Environmental sustainability and waste within the dental practice

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Key points

Although only 0.1% of the carbon emissions of a dental practice comes from waste, practices produce significant amounts of recycling, domestic, offensive hygiene, clinical, hazardous and food waste.

Argues the dental profession needs to reduce the generation of waste and ensure it is categorised and managed appropriately, and also be made aware that there are financial and sustainable benefits in doing this.

Highlights nitrous oxide is a potent greenhouse gas and its use and waste products need to be managed.

Abstract

This paper forms part of a series of papers, seven in total, which have been requested by colleagues to help them as clinicians understand sustainability as it relates to dentistry. This paper focuses on waste and how the dental team can influence how waste is processed and disposed of. It is the authors' hope that this series of papers stimulates interest, debate and discussion and, as well as being economically responsible, ultimately motivates and inspires the dental team to be more socially and environmentally sustainable which in turn will help promote health and illness prevention.

Introduction

Sustainability is about the sensible and responsible use of natural resources in order to avoid depletion and maintain an ecological balance.[1] From a sustainability perspective, the dental team should ensure that waste is dealt with in the most ecologically sound way. Ensuring clinical waste is kept to a minimum will reduce the carbon emissions associated with incineration. Recycling will help reduce the depletion of natural resources in terms of paper, plastic and glass products, with associated lower carbon emissions than landfill. Appropriate management of food waste will return nutrients to the soil, again, resulting in lower carbon emissions.

Readers may have knowledge of zero-waste or zero-carbon concepts. The concept of zero-waste means the conservation of all resources by means of responsible production, consumption, reuse and recovery of all products, packaging and materials without burning them, and without discharges to land, water or air that threaten the environment or human health.[2] The dental team should be cautious of using a 'waste to energy' system. The term waste to energy is where waste is produced to generate electricity, with the end result being that there is no actual waste. About one quarter of all waste in Europe is incinerated in this way,[2] however this practice is controversial. Producing resources that end up as waste is energy intensive, energy which could be saved by recycling the materials instead of extracting virgin material. Furthermore, recycling is cost-effective.[2] In healthcare environments, there are possible public health consequences of burning solid and regulated waste. Medical waste incinerators release toxic air pollutants and toxic ash, major contributors of dioxins in the environment.[3] The literature provides conflicting evidence of how problematic this is. A French study (2012) showed all incinerators operating within EU tolerable air quality limits,[4] however another 2011 paper shows an increased risk of non-Hodgkin lymphoma and serum organochlorine concentrations in populations living close to solid waste incinerators.[5]

As highlighted in the travel paper in this series, air pollution has become a key public health issue to solve.[6,7] Sources of air pollution originate from cigarette smoke, industry emissions, fossil fuel burning and incineration of rubbish.

Dental waste

Dental practices produce significant amounts of waste, including recycling, domestic (non-food), offensive hygiene, clinical, hazardous and food waste. Waste needs to be managed appropriately because it impacts on both carbon emissions and wider sustainability. The dental team have legal and professional responsibilities to ensure that waste is correctly managed in a way that does not cause pollution of the environment or harm to human health.[8,9,10,11,12]

Costs and carbon emissions

Correct waste management not only has environmental benefits, but also cost benefits, as demonstrated in a number of studies.[13,14] A recent study undertaken by Plymouth University measured the waste generated by the team of a general dental practice, with paper and nitrile gloves being the two most commonly disposed items within the

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Table 1 Costs and carbon emissions per waste disposal

Waste type	Cost/credit	Carbon emissions
Recycling (clear/blue)	Recycling can cost £144 per tonne.[14,19] £26 per tonne can be credited for segregated cardboard[13]	21.8 kg CO_2e/tonne[63]
Food waste/organic waste (brown)	Cost varies	6 kg CO_2e/tonne (based on removal and anaerobic digestion or composting)[63]
Domestic waste (black)	£101[13]-£142 per tonne[14,19]	345 kg CO_2e/tonne (based on average waste)[63]
Hygiene waste (yellow with black stripe)	£241 per tonne[14,19]	
Infectious waste contaminated with chemicals (yellow)	£337 to £457,[14,19] £725,[13] £1,630 per tonne[13]	220 kg CO_2e/tonne
Infectious waste not contaminated with chemicals (orange)		
Medicinal waste for incineration (black)	Cost not available	
Dental amalgam waste (white)	Cost not available	Carbon emission data not available
Plaster waste (no specific colour)	Cost not available	
X-ray fixer and developer (no specific colour)	Cost not available	

*Euros were converted into British pounds at £1 = €1.13, correct as of 4 May 2018[18]

dental practice.[15] The Plymouth study also demonstrated that it was possible to become more sustainable and reduce costs.[16] In Table 1, the description, cost and associated carbon emissions, and descriptions for each waste type is displayed. Further descriptions of waste types are provided later in this paper.[17]

Generally, costs increase as waste becomes more complex; incineration, for example, is costlier than landfill which in turn is more expensive than recycling. According to the Royal College of Nursing, recycling can cost around £144 per tonne, however, it is also known that clean, separated recycling can generate income (less collection fees) of around £26 per tonne.[13,14,19] Domestic waste is more expensive than recycling costing £142 a tonne, hygiene waste costing £241 per tonne and clinical waste ranges from £337 to £1,630 per tonne.[13]

Improving waste management

There are three main ways of improving waste management. Firstly, reduce the generation of waste, secondly, ensure waste is categorised and segregated/separated appropriately according to these categories.[13] Thirdly, ensure that practice is evaluated by performing an audit.

Reduce waste generation

One of the main ways dental practices can reduce waste is to purchase less; see also the procurement paper within this series.[20] This should include the management of stock levels to prevent expiration of unused consumables.[14] The Royal College of Surgeons suggests health care providers should review purchasing patterns against actual use and, if possible, amend which goods are ordered to reflect changes in clinical practice.[14] Stock rotation is also important to ensure that items closest to their 'use by date' are used in preference to newer stock.[14] There are a number of ways to reduce the generation of waste.

Influencing manufacturers and suppliers to produce less waste

The procurement paper within this series highlights the need for dental practices to influence suppliers, and in turn manufacturers, to produce environmentally conscious healthcare items.[20] Manufacturers of dental products could consider toolkits like the 'greenhouse gas accounting sector guidance for pharmaceutical products and medical devices' to aid them in the manufacturing of products that are more sustainable and are able to be easily recycled or reused with minimal environmental impact.[21]

Reducing paper use

Reducing paper usage can have a significant impact on both waste, financial costs and carbon dioxide emissions.[22] Assuming practices are compliant with data protection rules such as the General Data Protection Regulations (GDPR), electronic patient records, scanning, telephone calls, email and text messaging can be used as alternative methods of record keeping and communication.[23] Where the use of paper or 'documentation' is necessary, suggestions for reducing waste are: double-sided printing as a default setting, reduce print font size, keep white space on documents to a minimum, use recycled paper, recycle paper waste, and support paperless meetings. Regular monitoring and auditing of paper consumption is important, and a calculator can be used to determine the amount of carbon emissions created in current dental practice paper usage.[24]

Use of reusable instruments

Within dentistry, from an environmental perspective, there is very limited evidence on the superiority of either reusable or disposable instruments, although some evidence is developing in other areas of healthcare. A recent review of laparoscopic instruments (2017) compared the differences in quality, safety, sterility, ease of use and patient outcomes between single-use and reusable instruments. The review demonstrated that reusable instruments have a cost advantage, but social/ethical and environmental analysis, such as costs of labour, repairs, hidden environmental factors, sterilisation or disposal costs, were not consistent across studies.[25] In 2012, a study showed that a reusable laryngeal mask airway had two thirds of the carbon footprint of a single-use mask.[26] In a review of various life cycle analysis papers in the same year, disposable versus reusable gowns were compared. The author concluded that reusable gowns were superior in environmental terms, with a two- to three-fold reduction in energy, water and carbon emissions, and a seven-fold reduction in waste. The author concluded that it is no longer valid to indicate that disposable

Table 2 Waste types, descriptions and signage/colour[17]

Waste type (with usual associated colour)	Description	Disposal type
Recycling (clear/blue)[64]	All rigid plastics (including fruit trays), all cans, all paper and cardboard, Tetra Pak, glass. Excludes tissue paper, check plastic bags with your waste company*	Recycled
Recycling (clear/blue)[64]	All rigid plastics (including fruit trays), all cans, all paper and cardboard, Tetra Pak, glass. Excludes tissue paper, check plastic bags with your waste company*	Recycled
Food waste/organic waste (brown)		Composted/anaerobic digestion
Landfill waste (black)	All non-clinical waste and waste that cannot be recycled including tissue paper, paper towels, coffee cups (plastic lining) and products contaminated with food	Landfill
Hygiene waste (yellow with black stripe)	Sanitary protection, for example, nappies	Deep landfill or incineration
Infectious waste contaminated with chemicals (yellow)	Any waste which consists wholly or partly of human or animal tissue, blood or other body fluids, excretions, drugs or other pharmaceutical products, swabs or dressings, syringes, needles or other sharp instruments[12]	Alternative treatment or incineration[65]
Infectious waste not contaminated with chemicals (orange).	As above but additionally contaminated with chemicals	
Medicinal waste for incineration (black)	Non-cytotoxic and cytostatic medicines including used and out-of-date stock	Local recommended method for disposing of pharmaceuticals and packaging
Dental amalgam waste (white)	Waste consisting of amalgam in any form, including all other materials contaminated with amalgam[12]	Metal recovery
Plaster waste (no specific colour)	Gypsum or calcium sulphate study or working models[65]	Gypsum recovery or landfill in a separate dedicated cell for gypsum[56]**
X-ray fixer and developer (no specific colour)		Various recovery options[56]

*Dental teams should contact their waste management company to clarify whether plastic bags are able to be recycled; ideally the team should find a waste management company who can recycle these.
**Dental gypsum when landfilled with other landfill products can produce hydrogen sulphide gas. Under English legislation, this waste must go into separate landfill for high sulphate waste.

gowns are acceptable from an environmental perspective.[27] The dental team need to consider overall whole life cycle costs before deciding which products they purchase.

Reducing the impact of nitrous oxide waste

Nitrous oxide (N_2O) is a gas with a global warming potential of 298 times that of CO_2e.[13] On average, 163 litres of N_2O is used per patient episode, equating to around 90 kg CO_2e. This does not include the embedded carbon emissions of N_2O production or the embedded carbon emissions of its cylinder, which is usually rented.[28,29] In total, nitrous oxide used by NHS dental services in England is responsible for 1.3% of the total nitrous oxide use of NHS England and makes up 0.9% of the total carbon footprint of NHS dental services in England.[29,30] The addition of nitrous oxide to a patient's course of treatment can increase its environmental impact.

Nitrous oxide is an effective, simple form of treatment that can reduce the need for other more invasive and, potentially riskier, forms of care such as general anaesthetic. The dental team should, however, be aware of its potential impact on the environment. One way of reducing nitrous oxide levels is to capture and neutralise the gas during its use. This technology is often used in hospitals but not commonly used in dentistry; possibly due to lack of awareness or the expense of the equipment.[31,32,33]

Durable equipment

Dental practices should try to invest in equipment that is durable and designed to last for a long time. Purchasing products with a longer warranty and reviewing product ratings before purchasing can reduce costs and be more environmentally sustainable. Equipment should be regularly checked and repaired when necessary. Staff should report any breakages or concerns about equipment immediately so that early repair can be undertaken. A maintenance register and policy can support this process.

Water consumption

In England, the average water consumption of a dental practice is estimated at around 33 thousand litres per surgery each year.[34] Although this water use and the treatment of waste water contributes only 0.09% (587 tonnes of CO_2e) to the total carbon footprint of primary NHS England dental services, water is becoming more scarce and needs to be conserved.[29] Dental practices could undertake similar interventions as households to reduce water consumption. These interventions can include installing a meter to monitor water use, switching off water-using equipment when not in use, and checking for water leaks regularly. Options for retro-fitting water-using equipment to make the equipment more efficient should be considered and, for new purchases, equipment with low water consumption should be considered. Dry vacuum systems save a considerable amount of water.[35]

Reduce medicines waste

A new toolkit has been developed to support the dental team's need to reduce antibiotic prescribing in line with the growing global resistance to antibiotics.[36] In addition to antibiotic resistance, there is a growing environmental problem of pharmaceutical residue entering the environment through improper disposal. Patients not only excrete by-products of medication, but many also dispose of unused/surplus medicines in

toilets or sinks.[37] Pharmaceutical residue dissolved in waste-water can re-enter the food chain, thus impacting on the whole food chain.[38] Although evidence is scarce, concentrations of pharmaceutical residue has already been shown to adversely affect animals and humans.[37] The prescriber of medicines should advise patients on the safe, local recommended method for the disposal of pharmaceuticals and packaging, that is, by returning them to the dental team for disposal (if the dentist disposes of medication) or, more commonly, their pharmacist.[39]

Reuse, upcycle

To reduce landfill waste and its associated environmental consequences, reusing, upcycling or finding a new home for the items a dental practice no longer needs, such as furniture and computers, should be considered. Dental practices should have a system that identifies opportunities to convert useful waste into a resource; ideally documented in practice policy.[40] Functional equipment no longer required by the dental practice could be donated to local charities, community groups or advertised online. The use of online sites such as Freecycle, Gumtree and Dentaid (for dental-specific items) can assist this process. Warp It is used in the NHS for this purpose.[41,42,43,44]

Categorisation and segregation of waste

Dental practices need to be careful to segregate both clinical and non-clinical waste. Proper segregation of waste is not only a legal requirement in England but also important for safety, environmental and financial reasons.[45] There are a number of waste streams within dentistry which are laid out in the health technical memorandum, HTM 07-01, *Management and disposal of healthcare waste*.[46] The main waste streams, and their descriptions in order of the most environmentally sustainable to the least are shown in Table 2.

Recyclable waste

An average practice generates non-contaminated cardboard, plastic and paper waste, which should be placed into recycling bins before operative procedures begin to avoid contamination with clinical waste. To facilitate this, the dental team should consider the introduction of recycling waste bins into the dental surgery. Hospital operating theatres have started introducing recycling into their clinical areas. The Oxford University Hospitals Trust introduced recycling into operating theatres and reduced waste collection by 22%.[13]

Fig. 1 Contents of waste bin in staff canteen

Fig. 2 Importance of a non-contaminated and a contaminated zone

Food waste

In the Irish primary care survey, 15% of the waste within health care facilities was food waste. There are three alternative options for dental practices to consider regarding the disposal of their food waste rather than sending it to landfill. Firstly, if space is limited, food waste could be collected by waste collectors. Food waste can then be converted into energy through a process of anaerobic digestion, with the remaining digestate used as a soil conditioner. Separation of food waste and its appropriate management was recently recommended in a government report.[47] Secondly, composting in healthcare facilities can reduce the costs associated with the disposal of food and improve soil quality; alternatively, the compost generated could be sold to generate revenue.[48] Thirdly, healthcare facilities could consider installing worm farms to manage food waste.

Fig. 3 Need for recycling waste in an instrument preparation room

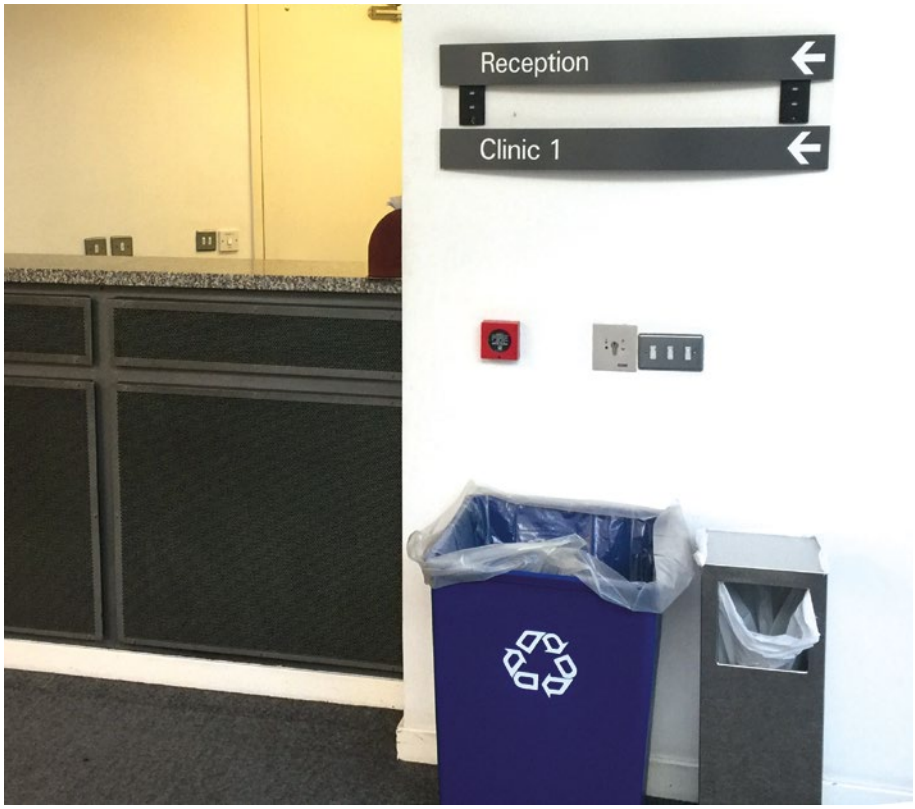

Fig. 4 Position of recycle bin

Clinical waste and landfill

In a number of healthcare facilities, despite the financial cost of disposing of more complex waste, waste is not well managed. In an audit of healthcare facilities in Ireland, 29% of landfill waste was nappies and incontinence wear (correct waste stream is hygiene waste), 18% tissues, 17% food waste, with 16% of waste recyclables (correct waste stream is recyclables) and 4% non-risk clinical type materials. In a similar audit of clinical waste, only 66% of waste was correctly allocated; the remaining 34% waste should have been recycled or gone to landfill. A poorly segregated waste bin can be seen in Figure 1.

Poorly segregated waste would go to landfill at a cost of £101–£142 per tonne.[13,14,19] Such poorly segregated waste can contain various recyclable products, hard plastics and food waste, each of which could be segregated and disposed of separately which would be not only more environmentally sustainable but also more cost-effective. Staff must be careful, however, when segregating infectious waste from non-infectious waste; contamination between the two means all waste needs to be categorised as infectious.[13]

Dental practice staff need to know which of the instruments used need to be disposed of as contaminated, clinical waste/non-contaminated waste. In Figure 2, a trauma bag can be seen with a collection of files, paper points etc. It is important that the trauma bag remains in the non-contaminated area or all contents will need to be disposed of as clinical waste. From a categorisation perspective, it is important to ensure waste bins are colour-coded, with instructional signage to ensure waste is placed in the correct bin.[13] This signage could be a basic laminated wipeable sign or something more permanent.

Placement, quantity and type of bins

In managing waste, the placement, quantity and type of bins in the dental surgery are important points to consider. Dental practice managers should work with staff to understand which types of waste bins are required in a particular area. All decontamination and sterilisation rooms should be surveyed carefully to determine the need for waste bins.[13]

Figure 3 demonstrates that within the clean preparation room in a dental surgery, there is no recycling bin, thus making correct segregation of waste into recycling difficult. The location and labelling of a waste bin is important. In areas where there is likely to be

a high recycling content, such as an office, the recycling bins should be placed closer to the source of the waste than the less sustainable landfill waste bin. In Figure 4, the size of the waste bins is correct, with the larger recycling bin placed closer to the source of waste (the reception desk). In addition, the general waste is smaller, and the size of the bin makes it more difficult to dispose of waste. Ideally, the smaller waste bin should be labelled appropriately.

Within the decontamination area, there should be a landfill waste bin available as well as a clinical waste bin so that waste can be managed correctly, at source, and easily. In the waiting room, it is best practice to have clearly labelled general waste bins and recycling bins. In clinical areas, handwashing sinks should have landfill waste bins as well as clinical waste bins. Clinical waste facilities in areas accessible to the public should be kept to a minimum, as some members of the public may be unaware of the implications of not using the appropriate waste bin.[13]

To ensure appropriate waste management, the correct size of waste bin should be provided. Office staff could be given large recycling bins to dispose of their office waste, along with smaller waste bins to dispose of their landfill waste. In larger dental clinics, waste compactors could help save room by compacting cardboard.

Waste audit

Within England, the Environment Agency requires that producers of waste, such as a dental practice, provide a bi-yearly audit of their waste before it can be legally collected by a licenced waste carrier. This pre-acceptance audit requests healthcare providers to categorise and provide weights of each waste type.[49]

Dental practices could consider conducting either a detailed waste survey or a less time-consuming bin placement survey. To undertake a waste survey, a practice needs appropriate weighing scales, personal protective equipment, record sheets, storage bins, a table and a camera. A sample of filled waste bags should be weighed, then the contents carefully emptied, with clinical, non-clinical, food waste etc being re-sorted, if required, into the appropriate categorised container. These containers can then be weighed to calculate the proportions of waste that have been miscategorised.[13] To undertake a bin placement survey, the dental team should identify the types of activity that normally take place in the room being surveyed, then decide which waste bins are required (recycling, landfill or clinical). The location and size requirements of the waste bins should also be noted along with the requirement for instructional signage.[50]

Barriers and facilitators to changing waste management in the dental setting

There are a number of barriers and facilitators to appropriate waste management, which can be local drivers, within the practice, or external drivers. Wrap, a major waste charity, summarises internal drivers to effective waste management as situational (space, containers, collection reliability), behavioural (time, changing routine), and knowledge.[51]

Local drivers

Situational

In most practices, space can be a problem. Although very large practices could consider balers/compactors to compress their waste, other practices will need to be clever to manage the space requirements of effective waste management. If space to segregate waste is an issue, 'mixed dry recycling', where several recyclates can be disposed of together, can be effective but different countries have different legal requirements and systems which could preclude this.[52,53] Alternatively, there are a number of stackable recycling containers which can help with space. Even worm farms can be very space efficient; at the time of writing a worm farm was seen as small as 30 cm by 20 cm).

Behavioural/attitudinal

In the same way that influencing health behaviour is difficult, changing the way we all conduct our lives in a sustainable way is seldom easy. Providing education is a useful start, but information-based campaigns do not always cause long-term behaviour change.[54] Improving facilitators and reducing barriers to appropriate waste management will help in behavioural change. Grose suggests staff need to be empowered to tackle waste and it is important that any change in waste management policy is not just a top down approach.[55] In keeping with appropriate guidance, individual staff should be encouraged to be innovative and proactive in reducing waste within the practice.[14] One staff member should be made responsible for effective waste management within the dental practice and any change in waste management procedures needs to be communicated effectively to all members of the practice staff.[13,14]

A dental practice should create a waste policy which specifies practice procedures that align with relevant legislation.[56] This policy should include a guide/training for staff on each waste category, their locations within the practice and how the waste should be segregated. The policy should also incorporate a 'reduce, reuse, recycle' element which explains the practice policy on how to reduce waste.

Knowledge

A dental practice, like any business, will have limited time for education. The Centre for Sustainable Healthcare has developed online resources such as the e-learning resource and other sustainable waste documents. It is important that any waste champions are directed to these resources to support training of the staff. Staff should be made aware of the financial costs and carbon emissions associated with each waste stream. More training resources specifically for dentistry are needed.[57,58]

External drivers

Pietzsch has categorised external drivers that can improve the management of waste.[59] To change behaviour of consumers, it is important for the dental team to engage in conversations with both manufacturers as well as the waste management industry.[20] Manufacturers need to redesign products to improve useful life, reduce packaging, eliminate toxicity in the composition of products, and prioritise the use of renewable material.[59] Further information can be found in the procurement paper in this series.[20] Producers being responsible for managing their waste, by collection, has also been mooted. Financial incentives and disincentives for the management of waste, through subsidies, taxes or penalties has also been shown to be effective.[59]

UK governments have legislated to some degree to support appropriate waste management. Within England, waste, including large landfills, waste incinerators and waste recover installations are regulated by the Environment Agency.[60] It is an offence under English law to treat or dispose of waste without an environment permit. The Hazardous Waste Regulations (England and Wales) 2005 outline the requirements for hazardous waste which must be properly segregated, packaged and labelled.[8] At the time of writing, there are

Fig. 5 Action on waste management

also various European directives provided for specific regimes (take-back, recovery and recycling) to deal with waste packaging, waste electrical, electronic equipment and waste batteries.[61] In Scotland, the dental team is legally responsible for safely disposing of all their waste. The law also requires dental practices to take all reasonable steps to recycle as much of this waste as possible, and for local authorities and waste contractors to meet high recycling standards. Dental practices must present metal, plastic, glass, paper and card separately for collection. If more than 5 kg of food waste is produced per week this must also be collected separately.[62]

Action points

The action box in this article (Fig. 5) provides a summary for readers to consider improving their waste management. The reader should be advised that the judgement of ease, cost and impact is subjective, and more evidence is needed.

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