in the air (Ma *et al.,* 2011) and from hospital waste (Tanada *et al.,* 1999). These have a large surface area and offer high porosity (Tanada *et al.,* 1999); this would suggest that the most effective materials would be those with similar properties.

It is known that urea and formaldehyde react to produce a copolymer and as a result neutralise formaldehyde; this method is used in chemical plants and laboratories to treat spillages of formaldehyde, which cannot otherwise be disposed of (Robbins, 1992). The formation of urea formaldehyde copolymer in relation to decomposition fluids would eliminate the risk posed by leachate, as in its resinous form the urea-formaldehyde condensate is a

water insoluble and a relatively non-toxic chemical entity (Brown *et al.,* 2011).

The specific objectives of the present work included:

1 selection of a range of adsorbents with desirable characteristics;
2 determination of adsorbent holding capacity with regards to embalming fluids;
3 evaluation of the ability of the various adsorbents to neutralise embalming fluids.

Materials

In the present study, Dodge Standard Cavity solution was used as the cavity embalming fluid and Dodge Chromatech Pink was used as the arterial embalming fluid, and these solutions were obtained from a local funeral director. The cavity solution is a clear green liquid with a pungent odour: its composition is given as 22.6% of formaldehyde, 10-30% of methanol and the remainder is water. The arterial embalming fluid is a translucent pink liquid with a pungent perfumed scent. It is composed of 20.5% formaldehyde and 5-10% methanol, and the remainder being water.

The main factors behind the choice of adsorbent included: cost, availability, toxicity, chemical activity, morphology, and particle size. The following adsorbents were selected to assess their capacity to hold and neutralise formaldehyde: clay, sawdust, chicken litter, ash and alumina (neutral and basic).

Clay is a naturally occurring aluminium silicate, composed primarily of fine-grained minerals (Guggenheim and Martin, 1995). The clay used in this study was obtained from a construction site in Coleraine, Northern Ireland. The sample was dried for 48 hours at 100°C, and ground to a fine powder using a mortar and pestle, before use.

Sawdust, used in this study, was generated as a waste product of timber and wood processing industries in the region. It is an inexpensive material, available in large quantities (Rajor *et al.,* 1996) and studies have shown it to be effective in removing a variety of pollutants such as oil, dye, salts, heavy metals and acids from water (Ajmal *et al.,* 1998; Shukla *et al.,* 2002; Shukla *et al.,* 2005). Owing to its poor biodegradability and low bulk density, disposal is considered as an economic and environmental problem. As such, finding a use for this material would be beneficial and would also enhance its sustainable end-use. Finer particles of the sawdust were selected for the study as it was expected that smaller particles would have a greater surface area and better adsorption capacity (Shukla *et al.,* 2002). The sawdust used in this study was obtained from Haldane Fisher Builders Merchant in Conlig, Northern Ireland.

Chicken litter is generated during the intensive rearing of broiler chickens, and the sample used during this study was obtained from a local farm. Chicken litter was shown to consist of a mixture of wood shavings, feathers, water, feed spillages and chicken excreta (McKenna, 2010). The traditional method of disposal involves its application to land. However, associated with this disposal method are subsequent environmental and legislative implications; therefore, it would be desirable to seek an alternative use for this material. Owing to the presence of nitrogenous-waste materials, chicken litter is known to contain basic chemical species. The basic nature of chicken litter was thought to be advantageous as this might neutralise the formic acid in the embalming solution formed from aerial oxidation reactions of the formaldehyde. Furthermore, there is also the likelihood of the formation of urea-formaldehyde resinous material, thus neutralising a portion of the formaldehyde from the leachate.

The process of chicken litter gasification yields a certain quantity of ash as a by-product, the disposal of which is also problematic. In a previous study, primarily through mineral analysis, the ash was found to be basic in nature (McKenna, 2010). Over time the formaldehyde within embalming fluid will form formic acid (Brown *et al.,* 2011), and as such, it was believed that the ash could neutralise the solution, thereby finding a sustainable use for an otherwise problematic material. The ash used was ground to a fine powder using a mortar and pestle to reduce particle size and increase surface area before use.

The samples of alumina, both neutral Al_2O_3(N) and basic Al_2O_3(B), were readily available in our laboratories, and were of Brockmann grade I. Both grades were activated, and are routinely used for chromatographic purpose (Zhang and Su, 2000). They are white powders with different mesh and particle sizes, and surface areas. Even though chemically alumina is a more or less inert substrate, depending on the pH (i.e. whether neutral or basic) and through surface modification, it can show residual chemical activity. Therefore, in the present study two different categories of alumina were utilised, primarily, with a view to evaluating their adsorption efficiencies as well as their chemical activities.

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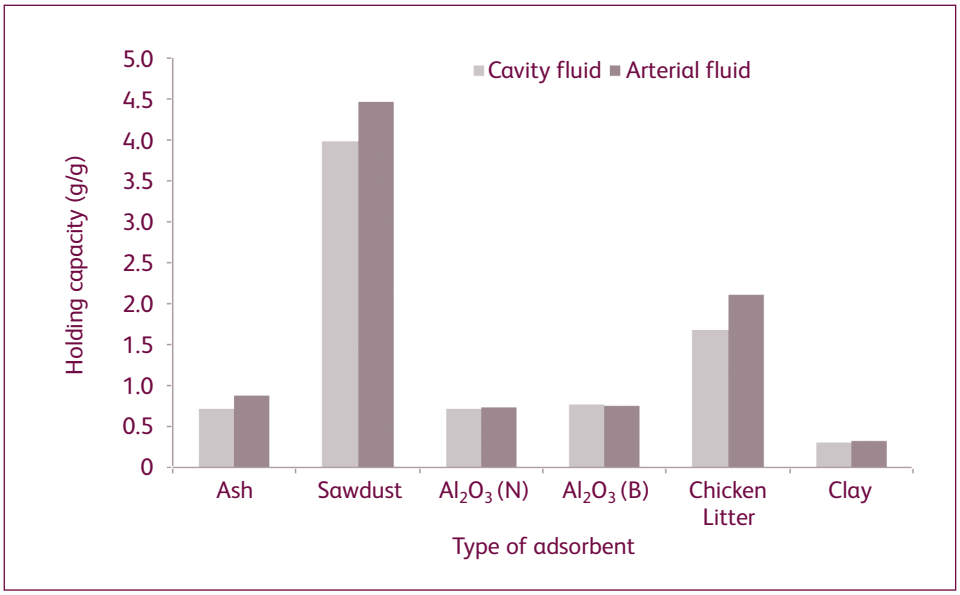

Figure 1.0
Holding capacity of each adsorbent for arterial and cavity embalming fluid through small-scale mixing.

Methods

The arterial embalming fluid was diluted (in the ratio of 2 parts formaldehyde to 10 parts distilled water) whereas the cavity embalming fluid was used without any further dilution, according to the standard practice. In small-scale mixing experiments, by using a Pasteur pipette formaldehyde was added into previously weighed adsorbents contained in small vials, until the adsorbents appeared to be saturated. The samples were weighed again, and the holding capacities of the embalming fluids per gram of the adsorbent were determined. The procedures were carried out in triplicate, and the results obtained were then averaged.

For determining the holding capacities of the different adsorbents, under gravity, approximately 28g of each adsorbent was weighed out and added to a glass column having a coarse sintered disc at the bottom. A known volume of embalming fluid was dripped slowly into the glass column containing the adsorbent from a graduated burette. Over time the adsorbent became saturated, and the eluate was collected, its colour was noted and the pH was measured via a calibrated Mettler Toledo Seveneasy pH meter. The values of the pH thus obtained were compared with that of fluid before eluting through the adsorbents. The volume of embalming fluid (cm3) required to saturate each adsorbent was recorded in order to estimate the holding capacity, under gravity, per gram of the adsorbent.

To determine the pH of aqueous-slurries of the adsorbents, approximately 50g of the adsorbent was added to a large beaker containing about 150cm^3 of distilled water. This mixture was then stirred at room temperature for about 48 hours, and was allowed to settle before being decanted and filtered. The pH of the filtrate was determined. Over the course of this study, the pH of the cavity and arterial embalming fluids were also regularly recorded. The pH of a mixture containing 60% arterial embalming fluid and 40% cavity embalming fluid, after the former was diluted to the required amount, was also determined. The given ratio and dilution of the respective fluids were used in actual practice for embalming bodies. The pH of this mixture was found to be 5.75.

Results

Determining holding capacity

Figure 1 illustrates that the sawdust was the most efficient adsorbent, having the greatest holding capacity for both arterial and cavity embalming fluids: holding capacities of 4.46g/g and 3.98g/g, respectively. Chicken litter displayed the second

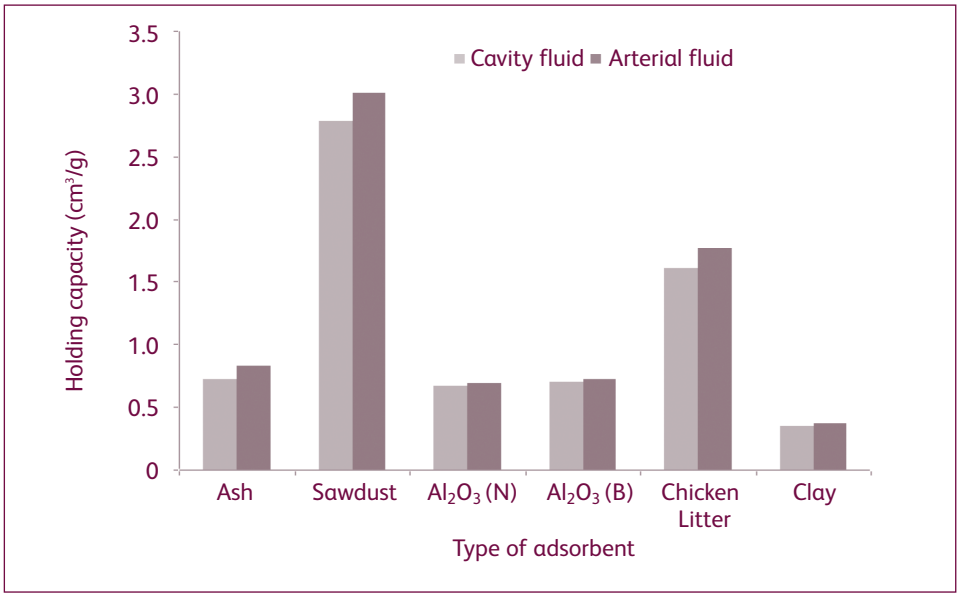

Figure 2.0
Holding capacity of each adsorbent for arterial and cavity embalming fluid through small-scale mixing.

greatest holding capacity: 1.68g/g for cavity fluid and 2.10g/g for arterial fluid. Ash, alumina (N) and alumina (B) demonstrated holdng capacites of approximately 0.70g/g for both cavity and arterial embalming fluids, while clay displayed a holding capcity of approimately 0.30g/g. Adsorbents' holding capacity for arterial embalming fluid was noted, generally, to be marginally higher than for cavity fluid.

As illustrated in Figure 2, the trends previously noted through the small-scale mixing experiments were more or less repeated in the corresponding runs under gravity. Sawdust was shown to be the most efficient adsorbent, holding 2.79 cm^3 of cavity embalming fluid and 3.01cm^3 of arterial embalming fluid per gram of adsorbent. Chicken litter was shown to hold 1.61cm^3 of cavity fluid and 1.77cm^3 of arterial embalming fluid per gram of adsorbent. Ash, alumina, neutral and basic, displayed a holding capacity of approximately 0.70cm^3/g and clay was shown to be least efficient, holding less than 0.4cm^3 of cavity and arterial fluids per gram. Holding capacity under gravity was in general noted to be lower than holding capacity in mixing. This was most evident in the case of sawdust; however, the corresponding values were closer for ash, clay and for alumina (neutral and basic). Figure 3 shows the resulting pH after the fluids ran through the column that was filled with an adsorbent, i.e. the pH of the eluates.

The pH of the cavity embalming fluid was found to be in the acidic region, i.e. with a pH ranging between 4.3 and 4.4. Clay is shown to be most efficient at neutralising this, achieving a pH level of 6.98 (i.e. almost neutral). Ash causes the fluid to become more basic (9.57), while in sawdust and chicken litter the pH of the eluate remains acidic (5.12 and 5.79 respectively). Neutral alumina resulted in a pH just below neutral at 6.86, while basic alumina caused the eluate to go just beyond neutral at 7.51.

Figure 3 also illustrates the effect of each adsorbent on the pH of arterial and cavity embalming fluid. For areterial embalming fluid, the pH values of arterial embalming fluid were noted to be between 7.3 and 7.7 fluid (neutral/mildly alkaline region); this is considerably different to that of cavity embalming fluid (acidic; between 4.3 and 4.4). Here again clay is shown to be most efficient in neutralising the embalming fluid; bringing pH nearer to neutral at 7.16. Ash was shown to increase pH into the alkaline range at 9.76 and interaction with sawdust and chicken litter resulted in an acidic pH range (5.45 and 6.32). Alumina showed minimal change in pH: from 7.7 to 7.47 for neutral form of adsorbent and from 7.62 to 7.66 for the basic form of alumina.

In spite of the difference in the initial pH of cavity and arterial embalming fluid (ranges between 4.3 to 4.4

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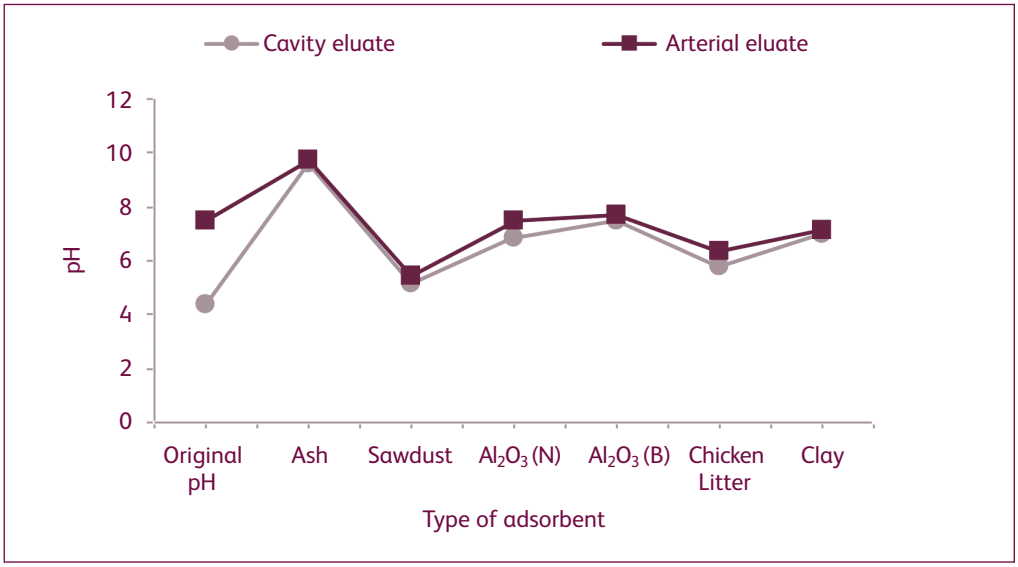

Figure 3.0
The neutralising abilities of adsorbents on the embalming fluids.

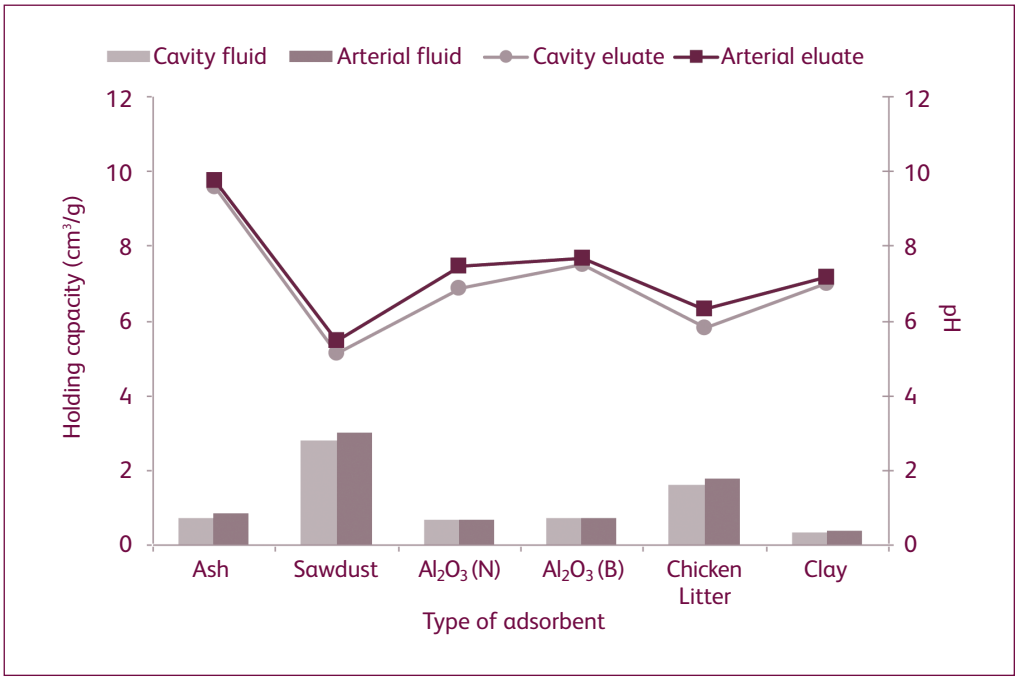

Figure 4.0
The efficacies of various adsorbents in neutralising and holding embalming fluids.

and 7.3 to 7.7, respectively), as illustrated in Figure 3, the pH of eluate obtained from both cavity and arteral embalming fluid is largely similar after interacting with each adsorbent. Furthermore, in both cases, the clay was shown to be the most efficient adsorbent in neutralising both arterial and cavity embalming fluids. Ash, alumina (neutral and basic) result in greater basicity, while sawdust and chicken litter shift pH values

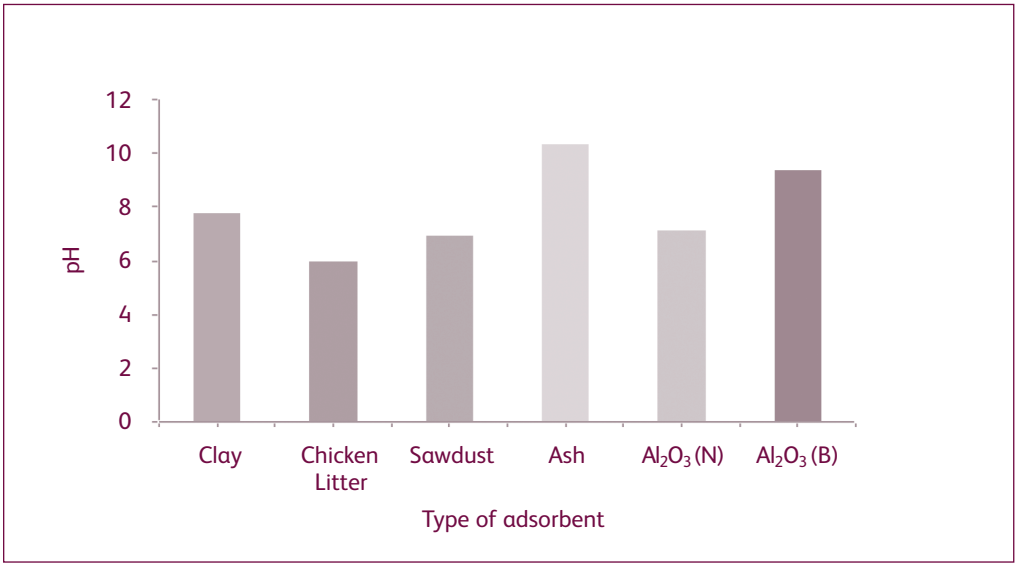

Figure 5.0
The pH of the filtrates obtained from aqueous slurries of the adsorbents.

in the acidic region. Visually, cavity embalming fluid was a clear green solution and arterial embalming fluid was transulcent pink before passing through the column. Sawdust and basic alumina are shown not to alter the colour of the embalming fluids; ash was shown to produce a black eluate, and chicken litter – a brown eluate. Clay and neutral alumina result in a clear and colourless eluate for both cavity and arterial embalming fluid.

Figure 4 illustrates the ability of each adsorbent to hold embalming fluids along with their effects on the pH levels. While sawdust and chicken litter are shown most effective in terms of holding capacity, they are ineffective in neutralising the embalming fluids, allowing them to remain acidic. Ash is shown to have a relatively low holding capacity and is ineffective in neutralising the embalming fluids, resulting in a basic pH. Clay was shown to have a low holding capacity; however, it was most effective at neutralising the embalming fluids, achieving a pH of 7.16 (for arterial fluid) and 6.98 (for cavity fluid). Both forms of alumina demonstrate a larger holding capacity than clay and are shown capable of bringing the fluids close to neutral.

Figure 5 illustrates the pH values of filtrates obtained from the aqueous slurries of the various adsorbents: chicken litter (pH 6.0); sawdust (pH 6.9); clay (pH 7.74); ash (pH 10.3); neutral Al_2O_3 (pH 7.13); basic Al_2O_3 (pH 9.27).

Discussion

Findings of this research suggest that the adsorbents under observation had a greater holding capacity for arterial embalming fluid than for cavity embalming fluid. This was most noticeable in those adsorbents with the higher holding capacities (sawdust and chicken litter). Results of the small-scale experiments show that on average sawdust was capable of holding an additional 0.22g of arterial embalming fluid per gram, and chicken litter an additional 0.42g per gram. As the end point for these experiments was that of visual estimation of saturation, it is possible that these figures arose through an error in judgement for either solution.

However, adsorbent holding capacity was also tested on a larger scale and the same trends were evident. The adsorbents had a greater holding capacity for arterial fluid; particularly, in the case of sawdust and chicken litter. Sawdust was capable of holding an additional 0.48cm^3 of arterial embalming fluid per gram and sawdust an additional 0.16cm^3 per gram. As this was a larger-scale experiment with a clear end point (the volume of embalming fluid required to produce a drip from the column), it is possible that compositional differences between the fluids could have an effect on adsorbents' holding capacities.

Adsorbent holding capacity was shown to be greater in the small-scale experiments. The larger-scale experiment

was conducted under gravity with a clear end point and therefore it can be said that these results are more reliable, as they are closer to the efficacies of the adsorbents in real-life scenarios. Despite these discrepancies, the trends remain the same; sawdust has the greatest holding capacity, followed by chicken litter, ash, alumina (basic and neutral), with clay exhibiting the lowest holding capacity.

Sawdust is known to have a high liquid holding capacity, as illustrated by Rajor *et al.,* (1996), where it was found that the addition of sawdust increased the water holding capacity of different types of soils. The holding capacity of chicken litter was shown to be lower than that of sawdust. The chicken litter consists of wood shavings, feathers, water, feed spillages and chicken excreta (McKenna, 2010). These various components could modify the morphological and structural features of the chicken litter, thus lowering its holding capacity. The holding capacity of clay was shown to be the lowest of the adsorbents under observation; it was approximately 10 times less than the capacity of sawdust. This is in agreement with a previous observation showing that clay is slow to adsorb water and also has a poor capacity for doing so (EAIS, 2010). The selection of ash and alumina (neutral and basic) was because of their potential surface chemical activity. This research shows that these adsorbents hold approximately 0.7cm^3 of fluid per gram. This is low in comparison to sawdust and chicken litter but significantly greater than for clay.

The pH of cavity embalming fluid was shown to be acidic (pH between 4.3 and 4.4), while the value of arterial embalming fluid was nearer to neutral pH value (registering as between 7.3 and 7.7). This can be related to a number of factors such as differences in the actual chemical composition of fluids, the presence of colouring materials in the case of the arterial fluid and the differences in the extents of dilutions before the use.

Clay (aqueous slurry had pH 7.74) was shown most effective in neutralising the embalming fluids; changing the pH of cavity fluid from 4.42 to 6.98 and the pH of arterial embalming fluid from 7.3 to 7.16. This can be attributed to the chemical activities of the various minerals species and other chemical constituents in the clay. Clay minerals are also believed to exhibit catalytic effects owing to the presence of varying amounts of radical and/or ionic centres (Guggenheim and Martin, 1995). It was also noted that clay produced the clear colourless eluates, from the pink arterial and from the green cavity embalming fluids. This might result from the enhanced ability of clays, in general, to adsorb colouring materials and dyes (Gupta *et al.,* 1992).

Sawdust (aqueous slurry had pH 6.9) was shown to be ineffective in neutralising embalming fluids; increasing the pH of cavity embalming fluid from 4.34 to 5.12 and lowering the pH of arterial embalming fluid from 7.32 to 5.45. These observed pH values mean that the eluates produced were acidic in nature and are potentially harmful to the environment. While sawdust has been shown effective in other studies in eliminating a variety of pollutants (Ajmal *et al.,* 1998; Shukla *et al.,* 2002; Shukla *et al.,* 2004), it was shown to be less effective than clay in this study. It was also noted that sawdust did not change the colour of the eluates.

Chicken litter (aqueous slurry had pH 6.0) was also shown to result in an eluate with an acidic pH of 5.79 for cavity embalming fluid and 6.32 for arterial embalming fluid. Owing to the presence of urea and other nitrogenous compounds within chicken litter (McKenna, 2010) and its resulting ability to neutralise formaldehyde (Robbins, 1992), it was expected to be more effective. It is possible that reactions between other constituents of this adsorbent material affected the expected result. It was noted that chicken litter produced eluates that were brown in colour.

Both neutral and basic alumina (pHs of the aqueous slurries of pH 7.13 and pH 9.37, respectively) were effective in bringing the pH of embalming fluids to a point near to neutral. Neutral alumina produced an eluate of pH 6.86 for cavity embalming fluid and pH 7.46 for arterial embalming fluid. Basic alumina produced an eluate of pH 7.51 for cavity embalming fluid and pH 7.66 for arterial embalming fluid. This may be owing to the fact that they possess chemical reactivities similar to the clay minerals, which are chemically 'aluminosilicates'. Neutral alumina resulted in clear and colourless eluates for both the cavity and arterial embalming fluids. Basic alumina did not change the colour of the fluids as well.

Ash (aqueous slurry had pH 10.3) caused the eluate to become more basic: pH 9.57 (cavity embalming fluid) and pH 9.76 (arterial embalming fluid), which is significantly different from the pH change resulting from chicken litter. Ash, as a by-product from the combustion of the chicken litter, was shown to be enriched with different metallic compounds/ionic species, making it very basic in nature (McKenna, 2010); this was confirmed in that the pH of its aqueous slurry was 10.3. It can therefore be assumed that not only acidic species

from the embalming fluids were completely neutralised, but also that the eluates leached out some of these basic components during the process of percolation. Ash imparted a black/brown colour to the eluates produced.

The pH of these slurries can be used to interpret the ability of the adsorbents to neutralise embalming fluids. Clay and neutral alumina exhibited a slightly basic pH (7.74 and 7.13 respectively); as such these were capable of neutralising acidic cavity embalming fluid and resulted in little change in arterial embalming fluid pH 7.3–7.7. Sawdust and chicken litter displayed an acidic pH (6.9 and 6.0 respectively). As such, cavity embalming fluid remained acidic, while arterial embalming fluid reacted to produce an acidic eluate; with the more acidic chicken litter producing a more acidic eluate.

Ash and basic Al_2O_3 were shown to possess a basic pH; pH 10.3 and pH 9.37 respectively. Results indicate that ash was too basic, resulting in eluates with a basic pH (9.76 for arterial fluid and 9.57 for cavity fluid). Basic Al_2O_3 was less basic than ash and was shown to be successful in reacting with embalming fluids, producing an eluate with a pH close to neutral; 7.66 for arterial fluid and 7.51 for cavity fluid.

Conclusion

- Despite its proven ability to neutralise and remove harmful chemicals demonstrated in other studies (Ajmal *et al.,* 1998; Shukla *et al.,* 2002; Shukla *et al.,* 2004), sawdust in the present study was shown ineffective in neutralising formaldehyde within embalming fluids, resulting in acidic eluates with the potential to harm the environment. This finding was found to be discouraging, given the large holding capacity of sawdust and known problems regarding its disposal (Rajor, 1996).

- Previous research suggested that owing to its high urea content (McKenna, 2010) chicken litter would be effective in neutralising formaldehyde (Robbins, 1996); however, findings of this study show that neutralisation was not achieved. Eluates produced were acidic in nature with the potential to harm the environment. This finding was also discouraging in the light of the high holding capacity demonstrated by chicken litter and its known difficultly regarding the disposal (McKenna, 2010).

- Clay and alumina (neutral and basic) were shown effective in bringing embalming fluids toward neutral pHs. Neutral and basic alumina had holding capacities under gravity by approximately 0.7 and 0.4cm^3/g greater than the holding capacity of the clay. Clay demonstrated the lowest holding capacity among the adsorbents used in the study. However, clay was deemed to be the most acceptable material, as it was more effective in neutralising embalming fluids and is naturally occurring, abundant and relatively inexpensive material; while Al_2O_3, both neutral and basic, are usually produced through chemical processes.

- Findings of this study show that, through the effective use of appropriate adsorbent(s), it is possible to hold and neutralise formaldehyde present in embalming fluids, thereby reducing the risk of contamination of soil and groundwater in cemeteries. It is suggested that such measures are being considered, particularly in sites previously deemed unsuitable and located below the water table.

- As some future directions for the study, the following are suggested:

    1) experiments should be repeated using embalming fluid in the ratio of 60% arterial and 40% cavity fluid, as this is the composition used within the embalming process;

    2) a synthetic mixture of decomposition fluids that closely mimics that from a decaying body should be formulated and added to the embalming fluid (60% arterial fluid to 40% cavity fluid), and the experiments repeated;

    3) information regarding the pHs, moisture contents, mineral compositions and salinities of different clay samples should be obtained, and these samples should be also tested for evaluating their relative efficacies;

    4) repetition of experiments with mixtures of the adsorbents with a view to potentially maximizing the holding and neutralisation capacities;

    5) the long-term environmental damage, owing to possible leachates, also needs to be evaluated through appropriately designed experiments.

The UK Environmental Agency's publication on the Assessment of Groundwater Pollution in the Development

of Cemeteries, and the references therein, may be useful as further sources of information.

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Wellbeing and Mental Health: an evolving role for environmental health practitioners through evidence based practice

Stuart Spear[1] BA (Hons), Dr Jill Stewart[2] PhD MSc BSc (Hons) MCIEH FRSH PGCE ACIH, Anneyce Knight[3] MSc BA (Hons) PGCE RN, Christine Stacey[2] MA PGDipHE BSc (Hons) RN DN Cert.

[1] CIEH Consultant, Chartered Institute of Environmental Health
[2] Senior Lecturer, School of Health and Social Care, University of Greenwich
[3] European Lead, School of Health and Social Care, University of Greenwich

Correspondence: Stuart Spear. Email: s.spear@cieh.org

Abstract

In the UK wellbeing is rapidly emerging as an agenda with a focus on positive mental health. Wellbeing is also seen as contributing to neighbourhood and community health and so helping add to social capital and social cohesion locally. Environmental health practitioners (EHPs) are key players in the front line delivery of the wellbeing agenda by helping provide a healthy environment for people to live and work in. EHPs also contribute towards positive mental health through their work in the fields of area regeneration, housing standards, food security, nutrition, addressing fuel poverty, workplace health, environmental quality, emergency planning and in allied roles within existing public health partnerships. The way environmental health has historically developed and the face-to-face contact EHPs have with their local communities make them ideally placed to carry the wellbeing agenda forward.

This work was carried out in the light of the Department of Health (DH 2010a) publication, *Confident Communities, Brighter Futures*. For the purposes of the publication the Department of Health (DH) carried out extensive background research into wellbeing, which has formed the evidence base used in this audit. Many of the DH findings on wellbeing relate directly to the role of EHPs.

After piloting, a combination of telephone and face-to-face interviews (20 in total) was carried out with members of the environmental health profession in England and Wales. The interviews aim to audit how EHPs currently perceive and contribute to the wellbeing agenda; main challenges and barriers faced; what evidence is being used to underpin their roles; strategic development and good practice at local level; and measures of service success and evaluation. We acknowledge that the sample size is small and that this is an initial audit with the potential for future study.

The audit revealed that wellbeing is seen as an implicit part of environmental health strategies and interventions. While most interviewed had an overall idea of the concept of wellbeing, there was variation in how it was defined, often relating to the respondent's particular discipline and expertise of work. The findings of this audit have important implications for how EHPs deliver their more traditional environmental and public health functions in the future in order to further enhance evidence-based wellbeing strategies, contributing further to positive mental health. In particular, there is a need to consider how evidence can be more effectively disseminated and used by EHPs in delivering their existing remit to even greater effect.

Key words: Environmental health, environmental health practitioner, wellbeing, mental health, local government, local authority.

Introduction

The delivery of the health agenda has significantly developed in recent years as organisational boundaries, policies and cultures have become increasingly integrated through the modernisation process. Concepts around environmental health, public health and more recently wellbeing have been of increasing interest to policy makers as attention is re-focused on the social and economic determinants of health and in the delivery of evidence-based interventions (Stewart and Cornish, 2009; Marmot *et al.*, 2010). In addition, the rising cost of health care – and in particular the social and financial costs to society of poor mental health – has focused attention on helping to encourage resilience in preventing the development of mental illness and promoting wellbeing in the first place:

- *In the UK mental illness accounts for 22.8% of total disease burden compared with 15.9% for cancer and 16.2% for cardiovascular disease;*
- *1-in-6 of the adult population experiences mental ill health. 1-in-4 will experience a mental health problem at some point in their lives; and*
- *The NHS spends 11% of its annual budget on mental health services. The annual cost of mental ill health to business is estimated at £77billion.*

(Source: DH 2010a).

This paper uses the wellbeing definition presented by the DH (DH 2010a):

> *"A positive state of mind and body, feeling safe and able to cope, with a sense of connection with people, communities and the wider environment."*

It is, however, recognised that there are multiple definitions, both nationally and internationally.

Background

Environmental health is concerned with assessing and correcting environmental stressors across a range of disciplines including housing, food, working conditions, noise environment and emergency planning. It focuses on socio-economic health determinants, so reducing

health inequalities and promoting a healthier, more sustainable environment (HDA 2012). Environmental health strategies and interventions affect both physical and mental wellbeing across the lifespan from the very young into extreme old age.

The wellbeing agenda offers the opportunity to proactively help promote longevity, reduce morbidity, encourage better lifestyle behaviours, education and employment opportunities and therefore greater productivity. As people feel better about themselves, both physically and mentally, they will become more productive citizens at home, within their neighbourhoods, communities, and in work. Those with a sense of wellbeing are less likely to take up smoking, abuse drugs or alcohol in the first place, find it easier to stop and are more likely to do regular exercise and eat relatively well (DH 2011).

While there may be much anecdotal evidence supporting the role EHPs play in this wellbeing agenda, there is little published research to date more formally establishing this. This paper will, therefore, be an initial audit and foundation for further investigation assessing the extent to which environmental health plays a role in the emerging wellbeing agenda, including the extent to which that agenda is understood by EHPs themselves.

Wellbeing is not a new concept and since the Local Government Act (2000) local authorities have had the power to develop community strategies that promote wellbeing. In 2008, a duty was introduced on local authorities and primary care trusts to produce a Joint Strategic Needs Assessment (JSNA) (DH 2007) of the health and wellbeing of local communities. When it comes to delivering the public health and more latterly the wellbeing agendas JSNAs require partners to form policies that are based on sound evidence of what works best, and why. JSNA (DH 2007) are required to identify current and future health and wellbeing needs and inequalities in the local population to inform strategic planning in commissioning services, with interventions leading to improved health outcomes. The Department of Health (DH 2007) emphasises the importance of partnership working, community engagement and evidence of effectiveness using best practice and innovations in research.

One document that establishes a range of evidence across many disciplines is the DH (2010a) document: Confident Communities, Brighter Futures, which in particular establishes mental wellbeing as crucial in developing resilience to mental ill health, illness and disease. Confident Communities Brighter Futures provides evidence that, among other things, unhealthy housing, degraded built environments, workplace stress, effective emergency planning, alcohol misuse controls and environmental noise all impact on wellbeing. These are all areas that EHPs have a direct influence on. Further unpublished DH research that comprises the DH wellbeing evidence base provides additional evidence of a link between the work of EHPs and the wellbeing agenda.

For example, the DH evidence base identifies that housing improvements have a positive impact on physical and mental health outcomes (Thomson *et al.,* 2001) while people who live in fuel poverty are more likely to suffer anxiety and depression (Green and Gilbertson, 2008 cited in DH, 2010a). Those who live in housing with structural problems increase the risk of mental disorders by 1.4 times, people who live in homes with mould are 1.5 times more likely to develop a mental disorder (McManus *et al.,* 2009 cited in DH, 2010a). Additionally Guite *et al.,* (2006) found an association between the physical environment and mental wellbeing closely correlating to neighbourhood noise, overcrowding, open spaces, community facilities, fear of crime and a need to focus on both residential design and social aspects to enhance wellbeing.

In the workplace there is evidence that stress management interventions at work (Richardson *et al.,* 2008 cited in DH, 2010a) along with workplace wellbeing programmes (NICE, 2009 cited in DH, 2010a) help build resilience among employees. Adults in work with low decision latitude have increased risk of depression and anxiety (Griffin *et al.,* 2002, cited in DH, 2010a).

In the field of emergency planning (Reacher *et al.,* 2004, cited in DH, 2010a) concluded that professional agencies responsible for flood warning, evacuation and guidance on water contamination can have a significant impact on the mental health outcomes related to flooding.

There is little doubt that EHPs are crucial in delivering much of this. This work therefore seeks to audit what EHPs are currently delivering in the wellbeing agenda, including their perceptions around their wellbeing interventions and partnership roles, and the extent to which this is evidence based.

Methods

The concept of wellbeing is relatively new and is being applied liberally to policies and strategies. The purpose of this work was to investigate how those shaping policy

in the environmental health profession and front line environmental health practitioners themselves felt they were able to contribute to the wellbeing agenda.

Following a pilot interview, semi-structured telephone interviews were used for the 17 front line practitioners, using discussion areas and a series of prompts. The following discussion areas were adopted as an interview guide, largely led by participants, to help capture their perceptions:

- Initial thoughts about what wellbeing means;
- How EHPs might contribute to the wellbeing agenda;
- Main challenges faced;
- Useful policies or documents in wellbeing;
- How this is activated into strategy at local level;
- known examples of good practice;
- How 'wellbeing' engages with public health partnerships and why; and
- Possible measures of success and evaluation.

As an exploratory audit, EHPs were recruited purposively: they were selected on the basis that first, they were EHPs and second, that they would be likely be able to provide insights into environmental health's relationship to the wellbeing agenda. Some were identified as having experience of wellbeing; for example the health and safety interviewees were known to have worked in the field of stress. With other interviewees their knowledge emerged, for example senior managers with their overall responsibility of environmental health. Inclusion criteria also required that an overall representation of participants from across the environmental health disciplines of health and safety, food safety, environmental protection, housing and public health was achieved. Participants were chosen from different organisations such as local authorities, the Health Protection Agency, the private sector and academia. They were also picked from a geographical spread across England and Wales representing rural and urban regions. While new practitioners were interviewed, the participants were mostly more senior and so likely to have had broader experience of environmental health in a number of disciplines. It was hoped that the initial list of 20 interviewees would lead on to a snowballing of others who may be of interest for this research.

Three (initial list comprised of five names) less structured one-hour-long interviews were carried out with CIEH policy officers covering the field of housing, health and safety, food safety and environmental protection. Each policy officer was asked to describe their understanding of wellbeing, how the profession currently contributes and what challenges existed to participation.

It is recognised that this method is qualitative and descriptive. It is also acknowledged that within the constraints of this project the sample size was small and so vulnerable to bias. However, direct interactions with the respondents allowed researchers to probe and clarify issues arising. Vast amounts of data were collected including personal opinions in the respondents' own words. Perspectives were taken from those developing policy, as well as those delivering policy at the front line and the additional challenges this presented. It is anticipated that the responses obtained should facilitate the development and implementation of environmental health and wellbeing policies and strategies at national and local level now and in the future.

Results

Telephone interviews with 17 EHPs were completed between October and November 2010 plus three face-to-face interviews with policy officers between January and February 2011. All interviews lasted between half an hour and one hour, were recorded, transcribed verbatim and scripts anonymised.

Findings were categorised into four main emerging themes. First, defining and contextualising wellbeing within the remits of the environmental health profession. Second, the current contribution EHPs make to the wellbeing agenda and the extent to which this is evidence based. Third, the potential scope for future involvement including existing challenges and barriers. Fourth, the extent to which EHPs understand the effectiveness of their roles as front line practitioners in promoting wellbeing and how this is evaluated in practice.

Defining and contextualising wellbeing within environmental health

The majority of participants immediately identified with wellbeing as an implicit part of their work, yet had more difficulty in providing a definition or context, suggesting a need for a more common understanding of the term/concept.

For most, wellbeing revolved around the specific discipline they worked within, with some suggesting that other organisations probably saw wellbeing differently. Several regretted the general demise of environmental health as a discrete discipline into disciplines fitting across other local authority departments.

While the profession has a strong sense of being part of the wellbeing agenda, there is no consistent definition of what wellbeing actually means, although several referred to the social determinants of health in thinking through what wellbeing might mean. The most commonly quoted measure was the WHO (1948) definition of health as well as Dahlgren and Whitehead's social model of health (1991), "still not referenced properly"; however, safe housing and environment were seen as key. Such a focus on health, rather than wellbeing, risks missing out on key components including positive mental health that provides resilience but also capacity to be able to be an active citizen, contributing back into society, although others recognised the importance of this:

> *"I think it (wellbeing) fits very tightly with the work that we do because the white paper is looking at pushing public health down to more of a preventative role, you know. It's looking far more at increasing the preventative role, which is what we do. So you're looking at the environment that people live in, air quality, housing environment, whether they're living in warm homes, whether they've got access to food, access to fruit and vegetables."* (Interview 8)

> *"I don't think there's an agreed definition of wellbeing, but for my purposes I kind of think of quality of life, I think of the sort of holistic view of health, so it has physical, social, mental, spiritual and environmental aspects."* (Interview 16)

> *"It's (wellbeing) going back to the World Health Organisation's definition of health and it being about a complete state of physical and mental wellbeing...I suppose it's about people feeling good about themselves...People can be happy and might be living in a tin hut somewhere in the valley in the mountains in Wales, or could be in a penthouse suite in London."* (Interview 12)

However, overall there was a good sense of what wellbeing entails – as opposed to that it might mean specifically – that is very much in line with the findings of the DH evidence base. There were overall two mentions of the DH evidence base, which is starting to find its place in environmental health. However, these interviews were carried out before it was promoted in Environmental Health News (Spear, 2010), the fortnightly news magazine published by the Chartered Institute of Environmental Health for UK environmental health practitioners.

No one interviewed felt that the Local Government Act 2000 wellbeing powers were being applied, but that the Act had added some weight to the definition and there was a suggestion that this Act has in itself been part of moving public health back into the local authority domain so that wellbeing could be further enhanced.

There was also some confusion around the role public health and wellbeing plays in the function of environmental health. In this context, participants tended to better understand public health owing to it having a more incremental history of law and practice than wellbeing. Some saw regulation being the driving force in environmental health and so separate from the wellbeing and public health agenda. This led, in some cases, to individual EHPs championing the wellbeing and public health agendas. However, regulation in itself was frequently seen as pivotal in ensuring wellbeing.

Current wellbeing contribution and evidence base

The DH evidence base aligns very closely to how the environmental health role is perceived by both front line officers and policy officers alike.

Looking more closely, results fell largely into the disciplines in which those interviews were working, or had worked in the past.

Housing and community

Housing is consistently quoted as having the most demonstrable link with wellbeing at both micro and macro levels.

This was felt to be in part owing to the Housing Health and Safety Rating System providing a dynamic evidence base to intervening in housing conditions. Indeed, out of the 29 potential hazards in the HHSRS, excess cold, excess heat, damp and mould, lead, noise, entry by intruders, crowding and space all have a direct impact on mental health.

> *"I think if your housing (is) poor, so that the conditions that you are living in are poor or the place*

is cold, your level of wellbeing will be poor, or is likely to be poor, I suppose...I think dampness, noise, poor hygiene, like surfaces you can't clean kind of thing. It relates closely I think to health and mental health, but wellbeing is probably a level above that." (Interview 12)

At its macro level, housing strategies and interventions were also reported as favourably contributing toward wellbeing. However, comments were not generally made under 'wellbeing' headings around housing need across the lifespan, or the importance of focusing on children. While there was an understanding about the relationship between the local environment and wellbeing in terms of graffiti, empty properties and feeling safe, there was a notable absence of commentary around social capital, which is considered fundamental in developing individual and community resilience.

Food

Food officers instinctively felt they were part of the wellbeing agenda but when probed, sometimes struggled to explain how food actually linked with it. The regulatory role was clearly defined, generally in terms of food hygiene and safety. EHPs also have a role around nutrition and obesity, a policy area of particular current concern. Some working in food struggled to see where they fitted into a sustainable wellbeing agenda with a definite split emerging between different EHP roles around food.

"When I started working in food, the focus was very much on the food standards within the business in individual businesses ... (but) because we've had the opportunity of some grant funding which we have taken, we feel that we have definitely made a difference to the nutritional side and actually, of course that's the greater side isn't it? There's more people die from poor nutrition than from food poisoning, so yeah, definitely it's changed and the amount of information has changed." (Interview 8)

"So in terms of the food, food safety aspects, you might want to be talking more about healthy eating rather than hygiene, you know, it's getting that balance I suppose. But I think environmental health is perfectly placed to take on that role." (Interview 11)

Nutrition was seen as the best fit with the wellbeing agenda, although various levels of intervention were reported. Some initiatives were seen as encouraging good practice by providing evidence of what works. For example, the Food Vision website (CIEH 2011) was cited as an example of sharing good practice and demonstrating a shift towards consideration of the wider food agenda. It may be worth developing similar ways of sharing good practice in other environmental health disciplines as a way of moving the wellbeing agenda forward.

Health and Safety at Work

Health and safety officers see an absolute fit between occupational health and stress with wellbeing to the point where they even quote health and safety in their definition of wellbeing. Health and safety was seen as making a vast contribution to the wellbeing agenda and was perceived as an area receiving a lot of positive attention in recent years, such as the introduction of a smoking ban in the workplace. There was a notable divide reported between health and safety and occupational health:

"I have two different concepts (of wellbeing). One is I think is in the context of health at work, so health in the workplace... which is very much treating symptoms and then there's another concept which is much more interesting in my view; it's the proactive one when you look at working conditions." (Interview 2)

"People who are fortunate enough to be in employment, their health and safety clearly has to be protected at work and that is done in a fairly obvious way by dealing with safety issues but it's less obvious when it comes to occupational health and there's been an over-concentration over the years on safety at the expense of health." (Interview 2)

The health aspect of health and safety incorporates stress management interventions, workplace wellbeing programmes, early treatment of common mental health problems and supported work for those recovering from mental illness. Respondents involved in health and safety focused on mental health issues arising at work, in particular stress and the idea of 'happiness'. However, respondents reported one major area of workplace wellbeing that they had no powers to address, that of level of salary.

The availability of evidence to support health interventions was favourably received by respondents.

Environmental protection

Environmental protection has a wide remit, including air and water quality, contaminated land, nuisances, graffiti, litter, safer neighbourhoods and green spaces; environmental planning; acceptable behaviour; and support during extreme weather events.

In this work, environmental protection officers overall saw noise nuisance as their main link with wellbeing, only one mention was made of odour and there was no mention of light nuisance causing stress.

> *"If you take something like noise, then noise in a huge way is impacting on people's quality of life and wellbeing, the enjoyment of their own property, the ability to be able to relax and have a reasonable quality of life, being able to wind down within your own, sort of, private space."* (Interview 15)

A link to the general environmental quality of a community and its impact on wellbeing – including quality of life – was reported:

> *"Obviously where someone lives has a huge impact on their health and wellbeing. Poor living conditions lead to obvious physical problems but also mental health problems potentially, feelings of isolation, suitability of accommodation, how run down an area is. You know, it all impacts on overall psychological wellbeing."* (Interview 11)

Only one interviewee mentioned a link between climate change and wellbeing as referenced in DH research (Reacher *et al.*, 2004, cited in DH, 2010a). There was only one mention of flooding, although that is possibly a result of this particular sample group.

Potential scope for future involvement: challenges and opportunities

Many referred to the successful partnerships they had been involved in across a whole range of policy areas and that this had set the stage for ongoing work within wellbeing.

However, up to the publication of the Health White Paper (Equity and excellence: Liberating the DH 2010b), there was no sense of wellbeing being an emerging issue with the exception of health and safety officers who felt it had been an issue for a number of years

> *"I would say no (wellbeing is not an emerging issue). I think we're still grappling with what it actually means, as is usual. The public are quite clear in their mind, maybe on an individual basis rather than collectively but I don't think government has actually ever… certainly not local government, in my experience, have taken it as a sort of key issue."* (Interview13)

However, there was an overall sense that wellbeing has become a more significant part of their work. Although this may be owing to interviewees taking on new jobs that have an aspect of wellbeing as part of their remit.

> *"NICE guidance on physical activity, about how to create and improve our built and natural environment to encourage physical activity, so this is looking at how we plan our streets and how we plan new housing and how we use the natural environment because physical activity really needs to be incorporated into daily lives, not just in a sort of a structured, go down the gym, or undertake sort of structured physical activity."* (Interview 1)

Since the 2010 public sector spending review, regulation has been seen as a priority and there is a fear that wellbeing will be pushed to one side. However, there was an overall perception that regulation is also part of the wellbeing story.

> *"(EHPs) feel slightly frustrated, there's a wish and a desire to do more but obviously quite often things are driven by targets and so the timing and the capacity to be able to do what is perceived to be add-ons is much reduced."* (Interview 1)

> *"Oh definitely, yeah (regulation is part of wellbeing). I mean in the office I'm in now, for instance we have enforcement around under-age sales, not through EH but through trading standards, so that impacts on obviously people drinking under age, so you've got the health implications of that, but also you've got the antisocial behaviour which messes up people's communities and things like that."* (Interview 6)

> *"Lets look at the statutory requirements around housing and how they contribute to say mental wellbeing."* (Interview 7)

The greatest obstacle to developing the wellbeing agenda was seen as cuts in local government spending, although in some cases the new health agenda, in

particular the transfer of pubic health from Primary Care Trusts (PCTs) to upper tier authorities (DH 2010b), was seen to present new opportunities:

> *"I think it's a challenge, especially with the new or the developing ideas of how local authorities are going to look, you know, the easy council, the virtual council type models are being talked about. If they're going to be pared down to mere commissioning organisations, that's going to be the real challenge, isn't it?"* (Interview 11)

> *"(Environmental health is) a service that's being told what to do rather than a service that's actually shaping what the Wellbeing Agenda should look like."* (Interview 3)

> *"I think it's helpful in some ways that the public health function will hopefully come back into local authorities because the fact that the environmental health officer does have a great impact on people's health and wellbeing is sometimes forgotten."* (Interview 5)

There is a recognition that if the profession is to benefit from the transfer of public health from PCT to local government, it is going to have to fight to be heard and so will need a presence on the emerging health and wellbeing boards.

There is a feeling that the profession does not engage enough in developing social capital. This is felt to be because it is easier to use enforcement or the threat of enforcement to elicit behaviour change.

> *"The honest answer is not as much as I'd like to (develop social capital)...Obviously as a local authority officer you're seen with some suspicion, especially by those that knew you as an inspecting officer."* (Interview 6)

> *"The answer is that we have got no system to try and engage (with social capital). I tend to see these days that people who want to engage with us will be banging on the door anyway; the ones who don't won't be and usually it's very hard to reach them, to be honest with you."* (Interview 12).

Effectiveness and evaluation of wellbeing roles

Questions around use of research and evidence in practice elicited mixed responses and there was no clear reason why. There was a general sense overall that there was too little time for front line practitioners and research was not really seen as part of the culture of either their role or organisation, with the added challenge – in some cases – of knowing how or where to access the right sources.

A recurring factor was the general lack of knowledge around where and how to access evidence on wellbeing to inform policy. Some evidence was mentioned, such as the Housing Health and Safety Rating System (ODPM 2006) (the Private Sector Housing Evidence Base had not been launched when the interviews were carried out), the Health and Safety Executive management standards (HSE 2006) and Food Vision (CIEH 2011).

> *"Actually I don't often have time to access it (evidence). Yeah, I mean when I did my Masters' degree it brings it home to you how much stuff there is there. Sadly it's more for sociologists and medics than for environmental health people at the moment, but we've never been good at writing down what we do, sadly."* (Interview 6).

Despite the opportunity to promote wellbeing under the Local Government Act (2000) and a plethora of documents including the word wellbeing, very few interviewees used any available resources, (internet, government reports etc) to further their understanding of wellbeing. As we have noted, this tended to be seen as something so integral to the environmental health role, it had not warranted consideration as a subject in its own right. As such, those interviewed tended to look at wellbeing from their own discipline's perspective, rather than seeing it as a wider concept, with more far-reaching concerns and implications.

> *"I think there are some resources but they're not widely used by… my colleagues. I am one of the few that is maybe aware of their existence. My colleagues would not be aware of the Working for Health portal; people will not use it. I think (that's) one of the reasons why we lack research in terms of return of investment, cost effectiveness."* (Interview 2)

The profession has a very inclusive idea of who is responsible for wellbeing from it being a political issue driven by central government to business, schools, quangos, even British Waterways.

Overall, the profession has a strong sense of its role as front line practitioners promoting wellbeing but struggles

owing to the lack of a clear definition of wellbeing. This leads to difficulties when it comes to citing examples of exactly how the profession impacts on wellbeing – and is therefore unable to evaluate its wellbeing contribution.

Discussion

It is clear from this audit of front line practitioners and policy officers that while there is a definite relationship between environmental health and wellbeing, it has proven difficult to tease out a firm professional definition and that in part it is 'something about' capacity and positive mental health that is sufficient to help protect and buffer against illness and disease, but also to enable citizens to be more active within the communities and to be able to positively contribute toward them now and in the future.

Confident Communities, Brighter Futures (DH, 2010a) is therefore of great importance to the environmental health profession in establishing what the DH means by wellbeing and providing a valuable evidence base which both justifies and has the potential to enhance wellbeing. This research shows that EHPs have an intuitive understanding of the factors that support wellbeing and that these factors correlate with the DH evidence base findings.

A new approach to wellbeing is required based on sound evidence within the proposed organisational health structures to help prevent people developing poor mental health in the first place. A population-level perspective needs to be taken, focusing on promoting wellbeing and preventing ill health through early intervention. A life course approach should be taken addressing all stages of people's lives (from pregnancy to old age) while addressing wider social and economic determinants such as housing and neighbourhood quality, employment, debt, and social inequalities through partnership working across disciplines and organisations.

The Public Mental Health Framework for Developing Wellbeing (cited in DH, 2010a) is concerned with reducing risk factors and promoting positive factors to help promote meaning and purpose; developing sustainable connected communities; integrating physical and mental health and wellbeing; building resilience and a safe and secure base and ensuring a positive start in life.

Taking the EHP role in housing as an example, there are many factors that can be addressed through both regulatory and non-regulatory processes. For example, interventions can help reduce adverse childhood experiences in poor quality houses in multiple occupation and in tackling overcrowding. Application of the housing health and safety rating system and sensitive approaches to area regeneration can deliver a positive approach to health through the lifespan. Fuel poverty strategies can both help tackle debt as well as ensure a healthier start for young children, helping reduce negative effects on both physical and mental health and wellbeing in the immediate and longer term. Such interventions also address wider wellbeing in contributing to a reduction in health inequality, between education and employment outcomes, increased productivity in the workplace and in social life as well as contributing toward pro-social behavior.

There is currently much going on in the rapidly moving wellbeing agenda (Knight, A and McNaught, A forth-coming). Confident Communities, Brighter Futures (DH, 2010a) provides a useful evidence base of great importance to the environmental health profession, one of several key professions involved in its delivery in partnership with others. The new proposals for public health and wellbeing delivery are also currently unfolding, with the publication of two white papers concerned with reorganising delivery of the public health agenda, with proposals for public health to be returned to local authorities and the establishment of new health and wellbeing boards.

Simultaneously, the Public Mental Health Strategy, No health without mental health (DH, 2011), requires a more proactive approach to preventing mental ill health. The strategy recognises the importance of the EHP-enforced Health and Safety Management Standards in reducing stress in the workplace while acknowledging the interconnections between mental health, housing, employment and safe communities. The strategy also acknowledges the importance of considering mental health when looking at emergency planning and recovery. An ongoing review of the Civil Contingencies Act (2004) is to include proposals to make the mental health of communities a key consideration when planning for emergencies.

The Coalition Government has also tasked the Office of National Statistics (2011) with finding a measure of national wellbeing.

In order to reduce the number of people suffering mental ill health, it is necessary to reduce risk and promote protection, focusing on promoting wellbeing

and preventing ill health through early intervention across the lifecourse. Like public health, this requires a focus on health determinants and partnership working to help ensure a sustainable approach. The document (DH, 2010a) recognises the need to address factors that may prevent a risk of poor mental health in later life. These include adverse childhood experiences; violence and abuse; poor physical health; alcohol and drug misuse; low educational attainment; unemployment and debt; poor quality housing and fuel poverty and vulnerability: looked after children; recently released prisoners; offenders; the homeless.

It is clear that environmental health with its various roles and disciplines has a role to play in positive mental health and wellbeing outcomes, but there is still some way to go. EHPs, for example, help reduce health inequalities, affecting morbidity and mortality and are involved in encouraging positive health behaviours (e.g. in food security and nutrition and health and safety, particularly stress at work). They also impact on educational outcomes by addressing overcrowding in the home or neighbourhood nuisance and behavioural issues, all of which have a positive effect on wellbeing.

EHPs often work in partnership on projects linked to safe drinking, controlled licensing, underage alcohol sales and alcohol-free zones. All these initiatives impact on anti-social behaviour and reduce alcohol-related violence and so contribute to better mental health.

There are, however, still areas where EHPs could more fully evaluate their influence on wellbeing and so play a far greater role. Most notably, Confident Communities, as well as this research, demonstrates the need for developing the social capital role and this is absent, despite the fact that housing and community-based EHPs work closely within their communities.

EHPs have a direct involvement in some issues such as good housing and better working conditions. In other areas, they have a more peripheral involvement, such as contributing toward a good quality family environment and improving childrens' educational attainment, addressing debt (e.g. through fuel poverty strategies), preventing smoking (through law enforcement and contributing toward health promotion campaigns) as well as encouraging more physical activity to help reduce obesity.

But it is perhaps their roles in sustainable communities where EHPs can potentially have most impact, working in partnership to improve local neighbourhoods, helping develop social capital and contributing toward personal and community resilience.

Griggs *et al.,* (2008) shows that improving the quality of neighbourhoods can help to tackle the wider determinants of health and wellbeing. The sort of factors that degrade the built environment and so negatively impact on wellbeing are graffiti; abandoned cars; abandoned buildings; poor maintenance of buildings; litter; overcrowding; lack of places to stop and chat; dampness; lack of recreational facilities and green spaces; fears for personal safety; traffic; parking, and noise. While EHPs have a role to play in trying to maintain existing built environments there is also a role for them when it comes to planning wellbeing into our communities.

Access and views to safe green spaces and greater engagement with the environment (Marmot Review 2010 policy objective E) has been shown to have multiple benefits on mental and physical wellbeing as well as influencing components of resilience.

Social capital, described as the collective value of a person's social networks, is a key aspect of mental wellbeing and of stronger connected communities. Three types of social capital are frequently identified: bonding, ties between groups including friends and family; bridging, social and work acquaintances; linking, local, political and community structures. This research reveals that despite the close relationship EHPs have with the communities they serve, there appears to be little awareness of the profession's opportunity to build on the bridging aspect of social capital.

Conclusions

It is clear from this work that there is a close synergy between Confident Communities, Brighter Futures (DH, 2010a) and the role of EHPs, which is clearly one of the most important front line professions actively implementing the wellbeing agenda. However, for many, this relationship is more implicit than explicit and there may be a need for the environmental health profession to further define wellbeing within the context of environmental health to help encourage further joined up thinking with other partners to further enhance wellbeing delivery based on sound evidence. This work also suggests a need to better disseminate existing research to the environmental health profession, which many help enhance interventions and strategies in order

that the wellbeing agenda can focus more closely on enhancing positive mental health for all.

However, these are challenging times for service delivery and the wellbeing agenda is under threat in light of the proposed public sector cuts; this provides both opportunities and threat, to environmental health in reviewing their roles where possible and demonstrating further the very positive contribution the profession already makes to wellbeing, but also the potential for future work in this area.

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Effects of legal aspects on the use of compulsory procedures in environmental health and food control

Outi Lepistö[1] DVM Ph.D, Prof Marja-Liisa Hänninen[2]

[1] Environmental health chief, Department of Food and Environmental Hygiene, University of Helsinki, Finland
[2] Department of Food and Environmental Hygiene, University of Helsinki, Finland

Correspondence: Prof Outi Lepistö, Department of Food and Environmental Hygiene, University of Helsinki, 00014 Helsinki University, Finland. Telephone: +35840 8249475. Email: outi.lepisto@helsinki.f

Abstract

The concept of compulsory procedure in this study describes situations in which restrictions are imposed by local environmental health authorities to establishments in the fields of environmental health or food industry. In these cases the various legal aspects and their enforcement must be considered in addition to potential health hazards, which are intended to be eliminated via the compulsory procedures. The purpose of the legal factors is to ensure appropriate legal protection and efficiency. The aim of this study was to determine whether the various legal factors influence the decision-making process in the compulsory procedures, public health protection and food safety. The legal aspects of compulsory procedures were examined through theoretical and empirical research. The study comprised interviews with 46 Finnish municipal environmental health authorities and meat inspection veterinarians to evaluate their attitudes and professional knowledge on the concepts of good governance and compulsory procedures. The focus in both the theoretical and empiric parts of the study was on the legal principles of administration, basic rights of citizens and efficiency of the regulations in both Finnish and EU legislation. The three main critical points in the decision-making of authorities in environmental health were the application of legal principles of administration, solution of the conflict between basic rights and the efficiency of the regulations applied in environmental health and food control. In conclusion, these factors impact the practice of compulsory procedures and through this to health protection and food safety. Furthermore, shortcomings in realisation of the legal aspects were observed in local environmental health and food control in Finland.

Key words: Administration, basic rights, compulsory procedures, food safety, health protection, legal principles, legality

Introduction

This study focuses on the legal aspects of compulsory procedures in local environmental health and food control in Finland (The Food Act, The Finnish Ministry of Agriculture and Forestry, 2006; The Health Protection Act, The Finnish Ministry of Social Affairs and Health, 1994). In Finland the municipalities are responsible for arranging the local environmental health control. The local authorities work in municipalities under orders and guidance of the Finnish Food Safety Authority Evira, which in turn is responsible for management, advice and guidance of local authorities (Laki Elintarviketurvallisuusvirastosta, The Finnish Ministry of Agriculture and Forestry, 2006).

The term compulsory procedure is considered as one in which a competent authority prescribes requests, orders or prohibitions to entrepreneurs or citizens, withdraws a food ingredient from the market, seizes foodstuffs, rejects the use of foodstuffs of animal origin supplied by another member state of the European Union at the first destination, cancels approvals or levies the penalty payments (The Finnish Ministry of Agriculture and Forestry, 1998; The Finnish National Food Agency, 2001; The Finnish Food Safety Authority, 2009). Another term used for these procedures is administrative coercive measures (The Food Act, The Finnish Ministry of Agriculture and Forestry, 2006). The use of compulsory procedures is advised in general guidance book published by Evira (The Finnish National Food Agency, 2001; The Finnish Food Safety Authority, 2009).

The legal aspects considered in this study are the legal principles of administration, the basic rights of citizens and the efficiency of regulations. These aspects can also be seen as factors comprising *the principle of good governance* (Lepistö, 2008), which refers to the regulations concerning governance and administration in The Constitution of Finland (The Finnish Ministry of Justice, 1999), Administrative Procedure Act (The Finnish Ministry of Justice, 2003) and the legal principles of administration in Finnish legislation.

The aim of this study is to investigate the impact and significance of legal aspects in protecting public health and ensuring food safety. The study includes both a theoretical examination of the legislation concerning administration and environmental health in Finland and the EU as well as an empirical study of the knowledge and attitudes of Finnish local environmental health and food control authorities regarding legal aspects and compulsory procedures.

Theoretical aspects on legality in environmental health

The basis for good governance is written in Finnish constitutional and governance legislation (The Constitution of Finland, The Finnish Ministry of Justice, 1999; Administrative Procedure Act, The Finnish Ministry of Justice, 2003). The basic principles of European administration are written in The European Code of Good Administrative Behaviour (European Parliament, 2001), Charter of Fundamental Rights of the European

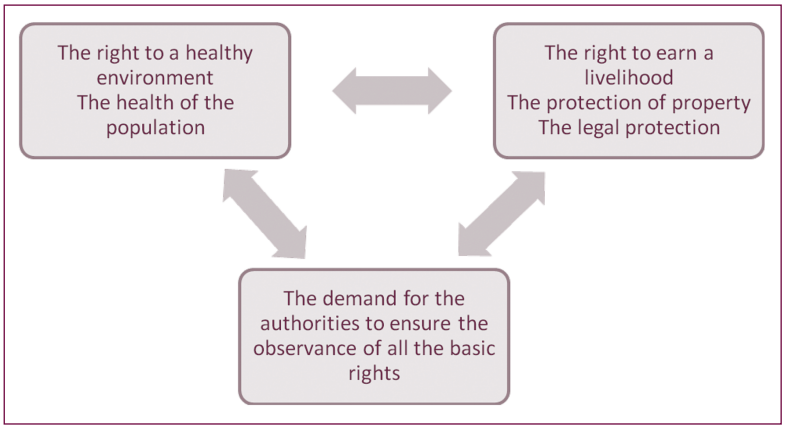

Figure 1.0
Conflict of the basic rights in the field of environmental health and food control.

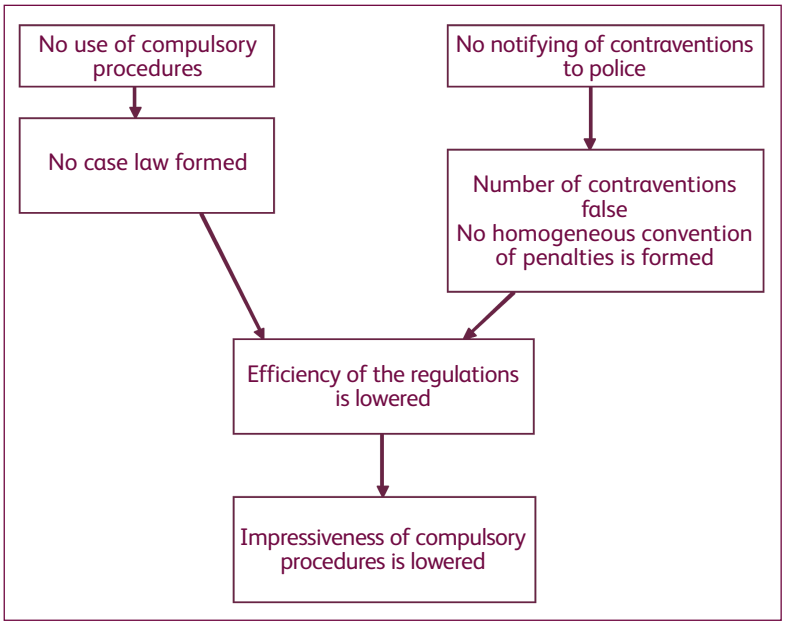

Figure 2.0
Impact of efficiency of the regulations on environmental health and food control compulsory procedures.

Union (The European Parliament and the Council and the Commission of European Communities, 2000) and in a White Paper of European Governance (Commission of European Communities, 2001). In both legislations, the legal principles of administration as well as the basic rights of citizens are strongly emphasised.

The legal principles of administration are regulated in the Finnish Administrative Procedure Act. Section 6 stipulates that an authority must treat everyone equally (the principle of equality) and use its competence in legally accepted means only (the principle of legality). Furthermore, the actions of authorities must be objective (the principle of objectivity). The legal principles of administration can also be seen as part of a legal system that is not written in any specific law but is formulated through legislation, legal order, case law, administration and values of society (Mäkinen, 2004; Ryynänen, 1991; Tähti, 1995). Public authorities are obliged to follow these principles in their actions in addition to the written and specific regulations. In the EU, the principles are of special significance, because the Union legislation does not include any uniform administrative regulations. The principles in the Union have been strongly influenced by

True or false questions	Municipal authorities		Meat inspection veterinarians	
	Yes	No	Yes	No
Have compulsory procedures been delegated to officers in the place where you work?	8 (33 %)	16 (67 %)	22 (100 %)	0
Do you believe that the compulsory procedures intensify the control and food safety?	22 (92 %)	1 (4 %)	18 (82 %)	3 (14 %)
Have you ever made a report to the police in accordance with compulsory procedures?	8 (33 %)	15 (63 %)	1 (5 %)	20 (91 %)
Do you know what the demands of the Administrative Procedure Act and good governance are?	17 (71 %)	6 (25 %)	7 (32 %)	14 (64 %)
Do you know what the legal principles of administration are?	20 (83 %)	2 (8 %)	8 (36 %)	14 (64 %)
Do you believe that the administrative processes in decision-making are important?	21 (88 %)	1 (4 %)	13 (59 %)	5 (23 %)
Do you believe that you need more advice and education in good governance and the practising of compulsory procedures?	20 (83 %)	4 (17 %)	18 (82 %)	1 (5 %)
Has the change in legislation had some effect on practising the compulsory procedures?	4 (17 %)	17 (71 %)	1 (5 %)	19 (86 %)
Do you believe that the change in legislation was for the better, considering the practice of compulsory procedures?	13 (54 %)	1 (4 %)	4 (18 %)	1 (5 %)

Table 1.0
True or false questionnaire and answers of Finnish municipal authorities and meat inspection veterinarians in environmental health and food control (n = 46).

European Court case law and are defined in detail in the White Paper of European Governance as well as in the Charter of Fundamental Rights of the European Union. An authority must be aware of these principles and in accordance with them must treat all similar cases equally, follow all the legislation and directions concerning the matter at stake and make a decision uninfluenced by any subjective views or opinions he or she may have.

In cases where it is necessary to undertake compulsory procedures, the main problem of the environmental health authority is how to comply with the various basic rights that are enshrined in legislation. The Constitution of Finland Section 19 stipulates that the public authority shall promote the health of the population. Furthermore, Section 20 specifies that the public authorities shall guarantee everyone the right to a healthy environment. On the other hand, Section 15 of The Constitution of Finland specifies that everyone's property is protected and that everyone has the right to earn his or her livelihood of his or her choice (Section 18). Furthermore, Section 22 of the Constitution of Finland stipulates that authorities guarantee the observance of all the basic rights mentioned.

Similarly Charter of Fundamental Rights of the European Union Article 16 states that everyone has the right to conduct a business and Article 17 that everyone has the right to own and use his or her lawfully acquired property. Article 35 specifies that a high level of health protection shall be ensured in definition and implementation of all Union policies and activities.

When it is necessary to engage in compulsory procedures, the authority is obliged to observe all these regulations pertaining to the basic rights of citizens. The basic rights in these situations, however, in many ways conflict with the issues of public health protection. An effort to observe them all can be described as a contradictory situation. The case is called conflict of the

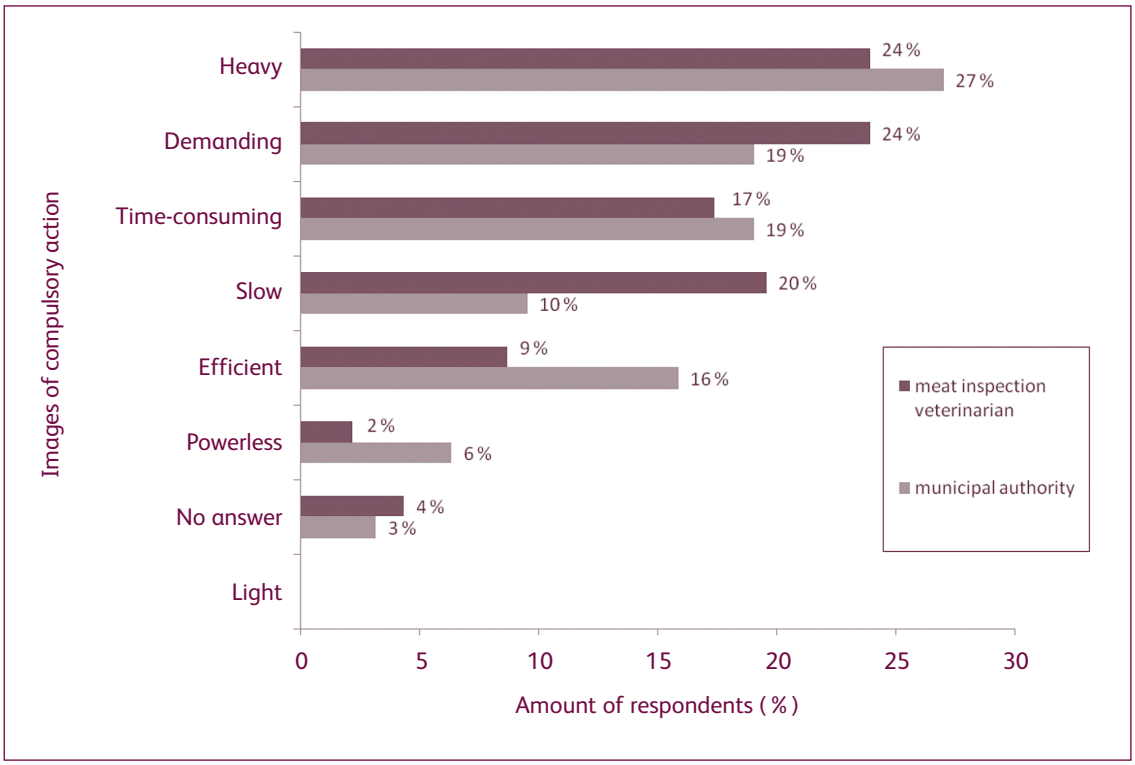

Figure 3.0
The view of Finnish local environmental health and food control authorities (n = 46) on the application of compulsory procedures.

basic rights in the field of environmental health and food control and is illustrated in Figure 1. The conflict can be considered as a critical point in application of both good governance and public health protection.

The regulations written in legislation are not automatically efficient in practice (Ross, 1951; Kelsen, 1968). The efficiency of regulations is influenced by many factors, one of which is the activities of authorities themselves. If the authorities regularly take action in every case of contravention of legislation, the probability of consequence is high. This probability of consequence forms the empiric validity of the regulation (Klami, 1980; Heuru, 2003). In environmental health, the efficiency of regulations is mostly affected by notifying the police in a case of contravention and in undertaking the compulsory procedures when necessary (Figure 2).

Empirical study

The empirical part of the research was conducted to explore the practical application of legislation in environmental health control among Finnish local environmental health and food control authorities. The aim was to explore the application of the legal principles of administration and compulsory procedures as well as actions in contravention situations. The study was conducted in August 2006 by sending an electronic questionnaire to 30 municipal regional control units and to 42 meat inspection veterinarians working under the Finnish Food Safety Authority (Evira) in slaughterhouses and meat-processing establishments.

The answers were recorded and analysed, using MS Excel Software (Microsoft Corporation, Redmond, WA, USA). Statistical analysis was conducted, using SPSS 15.0 software for Windows (SPSS Inc, Chicago, IL, USA). A Chi-square test was performed to analyse the differences between the municipal authorities and meat inspection veterinarians at the 95 % level (p-value < 0,05).

Results

46 (67 %) of the 72 veterinarians responded. The answers to the true-or-false questions are shown in Table 1. A total of 22 municipal authorities (92 %) and 18 meat

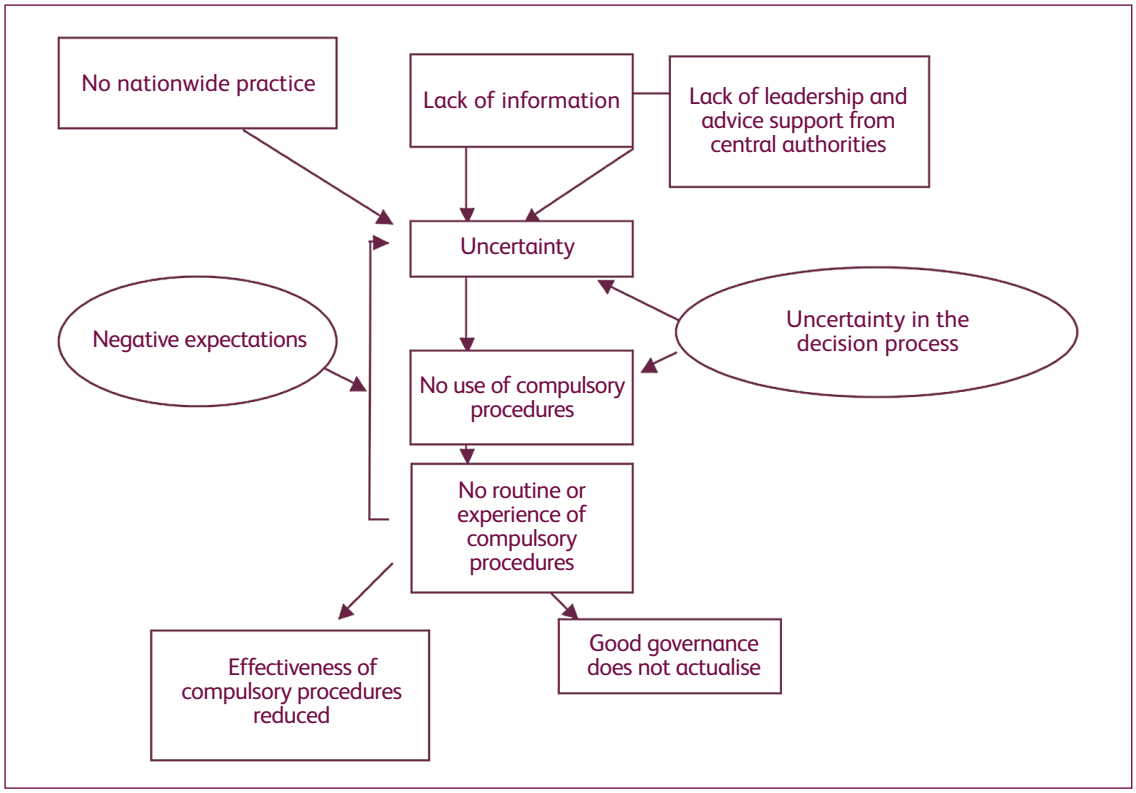

Figure 4.0
Effect of professional knowledge and attitudes on environmental health and food control compulsory procedures among Finnish municipal authorities and meat inspection veterinarians.

inspection veterinarians (82%) believed that the compulsory procedures intensify control actions and thus improve food safety. The views of compulsory procedures among the respondents are shown in Figure 3. The respondents also described the process as the only feasible way in severe cases and a failure as a bad way to handle things or "meat inspection veterinarians *never* use the compulsory procedures". Answers to the question of how authorities would like to change or develop the procedure included the following: uniform directions and guidance, encouragement from the central administration, models that can be applied, or standard forms and judicial aid. Five municipal authorities and one meat inspection veterinarian believed that the situation would not improve except through better guidance and national uniformity in performance of the processes throughout Finland.

An abundance of uncertainty among the respondents, concerning the demands of good governance and legal principles of administration, was noted. Many respondents were not certain what the demands were. Answers such as "the reason for not using the compulsory procedures is exactly the uncertainty about these things" demonstrated much about the uncertainty and confusion of the authorities. The consequences of this insecurity are shown in Figure 4. The knowledge of the demands of the Administrative Procedure Act and good governance among municipal authorities and meat inspection veterinarians differed significantly (Chi-square test, $p < 0{,}001$). The difference between the two professional groups concerning perception of the importance of administrative processes was statistically significant with Chi-square test ($p < 0{,}001$) so that municipal authorities were more aware of importance of these processes.

The majority of authorities (83% municipal authorities and 82% meat inspection veterinarians, respectively) believed that they would need more advice, training and practice in the management of good governance and compulsory procedures. Ten of the municipal authorities also presented proposals on how to improve their administrative skills, such as model cases prepared by the leading central food authorities, implementation of brief

but practical guidance packages and organisation of annual mandatory training for all authorities on the use of compulsory procedures.

According to the Finnish Food Act (2006), when an authority observes that the legislation is not being followed, an officer must, besides using the compulsory procedure, also make a report to police office. A total of eight (33%) of the municipal authorities and only one meat inspection veterinarian (5%) had prepared a report to the police office in accordance with compulsory procedures, which was found to be statistically significant ($p = 0{,}023$).

Discussion

Strict follow-up of the legal principles of administration is of crucial importance in situations where the basic rights of entrepreneurs are restricted, such as in application of compulsory procedures. The results of the empirical part of this study showed that these principles are nevertheless not well known among Finnish local environmental health and food control authorities. The other demands of good governance were likewise not well known, which can diminish their application. The knowledge and practice of implementation of compulsory procedures of the meat inspection veterinarians' was more substandard than that of municipal authorities. Compulsory procedures were not considered as practical and efficient tools but rather as a cumbersome process. Only 16% of municipal authorities and 9% of meat inspection veterinarians considered the procedure to be efficient. Furthermore, the answers of the respondents concerning the demands of administration and the use of compulsory procedures showed that the legal principles of administration were not necessarily fulfilled in the decision-making process of the authorities. If the authorities have negative attitudes towards the procedure and the demands of administration, this may influence their activities, which is apparently the case among some meat inspection veterinarians, according to their opinions. If the knowledge and preconditions of using compulsory procedures are not similar among all authorities, this leads to a situation where in similar cases some authorities use the compulsory procedures when needed while other authorities do not. This can cause regional inequality among the targets of the control actions and the principle of equality is not realised. This shows clear shortcomings in the decisions of Finnish local environmental health authorities concerning compulsory procedures and this in turn caused inequality among entrepreneurs (Lepistö *et al.,* 2009). A similar trend can be seen in other EU Member states, too. A study carried out by the Food Standards Agency (2003) in England shows that only 5% of all control actions were classified as compulsory procedures. Furthermore, over half of the local authorities have not taken any prosecution actions and the number of prosecutions seems to be falling. The local authorities feel that they do not always have necessary competence to carry on the processes (The Food Standards Agency, 2003). In addition, if the authorities are not aware of all existing administrative legislation in their decision-making, the principle of legality is strongly endangered, a situation that can occur because of inadequate training, guidance and directions. The lack of a common, nationwide practice, advice and directions given by the central authorities causes uncertainty, which prevents the local authorities from undertaking the compulsory procedures. The authorities' own negative expectations and their fear of appeals or mistakes can also have the same effect. The culture of control in Finland has been more directional than authoritative, and that can prevent those authorities who otherwise think these procedures are effective, from using them. The results from this study suggest a clear need for more specialised training, additional advice and detailed regulations concerning the application of compulsory procedures and their legal aspects.

The balanced handling of the "conflict of basic rights in the field of environmental health and food control" can be considered as another critical point in the practice of compulsory procedures. To decide whether to use this procedure, an authority must observe and weigh all the basic rights and ensure their realisation. This entity includes consideration of the basic rights of the population or of the individual person whose rights of health and healthy environment can be endangered. In addition, the basic rights of the targets of the procedure, which include the right to property and the right to earn a livelihood, will be endangered as well. The capability of resolving and balancing the conflict is dependent considerably on the authority's professional skills, attitudes and experience, especially in the demands of good governance. This balancing between seemingly contrasting rights requires extensive knowledge and experience of administrative and special legislation and demands.

The third important aspect in the practical application of legal aspects in compulsory procedures and, especially, their final targets, ensuring healthy environment and food safety, is the efficiency of the existing regulations. The efficiency of these regulations can strongly influence the public health sector. This efficiency was affected mostly

through the authorities' own activities. In this light, it is important to note that only one meat inspection veterinarian and eight municipal authorities had ever notified the police office in the context of compulsory procedures. In addition, many of the authorities had never used compulsory procedures, answering that they never would do so. This may endanger the fulfilment of EU legislation's demand concerning the goals of food control, which is stated in Regulation 882/2004 (European Parliament and Council Regulation 882/2004), Article 55 of which states that "every member state shall lay the rules on sanctions applicable to infringements of feed and food law and take all measures necessary to ensure that they are implemented. The sanctions must be effective, proportionate and dissuasive." However, if the police are not notified, the sanctions cannot be carried out and the probability of consequences is diminished. Furthermore, the perception of criminality rate in the environmental health and food sector is distorted and there will be no case law formed in the field. On the other hand, the requirement to involve the police in the process can make the authorities less reluctant to use the compulsory procedures. If there were a homogeneous convention of penalties, this would also serve as a preventive factor in control. To switch the emphasis of control in environmental health to a more preventive direction requires actions to increase the effectiveness of the regulations. This could be mainly done by the professional training of authorities, developing practical guidance and constructing nationwide uniformity in practice of the compulsory procedures.

Conclusions

The results from this study clearly indicate that the legal aspects of compulsory procedures in environmental health and food control have a definite impact on furthering the protection of public health and ensuring food safety. The three main critical points in the procedure were:

1 application of the legal principles of administration;

2 solution of the conflict of basic rights; and

3 efficiency of the regulations applied in environmental health and food control.

The main means of influencing these factors are:

1 focusing the knowledge and attitudes of competent authorities on the practice of compulsory procedures and demands of good governance through training, guidance and directions;

2 increasing the consequences of contraventions by undertaking the compulsory procedures and notifying them to the police; and

3 developing more uniform nationwide practices that authorities can consistently follow. Improvement in these areas will change the emphasis of control towards more preventive means and thus increase the efficiency of public health protection. There is an increased need for research in this sector, especially in the administrative and legal aspects of environmental health and food control.

Acknowledgements

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Lead in drinking water – a contemporary public health concern

S Jones[1], D Russell[2], C Whiteside[1], R Atenstaedt[1], A Jones[1], J Cannon[3], J Thompson[4], H Brunt[5]

[1] Public Health Wales, North Wales
[2] Chemical Hazards and Poisons Division, Health Protection Agency, UWIC
[3] United Utilities Operational Services, Dinas, Llanwnda, Caernarfon, Gwynedd
[4] National Poisons Information Service, Cardiff
[5] Public Health Wales, Cardiff

Correspondence: Ms Siobhan Jones, Specialty Registrar Public Health, Preswylfa, Hendy Road, Mold, Flintshire CH7 1PZ. Telephone: 01352 80 3551 / 07738861943. Email: siobhan.jones2@wales.nhs.uk

Abstract

The acute and chronic health effects of lead exposure are numerous and well documented. Legislation to control the use of lead has ensured that acute poisoning from high levels of lead exposure is now rare in developed countries. Evidence suggests that there is no safe threshold of exposure and thus health effects from chronic exposure to low levels of environmental lead have been shown

Historically, lead in drinking water has been associated with lead piping used in the plumbing of older houses. More recently, the issue of high lead levels in drinking water in new houses because of the use of lead solder on drinking water pipework has been highlighted in Scotland. This paper details the multi-agency response to an incident where high lead levels were found in the drinking water of a number of new properties and developments in North Wales, UK.

Following a complaint by a resident, water samples were obtained from a house in a new residential development. The level of lead in the free flowing water sample taken at the kitchen tap was 205µg/l, compared with the regulatory limit of 25µg/l. Further testing found high lead levels in neighbouring properties and estates. In total, six new housing estates were identified as part of this incident, involving a total of 31 properties and 52 residents. Further analysis showed lead solder used on the drinking water pipework within the house was responsible for the lead contamination of the water and not the external water supplies.

A multi-agency Incident Management Team (IMT) was convened. The IMT agreed a process for hazard identification, risk assessment, risk management and risk communication. Residents were advised to flush water through before drinking or using for cooking. In addition, an alternative supply of water was provided. Questionnaires were used to assess risk to the individuals in the affected properties and 26 individuals provided biological samples to inform the exposure assessment component of the risk assessment. Risks were communicated to residents via letters and press statements, and advice was provided by the Incident Management Team to local NHS services. The issue was resolved through appropriate plumbing remedial works

Key words: Lead, drinking water, multi-agency public health response.

Introduction

Lead is a naturally occurring, abundant and versatile heavy metal which has a long history of use in industry, paint, plumbing and fuel. It is consequently widely distributed in the environment in air, soil, food and water. The acute and chronic health effects of lead exposure are numerous. Long-term exposure can cause anaemia, gastro-intestinal disturbances and can affect the peripheral and central nervous system. The symptoms of lead exposure can include headaches, irritability, tiredness, muscle weakness and impaired cognitive development in children (HPA, 2007a; Tong *et al.,* 2000). At very high levels of exposure, lead can cause damage to most organs in the body, particularly kidneys, blood and central nervous system and death can occur at very excessive levels (Tong *et al.,* 2000).

Legislation to control the use of lead in industry, fuel, water and paint has ensured that acute poisoning from high levels of lead exposure is now rare in developed countries (SCIEH, 2003). However, studies from the last 30 years have shown that health effects can also result from chronic exposure to lower levels of lead. In particular, the epidemiological evidence indicates that chronic exposure to low levels of environmental lead can adversely affect cognitive development in children (Canfield *et al.,* 2003; Chandramouli *et al.,* 2009). The World Health Organisation and the US Centers for Disease Control have set the international acceptable level of lead in the blood – the 'threshold of concern' at 10µg/dl (CDC 1991; WHO, 1995) . Recent studies however, suggest that there are effects on children's educational attainment even at blood lead levels below 10µg/dl(Canfield *et al.,* 2003; Chandramouli *et al.,* 2009).

Children are still growing and developing which means they can be more susceptible to harm from environmental exposures. They are also more likely to put objects contaminated with dust and soil in their mouths. It is known that "intake of lead per unit body weight is higher for children than for adults" (Tong *et al.,* 2000). Pregnant women are also considered to be more vulnerable to environmental exposures owing to the risks to the developing foetus (SCIEH, 2003; HPA, 2007a). In response to this, a new drinking water quality standard will come into force in 2013 (HPA, 2007b). The new standard requires that levels of lead in drinking water must be below 10µg/l (currently the standard is below 25µg/l). The Children's Environment and Health Action plan (HPA, 2007b) highlights lead in water as a priority

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area for action and emphasises the need to improve the monitoring of drinking water for high lead levels in anticipation of the new drinking water standard. All these issues have particular relevance to the incident described in this paper, as it involved high lead water levels in new housing estates, often popular with families.

Historically, lead in drinking water has been associated with lead piping used in the plumbing of older houses, typically Victorian. More recently however, the Scottish New Homes Lead Survey (SCIEH, 2003) highlighted the issue of high lead levels in drinking water in new houses owing to the use of lead solder on drinking water pipework. The survey found 15% of the 661 houses surveyed had "elevated levels of lead in tap water consistent with the use of leaded solder", with a follow-up survey highlighting that this was likely to be an underestimate of the extent of its use in new homes in Scotland (SCIEH 2003). Water Supply Bylaws and the Water Supply (Water Fittings) Regulations 1999 banned the use of lead solder as a jointing agent. The Scottish Survey report concluded that the *"use of lead solder represents an avoidable hazard in terms of an unnecessary additional body burden of lead and a potential cause of lead toxicity, especially for vulnerable groups including very young children and pregnant women",* (SCIEH 2003).

The paper investigates an incident where high lead levels were found in the drinking water of a number of new properties and developments in North Wales, UK. The paper describes the incident in detail, the subsequent investigation and the multi-agency public health response. Policy development and regulation are also discussed.

The incident

In March 2007, following a complaint by a resident of 'cloudy tap water', water samples were obtained from the kitchen tap at a house in a new residential development in Anglesey, North Wales.

The level of lead in the free flowing water sample was reported to be 205µg/l, as compared with the current regulatory limit of 25µg/l. This finding was incidental and unrelated to the initial complaint about cloudy water. Dwr Cymru Welsh Water (DCWW) informed the National Public Health Service for Wales (NPHS) Health Protection Team of the result.

Further water samples obtained from a neighbouring house on the same estate showed lead levels of 49µg/l. All water samples were collected in a 1,000ml high density polythene bottle (HDP). The samples were then submitted for analysis to Severn Trent Services, a NAMAS accredited laboratory. The method used to analyse the lead samples by Severn Trent is an in-house method based on SCA bluebooks, and Agilent 7500 Series ICPMS Chemstation (G1834B) – Operator's Manual Rev A 2006/06. The isotopes detected were 206, 207 and 208 (Severn Trent Services SBC 44).

Analysis of the solder sample taken from the kitchen tap pipework at this property confirmed that the solder comprised 61% lead. Samples collected from the hydrant outside the residential properties were compliant with drinking water quality standards for lead, suggesting that the lead solder used on the drinking water pipework was responsible for the lead contamination of the water and not the external water supplies.

Public health response

In response to the incident, a multi-agency Incident Management Team (IMT) was convened, comprising representatives from NPHS (Local Public Health Team, Health Protection Team, Communications Team and Communicable Disease Surveillance Centre), Anglesey and Gwynedd Local Health Board's and Local Authorities, National Poisons Information Service, Health Protection Agency and DCWW. This was deemed to be the most appropriate way to ensure a timely and coordinated public health response.

The IMT, co-chaired by the NPHS Local Public Health Director and the Consultant in Communicable Disease Control, agreed that a full water survey of all residential properties on the estate should be undertaken. As part of the immediate public health response, letters were distributed to all residents to inform them of the planned testing of their drinking water and to advise them to flush the water supplies for at least five minutes before drinking or using the water for cooking purposes. Bottled water was also provided by DCWW. NPHS Staff were available to address related queries from residents.

Exposure assessment

In order to assess the extent of the problem, DCWW collected samples from other new housing estates in the area. From these samples, high lead levels were

Properties	Overnight Stagnation (µg/l) (Collected from kitchen tap)	Kitchen Cold Tap (µg/l)	Kitchen Hot Tap (µg/l)	Bathroom Cold Tap (µg/l)	Bathroom Hot Tap (µg/l)	Kitchen Cold Tap after 5 min flush (µg/l)
Anglesey 1	230	205	94	25	170	3.1
Anglesey 2	Not tested	69	16	9.1	4.6	2.3
Anglesey 3	225	43	225	174	62	<0.5
Anglesey 4	83	17	90	208	1570	<0.5
Anglesey 5	320	18	73	0.7	20	1.9
Anglesey 6	590	28	17	3.5	33	<0.5
Anglesey 7	90	63	8	80	42	1.4
Anglesey 8	82	Not tested	Not tested	Not tested	Not tested	Not tested
Anglesey 9	99	33	6.4	52	11	0.7
Anglesey 10	24	13	53	5.2	37	<0.5
Anglesey 11	425	60	32	3	12	1.7
Anglesey 12	230	Not tested	Not tested	Not tested	Not tested	Not tested
Anglesey 13	<0.5	Not tested	Not tested	Not tested	Not tested	Not tested
Gwynedd 1	250	255	35	700	730	4.2
Gwynedd 2	72	14	73	61	57	1.9
Gwynedd 3	37	13	47	112	9.4	1.3
Gwynedd 4	26	33	42	405	37	1.4
Gwynedd 5	88	47	45	1300	1080	3.2

Table 1.0
Results from water sampling.

found in one small housing estate in a nearby town in Gwynedd. Initial results from a property on this second estate showed overnight stagnation lead levels of 91µg/l. Water sampling activity was extended to cover all five properties on this estate. Residents were advised to flush through drinking water or were offered bottled water to use for drinking and cooking.

Results of all water samples taken showed high lead levels in at least one water sample in 12 of the 13 sets of sampling results from the Anglesey properties and all of the five Gwynedd properties (Table 1). Lead levels ranged from 3µg/l to 1,570µg/l. Overnight stagnation levels were collected from the kitchen taps in the properties and ranged from 24µg/l to 590µg/l. Flushing the taps for 5 minutes was shown to reduce lead levels to within acceptable limits (<5µg/l).

Local knowledge of the incident led to links being made with other housing developments built by the same developer in North West Wales. Further water testing was carried out on these properties, and the results also showed high levels of lead in their drinking water. In total, six new housing estates were identified as part of this incident, involving a total of 31 properties and 52 residents

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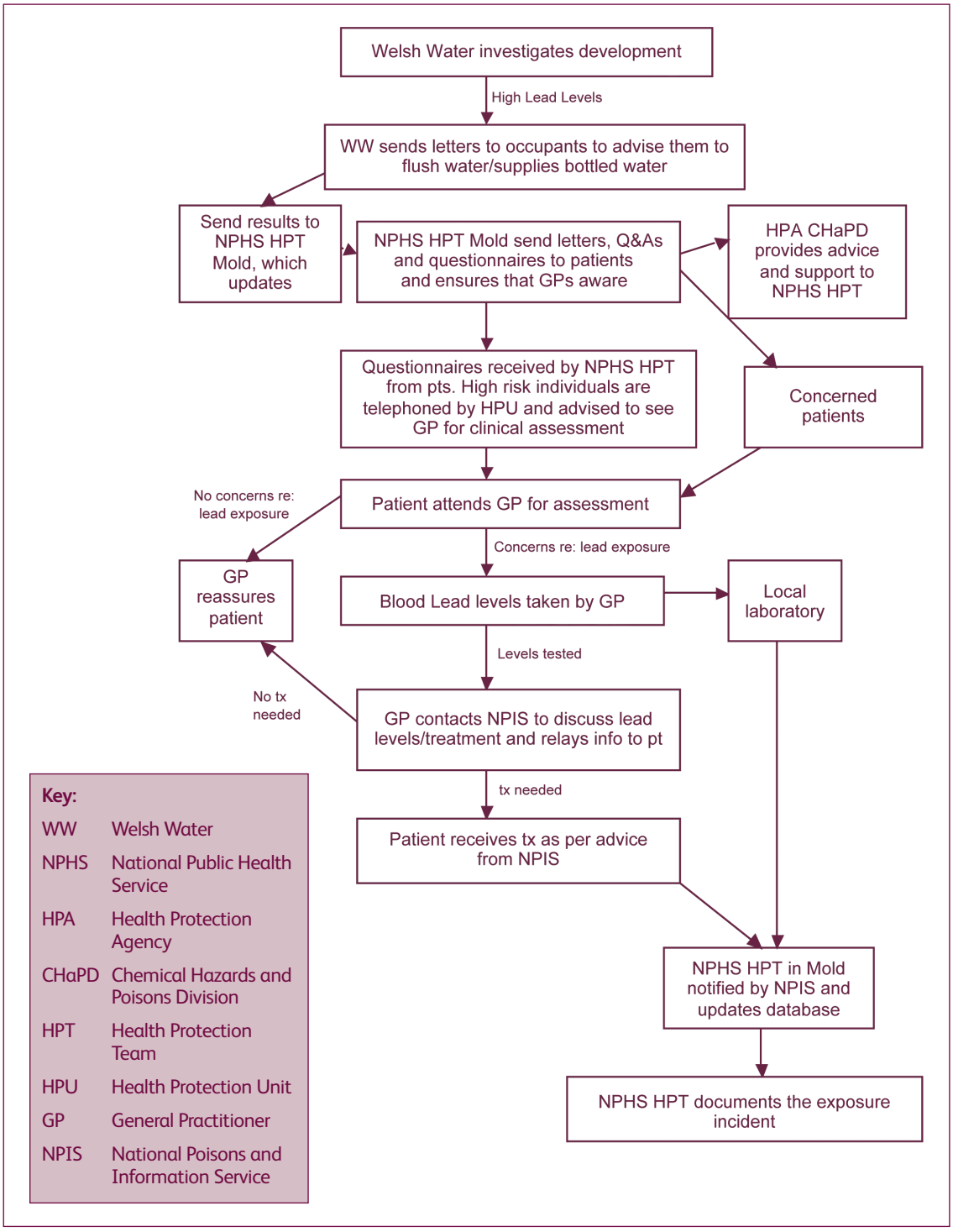

Figure 1.0
Flow chart for public health management of lead incident in Wales.

Risk assessment

The IMT agreed a process for the assessment of risk to the individuals in the affected properties. This process involved questionnaires being sent to residents in order to obtain details of the household members and determine whether they met the pre-agreed selection criteria for vulnerability (young children aged six years or under, pregnant women and women who are breastfeeding) and length of time resident in the property. Figure 1 shows the process developed by the IMT for the management of the risk assessment process.

Following the risk assessment, 26 individuals were contacted and invited to attend their GP practice for clinical assessment including testing of whole blood lead levels. Bloods were taken at the GP practice and sent to the local acute hospital. They were then sent to the specialist trace elements reference laboratory at University Hospital Wales, Cardiff, a CPA accredited laboratory (see Figure 1). There were complaints of symptoms such as fatigue, weight loss and gastro-intestinal disturbances, in a minority of these individuals. These individuals were assessed and followed up by their GP.

According to A Wayte, the principal biochemist at Ysbyty Gwynedd, an 'acceptable' blood lead level would be expected to be below 0.5µmol/l. For occupational exposures, only those with blood lead levels over 1.45µmol/l would be followed up (Health and Safety Executive 2002). Reassuringly, the majority of residents tested had blood lead levels below 0.5µmol/l (23/26). The highest blood lead concentration result obtained was 0.79µmol/l.

Risk communication

In light of the scale of this incident the IMT considered risk communication to be a priority. Regular updates (advice letters, Q&A sheets) were provided by the IMT to keep residents informed of the investigation. DCWW informed residents of water sampling outcomes. The IMT also issued press statements and provided advice to all GPs in Anglesey and Gwynedd, the local acute hospital and to those covering out of hours primary care services.

Remedial action

DCWW continued to supply bottled water to residents at the affected properties until appropriate remediation was carried out on the plumbing. The plumbing contractor replaced the plumbing in the Anglesey properties and the Gwynedd residents had to claim on their buildings insurance for the remediation work because the developer was declared bankrupt.

Discussion

The introduction of unleaded petrol in recent years has had a significant public health impact and ensured reductions in ambient air lead levels (Tong *et al.,* 2000). This paper highlights to environmental and public health professionals that despite these advances, lead is still an important and contemporary public health issue.

Public health professionals need to be aware of this and consider lead exposure as a possibility, for example when dealing with water incidents or a cluster of cases with consistent symptomatology.

The multi-agency public health response

The incident also highlights the importance of an effective multi-agency, multi-disciplinary response to an identified public health risk. In this incident multi-agency working between NPHS, Anglesey and Gwynedd Local Health Boards, local authorities, National Poisons Information Service, Health Protection Agency and DCWW through the IMT ensured that potential health risks were identified and addressed in a timely manner, with residents being advised early on in the incident to flush water through. Bottled water was provided for drinking and cooking purposes.

Recognising that the scale of this problem may extend beyond the areas of Anglesey and Gwynedd, a letter was sent by the Welsh Assembly Government (Chief Medical Officer/Chief Environmental Health Adviser) to all local authorities in Wales. This letter summarised the incident and its potential public health impact; it requested that local authorities consider risk assessing recent developments and "potentially submit samples for analysis for lead" or for them to discuss with the water providers what assessments have been made and any actions being taken. The actions taken as a result of this letter are currently being reviewed.

This incident and other water-related public health events in Wales supported the development of a Water Health Partnership. This partnership has since agreed a framework for the multi-agency response to potential health-related incidents and outbreaks in Wales and some parts of England that involve contaminated drinking water supplies

Policy and regulation

This incident highlights that some property developers of new houses continue to use lead solder in the plumbing of drinking water pipes, despite its use for this purpose being illegal. Lead solder is easily available, being sold in most DIY stores, and its use is not illegal for central heating pipes. It is also less expensive than the legal alternative by approximately £10 per roll. Water pipes are not fully covered in the building regulations and developers do not need certification for the plumbing of new homes as is required for the electrical installations. This incident highlights the need for an urgent review of the availability of lead solder and the regulation of plumbing systems in new homes, and of the plumbing industry generally in terms of training and supervision arrangements. A systematic approach to prevention and strict enforcement of the regulations will be key to ensuring similar incidents do not occur in the future.

Following the work done by the Scottish Centre for Infection and Environmental Health in 2003, the issue of the use of lead solder in the plumbing of new homes was highlighted as an important public health issue (SCIEH 2003). New housing developments are popular with families with young children, and the SCIEH highlighted that high lead water levels owing to this cause represents an avoidable and unacceptably high source of lead for vulnerable people such as young children and pregnant women. There needs to be consideration by local authorities as to their inspection and monitoring strategies for lead, not only in new housing developments but in schools, childcare centres and other children's settings. This is a priority of the Children's Environment and Health Action Plan (HPA 2007b). This is particularly important in anticipation of the revised drinking water quality standard for lead that will come into force in 2013 (HPA 2007b).

This incident did not come to light as a result of routine monitoring but as a result of the investigation of an unrelated complaint by a resident. Following this complaint and opportunistic testing, the extent of the problem was greater than first anticipated. As a direct result of this incident, DCWW has now included in its routine inspections of newly built properties (5% of new build residential properties and all commercial properties) a 'lead check' swab test for the detection of lead solder on the drinking water plumbing and services and continues to carry out random lead sampling on new developments.

Conclusions

This incident details the illegal use of lead solder in the plumbing works of new homes and highlights the continued importance of lead as a recognised public health hazard in the modern environment. The multi-agency IMT successfully co-ordinated the public health response of key stakeholders and ensured prompt risk identification in potentially affected properties. Through subsequent risk assessment and risk communication, risks to public health were minimised. Wider multi-agency working at a national level led to communication to local authorities from the Chief Medical Officer and Chief Environmental Health Adviser to highlight the issue and recommended appropriate action to be taken across Wales. The incident has led to the introduction of testing for the presence of lead solder on drinking water plumbing and services in new commercial and residential properties across Wales. A multi-agency Water Health Partnership was also informed by this and other water related public health incidents in Wales.

The authors conclude that there needs to be an urgent review of the availability of lead solder and the regulation of its use. Local authorities should consider their future monitoring strategies for lead levels in water in light of this incident and the work done by the SCIEH, the Children's Environmental Health Action Plan and the new drinking water quality standard for lead

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