SDG COLUMN

An update on waste disposal in dentistry

Continuing with our cover series on the UN's Sustainable Development Goals (SDGs), we reach SDG 6: Clean Water and Sanitation. Our focus for this issue's cover was to illustrate how we can reduce waste and keep the water source clean, helping our tap water stay safe for all to drink. **Sheryl Wilmott**[1] and **Brett Duane**[2] situate SDG 6 within dentistry by providing an update on a previously published book chapter of theirs which explored responsible waste management, the first half of which has been republished in this issue of the *BDJ*. In doing so, the authors demonstrate how proper segregation of waste translates to a positive impact on the quality and availability of clean water.

In this article, we provide an update on 'Responsible waste management: using resources efficiently',[1] a chapter from *Sustainable Dentistry* which has been partially republished in this issue of the *BDJ*.[2] Here, we aim to use updated life cycle assessment (LCA) data to highlight how proper segregation of waste is an easy and low-cost way to reduce the environmental impact of care, with wide-reaching global health impacts, including the impact on the quality and availability of clean water.

Proper waste segregation is necessary because the wide range of products that we use in dental practice each need to be disposed of in a way that minimises their impact on the environment and that limits the damage that they can cause to human health. This is a legal, ethical and professional duty. The updated waste hierarchy adapted for clinical waste includes 'correctly segregate' as second to only prevention as the most desirable way to manage clinical waste.[3]

To establish a comprehensive waste management strategy, it is essential to focus on waste reduction, reuse, recycling, and responsible disposal to minimise environmental harm while maximising resource recovery and economic benefits.

For six healthcare waste streams, an LCA was performed using OpenLCA v2.0 software and the Ecoinvent v3.91 reference database.[4,5] The methodology of the LCA followed the recommendations of the International Standard Office and the European Commission's Product Environmental Footprint guidelines (ISO, European Commission, 2018).[6] The main outcome of the LCA was a life cycle impact assessment (LCIA) consisting of 25 environmental impact categories. Each impact category and its corresponding LCIA method and units have been described in other papers.

> 'It is essential to focus on waste reduction, reuse, recycling and responsible disposal'

Figure 1 shows the data from an LCIA of the disposal of 1,000 kg of six of the waste streams produced in healthcare environments. Each impact category was recalculated based on amended workings in line with Duane *et al.*[7] Each impact category row has been formatted, from low impact (green) to high impact (orange), which clearly shows that disposal of the contaminated waste stream has the highest impact on the environment and human health, followed by disposal of plastic waste.

Figure 2 shows the impact of six healthcare waste streams on human health in disability adjusted life years (DALYs). Over 91% of the total DALYs from disposal of the six waste streams are associated with the effects of global warming. Less than 8% are associated with water consumption and the rest make up 1% of the total.

There is notable variation in the environmental and human health impacts of disposal of different healthcare waste streams, but contaminated waste followed by plastic waste make a substantial contribution. Reducing the use of single-use plastics and ensuring that only appropriate waste is disposed of in the contaminated stream can reduce this impact.

There are three LCA impact categories that specifically relate to water quality (blue):

1. Natural **acidification** can take place, such as when volcanic eruptions release acidic sulphur dioxide into the atmosphere. However, contemporary rises in emissions of sulphur dioxide (SO4) and nitrogen oxides (NO(x)) from human industrial endeavours lead to a reaction with rainwater, resulting in the formation of acid rain. This, in turn, can lower the pH levels of the soil upon which it descends. Acidification has consequences for plant health and can disrupt the equilibrium of agriculture and the food chain. Given that acidification is predominantly driven by human actions, adopting sustainable practices can effectively mitigate its impact.[8] Figure 1 shows that disposal of contaminated waste has a high impact on acidification; this is likely due to the incineration processes involved
2. **Eutrophication** is the term used to describe environments that have

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Fig. 1 Life cycle impact assessment of the disposal of 1,000 kg of six of the waste streams produced in healthcare environments

Impact category	Food waste	Contaminated waste	Plaster waste	Plastic waste	Cardboard waste UK	Landfill waste	Unit
Acidification – accumulated exceedance (AE)	0.09	2.54	0.05	0.46	0.33	0.04	mol H+-Eq
Climate change – global warming potential (GWP100)	23.54	1552.62	6.08	1596.45	548.51	784.02	kg CO2-Eq
Climate change: biogenic – global warming potential (GWP100)	1.27	0.89	2.40E-03	0.10	508.66	741.34	kg CO2-Eq
Climate change: fossil – global warming potential (GWP100)	22.26	1551.14	6.08	1596.33	39.83	42.68	kg CO2-Eq
Climate change: land use and land use change – global warming potential (GWP100)	2.91E-03	0.59	3.67E-03	0.02	0.02	0.00	kg CO2-Eq
Ecotoxicity: freshwater – comparative toxic unit for ecosystems (CTUe)	108.23	52762.28	71.09	3418.58	2773.61	3034.65	CTUe
Ecotoxicity: freshwater, inorganics – comparative toxic unit for ecosystems (CTUe)	13.90	52611.13	66.98	3405.52	2756.43	3025.48	CTUe
Ecotoxicity: freshwater, organics – comparative toxic unit for ecosystems (CTUe)	94.33	151.15	4.11	13.06	17.18	9.17	CTUe
Energy resources: non-renewable – abiotic depletion potential (ADP): fossil fuels	106.98	10615.61	152.53	537.89	435.78	0.00	MJ, net calorific value
Eutrophication: freshwater – fraction of nutrients reaching freshwater end compartment (P)	1.02E-03	0.14	5.06E-04	0.01	0.01	0.07	kg P-Eq
Eutrophication: marine – fraction of nutrients reaching marine end compartment (N)	0.01	0.67	0.02	0.98	0.76	1.01	kg N-Eq
Eutrophication: terrestrial – accumulated exceedance (AE)	0.35	6.83	0.19	2.17	1.27	3.68E-03	mol N-Eq
Human toxicity: carcinogenic – comparative toxic unit for human (CTUh)	1.25E-09	5.95E-07	2.60E-09	2.74E-07	1.41E-07	4.06E-08	CTUh
Human toxicity: carcinogenic, inorganics – comparative toxic unit for human (CTUh)	7.34E-10	2.74E-07	1.19E-09	1.30E-07	5.63E-08	4.06E-08	CTUh
Human toxicity: carcinogenic, organics – comparative toxic unit for human (CTUh)	5.12E-10	3.21E-07	1.41E-09	1.44E-07	8.49E-08	0.00E+00	CTUh
Human toxicity: non-carcinogenic – comparative toxic unit for human (CTUh)	1.12E-06	9.20E-06	3.27E-08	5.33E-06	3.55E-06	1.84E-06	CTUh
Human toxicity: non-carcinogenic, inorganics – comparative toxic unit for human (CTUh)	2.67E-08	8.89E-06	2.95E-08	5.25E-06	2.63E-06	4.89E-07	CTUh
Human toxicity: non-carcinogenic, organics – comparative toxic unit for human (CTUh)	1.09E-06	3.13E-07	3.22E-09	7.45E-08	9.16E-07	1.35E-06	CTUh
Ionising radiation: human health – human exposure efficiency relative to u235	0.46	89.30	9.59E-02	0.93	1.10	0.00	kBq U235-Eq
Land use – soil quality index	11.62	2254.71	300.66	402.89	371.10	375.85	dimensionless
Material resources: metals/minerals – abiotic depletion potential (ADP): elements (ultimate reserves)	1.29E-05	6.14E-03	8.61E-06	1.49E-04	1.16E-04	0.00	kg Sb-Eq
Ozone depletion – ozone depletion potential (ODP)	5.25E-08	1.32E-04	1.76E-07	1.92E-06	1.22E-06	0	kg CFC-11-Eq
Particulate matter formation – impact on human health	4.62E-07	2.52E-05	1.00E-06	1.26E-05	6.98E-06	2.73E-08	disease incidence
Photochemical oxidant formation: human health – tropospheric ozone concentration increase	9.85	2.32	0.07	0.60	0.55	0.29	kg NMVOC-Eq
Water use – user deprivation potential (deprivation-weighted water consumption)	25.71	346.58	0.47	62.28	47.41	0.00	m3 world eq. deprived

Fig. 2 The impact of six healthcare waste streams on human health (in DALYs)

Category	Food waste	Contaminated waste	Plaster waste	Plastic waste	Cardboard waste UK	Landfill waste	Total
Global warming – human health	2.18E-05	0.001	5.64E-06	0.001	0.001	0.001	4.19E-03
Stratospheric ozone depletion – human health	2.79E-11	7.02E-08	9.34E-11	1.02E-09	6.48E-10	0.00E+00	7.20E-08
Ionising radiation – human health	3.91E-09	7.59E-07	8.15E-10	7.87E-09	9.32E-09	0.00E+00	7.81E-07
Fine particulate matter formation – human health	2.91E-10	1.59E-08	6.31E-10	7.95E-09	4.39E-09	1.72E-11	2.92E-08
Photochemical ozone formation – human health	8.63E-06	2.04E-06	5.75E-08	5.24E-07	4.83E-07	2.57E-07	1.20E-05
Toxicity – human health (cancer)	4.14E-15	1.98E-12	8.62E-15	9.11E-13	4.69E-13	1.35E-13	3.50E-12
Toxicity – human health (non-cancer)	7.43E-15	6.12E-14	2.18E-16	3.54E-14	2.36E-14	1.22E-14	1.40E-13
Water consumption – human health	1.89E-05	2.55E-04	3.49E-07	4.58E-05	3.49E-05	0.00E+00	3.55E-04
DALY (years)	4.94E-05	1.70E-03	6.05E-06	1.53E-03	0.001	0.001	4.55E-03
DALY (days)	0.018	0.620	0.002	0.558	0.199	0.266	1.66
DALY (hours)	0.43	14.88	0.05	13.38	4.77	6.38	39.89

an excess of minerals and nutrients, resulting in the excessive growth of algae. As these algae die and break down, they deplete the oxygen levels in the water, which can lead to the death or displacement of various plant and animal species. Nitrogen oxide emissions represent just one of several factors contributing to eutrophication.[9] Figure 1 shows that landfill waste impacts both marine and freshwater eutrophication, likely due to leachate entering the water table

3. **Ecotoxicity** is a gauge of the disruptive influence exerted by toxic compounds on freshwater ecosystems. These harmful substances have the potential to move from aquatic settings, such as sources of drinking water, to various animal species, which could subsequently be part of the human food chain. These toxins include materials like microplastics, chemicals, and substances detrimental to life. Both food waste and contaminated waste contribute to ecotoxicity in the environment.[10]

In addition to the above measures of water pollution, '**Water use – user deprivation potential**' describes a combination of the volume of freshwater consumed and the water stress index of the region where that water has been extracted. The use of the same amount of water in a region of water scarcity will have a larger impact on the deprivation potential.[11]

These findings highlight how waste reduction, reuse, recycling, and responsible disposal, including proper segregation of waste, are low-cost ways for the dental practice to reduce environmental harm and harm to human health, and support the availability and quality of our water supplies.

The following practical steps can be taken by dental practices:

- Education – Regular refresher courses in waste management are 'critical' for healthcare professionals.[12] Dental staff can access Healthcare Waste Management and Disposal training on the e-learning for health portal[13]
- Guidelines – In addition to segregating waste into recycling, domestic and clinical waste, Domain 3 of the recently published *Clinical guidelines for environmentally sustainable dentistry* (2023) recommends raising awareness and implementing behavioural change programmes, as well as providing clear guidance and labelling of bins. Education organisations should also highlight the planetary and human health benefits of proper segregation of clinical and non-clinical waste[14]
- Action – Dental practice staff can undertake an in-house comprehensive waste audit or a bin placement survey. Information for how to carry these out can be found in 'Responsible waste management: using resources efficiently'.[1] ■

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