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July 2016 Issue 27

WASTE

The Commonwealth Human Ecology Council (CHEC)
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It has been a catalyst in promoting sustainability, particularly in terms of human settlements, fisheries, afforestation and strengthening community action, especially for the advancement of women and youth.

CHEC is highly active in advocating and promoting the role of civil society and participatory decision making in good governance and sustainable development.

Message from
Rt Hon Patricia Scotland QC
Commonwealth
Secretary-General

Commonwealth Secretary-General

In this year when we celebrate 'An Inclusive Commonwealth' I thank the Commonwealth Human Ecology Council for its valuable contribution towards deepening practical understanding of how we can cooperate to help build safer, fairer and more sustainable communities in all our member states and beyond.

Under the heading Sustainable Development the Commonwealth Charter affirms: 'We recognise that sustainable development can help to eradicate poverty by pursuing inclusive growth whilst preserving and conserving natural ecosystems and promoting social equity'.

We can only truly live and work together in peace and prosperity if the needs of all are fully taken into account, and the fruits of progress are shared equitably and inclusively by all and with all.

Patricia Scotland

The Rt Hon Patricia Scotland QC

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Waste

Introduction: There is no Such Thing as Waste

Eva Ekehorn and Ian Douglas *Commonwealth Human Ecology Council*

Waste – something that could be discarded, of no use, and mostly quickly forgotten. Out of sight, out of mind! But our waste has become so enormous and so complex it can't any longer be ignored – and it isn't ignored.

If you throw a half-eaten apple into the woods it usually does no harm to the woodland ecosystem because decomposers will break it down and recycle it into new plants. But if you throw your plastic water bottle away in the woods, it becomes a problem. Artificial materials made by humans do not easily become part of ecological nutrient cycles. They have to be disposed of more carefully.

When we lived as hunters and gatherers all food waste was organic. Early farmers lived along the same lines – all waste was organic and could be returned to ecosystems and contribute to new life. Modern industrial farmers have added chemical compounds to the ecosystem, making waste itself less organic and with some poisonous side-effects. Today, most of us live in a truly global food market, where food is packaged and transported across the world. Plastic has become necessary as packaging to keep food fresh but it does not decompose readily like organic compounds and has to be dealt with separately. Our houses are no longer only built from wood, reeds and straw, but also from bricks, concrete and steel. When houses are disused and demolished the construction materials have to go somewhere else. We don't communicate by sending messengers from place to place, but by mobile phones and radios. Our clothes are not solely made of natural fibres or leather, but of oil based polyester and nylon. Somewhere, all the new manufactured materials that are used in the daily lives of the world's 7.5 billion people have an impact, especially through the mountains of waste our present lifestyles and consumption patterns produce. Nowhere is this problem more pressing than in our expanding towns and cities in which more than half of the world's population now lives. Waste management, treatment and disposal affect the way the natural ecological processes can handle liquid and solid waste.

Many of the articles in this issue of *Human Ecology* both highlight these problems with waste, and point to possible solutions. The classic notion of 'Reduce – Reuse – Recycle' is a first step, especially for individuals, but we can go further. Industries can do, and are doing, much to turn scrap into useful new things, and some industries use the concept of industrial ecology: a parallel with the recycling of nutrients in biological ecosystems. Action can be taken at various scales, from the firm to the nation and to entire continents in order to ensure that efficiency in the use of materials is increased.

National and local governments have waste management policies that aim to prevent the worst side-effects of waste disposal and to control the disposal of dangerous substances. Many governments are endeavouring to reduce the amount of waste being dumped in landfill sites and to increase the re-use of discarded materials. In Europe, such actions are now described as implementing the 'circular economy' (see article by Ian Douglas, this volume). First proposed as a concept in the 1970's, the circular economy is an alternative to the conventional and unsustainable linear manufacturing process, where the majority of products are made, used and then disposed of at the end of their life with very few materials recycled or re-used.

The advantages of the circular economy include: the reduction of the environmental impact of production and consumption; less waste; a more competitive economy; practical solutions to our resource problems; improved resilience to changing markets; and new job opportunities.

Logically, the curricular economy can lead to Zero Waste, a philosophy that encourages the redesign of resource life cycles so that all products are reused. It promotes sustainable practices to emulate natural cycles, where all discarded materials are designed to become resources for others to use. Zero Waste involves designing and managing products and processes systematically to avoid and eliminate the volume and toxicity of waste and materials, to conserve and recover all resources, and not to burn or bury them. No trash is sent to landfills and incinerators.

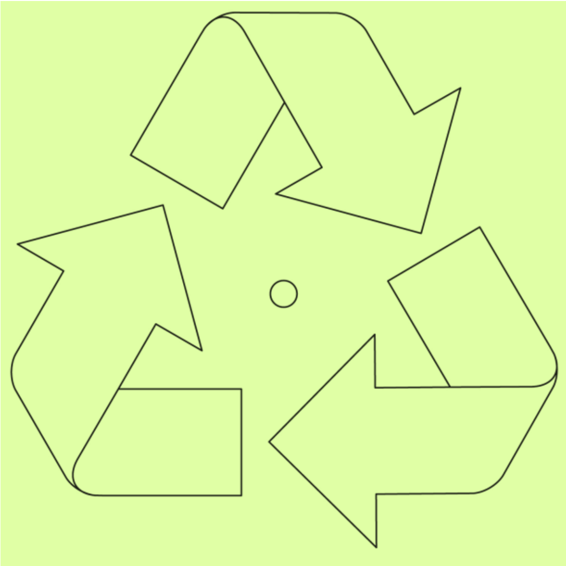
Conclusion: the reasons for this special issue of *Human Ecology*

The paragraphs above indicate: the diversity of waste issues; the need for improved waste management; the scope for further increases in recycling; the value of thinking not of waste, but of experienced or potential resources; the potential of applying industrial ecology; the importance of developing the circular economy; and the value of the goal of Zero Waste. In many Commonwealth countries the circular economy and Zero Waste concepts have been adopted in planning and strategic management goals. In practice, in many places, potentially useful materials are being dumped or taken to landfill in increasing quantities. Waste generation per capita is getting larger, particularly in expanding urban areas.

Many impacts of waste are felt away from where that waste is generated. Plastic debris in the oceans is affecting fish stocks and is being washed up on distant beaches (articles from Canada, Australia, Belize, USA and the Mediterranean, this volume). Demands for aggregates and crushed rock are leaving voids in the landscape close to National Parks and expanding towns (Lawson, this volume). Discarded electronic materials that have been exported to other countries for dismantling are polluting drainage and are often causing ill-health among children involved in the dis-assembly process (Douglas and Kalra, this volume). However, for every problem area there is an alternative if people, businesses and governments are willing to pursue it.

In part two of the volume, we set out alternatives, giving examples of current good practice and achievements in applying the 'reduce, re-use and recycle' elements of the waste hierarchy. The way in which European countries have cut the quantities of waste going landfill and have successfully recycled increasing amounts of municipal waste shows what can be done with determination, soundly implemented legislation, and appropriate financial incentives. The important element in all this is the thinking at multiple scales from the individual household to the global impacts of discarded materials.

All sectors of society have a role to play: from actions at the household level; to good practice in business and industry; responsible, active and caring governance at municipal, regional and national levels; and international collaboration and responsibility-sharing to mitigate the impacts of waste on the global commons. All concerned have to recognize their individual responsibility in caring for the ecosystems and human ecology of our planet.



The Mobius Loop which indicates that an object is capable of being recycled – not that the object has been recycled or will be accepted in all recycling systems. Sometimes this symbol is used with a percentage figure in the middle to explain that the packaging contains x% of recycled material. www.recyclenow.com

RECYCLING IS NOT AN OPTION – IT IS A RESPONSIBILITY

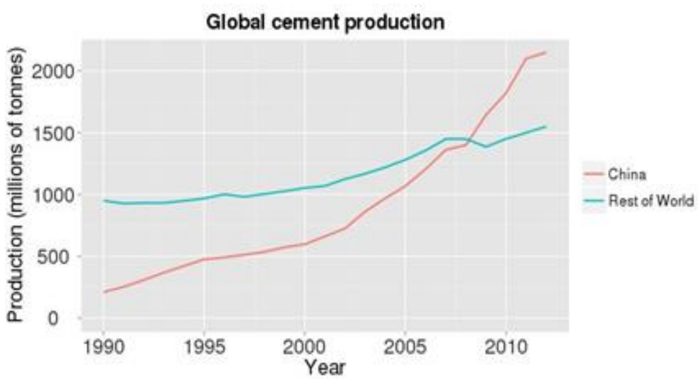
1. Construction and Demolition: Resource Usage and Recycling.

Nigel Lawson *University of Manchester*

Introduction

Primary raw materials and products which become surplus to requirements are commonly referred to as waste or secondary raw materials. Those arising during construction and demolition can become valuable sources of alternative raw materials. Recycling reduces the need for mining and quarrying primary construction materials, land degradation, disposal costs and carbon emissions. The need to exploit these alternative resources is demonstrated by the exponential growth in the global population and in urbanization since the 1950s and the double demand on land which this creates: land on which to build houses and land needed for extraction of the materials with which to build them. The expected life span of urban housing is falling: in the UK 39% of houses are already over 65 years old but now new buildings are expected to last only 60 years. A 50 year theoretical building lifespan is now suggested for assessing new developments (Oliver, 2012). In China the lifespan of current buildings is estimated at a mere 30-40 years (Zhao et al 2008). Advances in the standard of living in many newly industrialized countries is further increasing the requirement for building materials: for example the per capita building space of urban households in China has increased from 24.5 square meters per person in 2002 to 32.9 square meters in 2012 (China Statistical Yearbook, 2014). The increase in the need for raw materials for construction is illustrated graphically by the production of cement both globally and in China during the last 20 years (Figure 1).

Fig. 1 Global Cement Production
(Source: Watson, R. 2015).



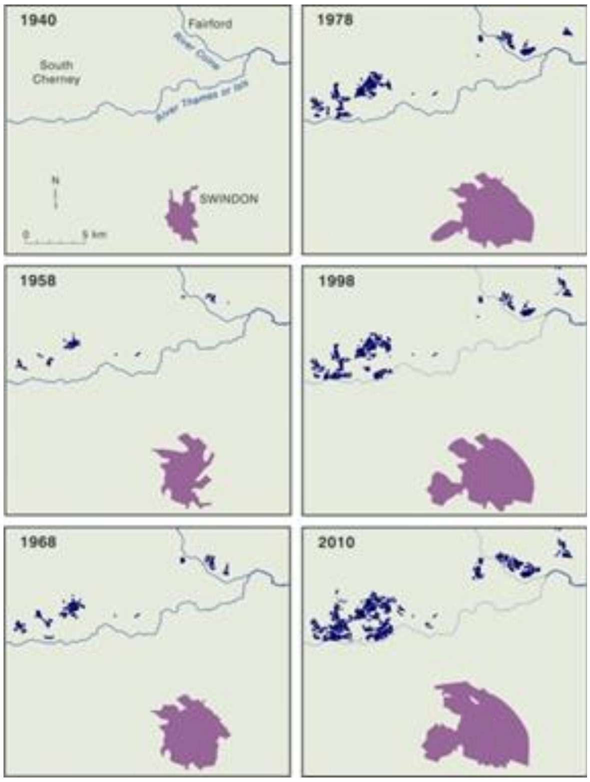


Fig. 2 Land transformed by gravel extraction in the Colne Valley and urban expansion of Swindon, UK 1940-2010

The environmental impacts of extractive industries are underestimated. Mining and quarrying for construction materials and the disposal of waste to landfill leave behind large areas of disturbed areas of land. Restoration of such areas is difficult and expensive and the agricultural productivity of restored sites is low. Gravel pits near Swindon in the south-east of England have filled with water (Figure 2) and the large limestone quarries around Buxton in the English Peak District scar the landscape
(Figure 3 and Figure 4).

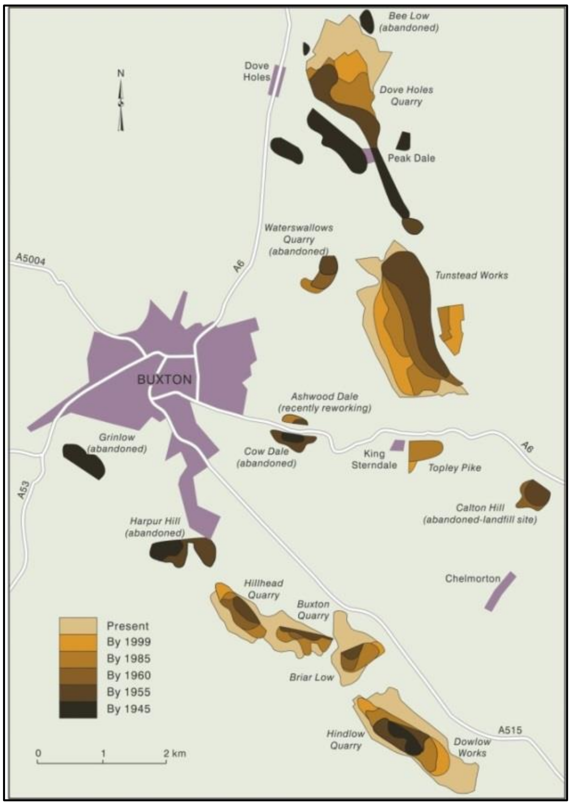


Fig. 3 Limestone extractions around Buxton, UK, 1945 – 2015.

Fig. 4 Tunstead Quarry, Buxton, UK

The environmental impact caused by urban growth and rising living standards can be reduced by recycling construction and demolition waste (C&DW) and by increasing the usage of other secondary raw materials in the construction of urban infrastructure.

Construction and demolition waste

Construction and demolition waste (C&DW) accounts for approximately 25% - 30% of all waste generated in developed countries. In England the annual production of C&DW (excluding excavation waste which is primarily used for on-site land modelling and landfill cover) averages 40 Mt $^{-1}$ and has only varied by +/- 5% since 2001. Approximately one quarter arises during construction and three quarters during demolition (Deloite et al 2015). Despite approximately 85% of UK arisings being recovered and C&DW increasingly being recognised as a valuable source of engineering materials for the construction industry, large quantities are only used for low grade activities such as site levelling and landscaping, with a maximum of about 20% being directly recycled as a graded aggregate product (Department for the Environment, Food and Rural Affairs 2015).

C&DW has been identified as a priority waste stream by the European Union (European Environment Agency 2016). There is great potential for recycling and re-use of CDW because its components have a high resource value. In particular, there is a re-use market for aggregates derived from CDW waste in roads, drainage and other construction projects and using C&D wastes reduces reliance on primary aggregates and lowers the environmental impact of construction. The technology for the separation and recovery of construction and demolition waste is well established, readily accessible and in general inexpensive. Fixed and mobile crushers transform concrete and broken bricks into graded aggregate. Whole bricks can be reused and many older varieties of brick in the UK are increasingly sought after for their quality and their aesthetic value. The recycling of clean separated construction wastes such as metals, plastics, glass, wood and paper/cardboard is well established.

Construction waste

Waste products from new construction are usually clean and relatively uncontaminated. They are composed primarily of a mixture of unused or damaged raw materials as well as off-cuts (discarded cut material) and packaging (Table 1) (Figure 5).

Fig. 5 Construction waste

CONSTRUCTION WASTE	%
concrete, bricks, blocks, aggregate	35
metals	28
excess mortar/concrete	12
timber & products	8
plastic packaging & plastic products	9
plasterboard & plaster	3
paper and cardboard	2
vegetation	1
soil	1

Table 1 Composition of construction waste in the UK

Most construction waste can be recycled as graded products but, as with virtually all waste streams, the successful recycling of these materials depends largely on the degree to which they are separated into their prime components.

Demolition waste

Demolition waste is the material arising from the demolition or stripping out of existing structures. Demolition waste includes actual building components, such as full-length studs and concrete slabs. The largest component of demolition waste is concrete, followed by brick, clay, wood and metals (Table 2) (Figure 6).

DEMOLITION WASTE	%
concrete	36
masonry	22
paper, cardboard, plastic & other.	15
asphalt	13
wood based	3

Table 2 Composition of demolition waste in the UK

Fig. 6 Demolition waste

Demolition waste materials are often dirty, consisting of materials transformed during the construction process and are mixed with other materials. For example, waste concrete removed from the floor of an industrial building may be mixed with soil or mobile soluble contaminants that have been absorbed into porous building materials. Surfaces may be contaminated by coatings that have been used to protect them during their service life. Laboratory testing for contaminants in demolition waste is time consuming and the decision whether or not material is contaminated is invariably made solely on the basis of knowledge of previous activities within the building and on visual inspection. Again, separation is the key to sustainable recycling because the vast majority of the mass of these materials are free from contaminants (Craven, 2013; Lawson et al 2000).

Other secondary raw materials

Large quantities of construction materials can also be sourced from other industrial waste streams (Douglas and Lawson, 2005). In many parts of the world disadvantaged communities obtain their building materials from domestic and municipal waste. Examples of the diverse sources will now be described.

Colliery spoil and coal ash

Coal mining waste is widely available and generally is suitable for reuse as a substitute for fresh aggregates. Both burnt and unburnt colliery spoil are can be used as engineering fill in construction and are potentially useable in concrete if processed to produce a synthetic aggregate.

Oil shale waste.

This material has similar chemical and physical properties to burnt colliery spoil and can be used as a substitute for primary aggregates. It has been widely and successfully used as bulk fill and as selected granular fill.

Pulverised fuel ash

Pulverised fuel ash can be used as structural fill, in block and lightweight aggregate manufacture; as a cement replacement; and as an additive in concrete and in brick manufacture.

China clay and slate waste

Large quantities are stock-piled where arising. They are suitable for all applications where crushed rock is specified but the cost of transport is restricting their reuse.

Glass

Fragmented glass can be used as an aggregate substitute or as an additive to asphalt for road construction.

Tyres.

Malaysia has for long used rubber in road surfacing materials, providing an outlet for shredded tyres. The springy surfaces of modern children's playgrounds are made from used vehicle tyres. Tyres are also used as an additive in the manufacture of concrete.

Foundry sand.

Recycled foundry sand can be used for the manufacture of concrete blocks as a substitute for silica sand; in the production of asphalt; and in roofing felt manufacture.

Incinerator bottom ash.

The ash from municipal solid waste incineration is another substitute for primary aggregates that is being used successfully in European countries for embankment fill; road-base material; asphalt; and concrete building blocks.

Ceramic waste

Fired ceramic waste is used as bulk fill for roads and paths.

Innovative building products from solid waste in urban settlements

Municipal solid waste is another valuable source of building materials to many disadvantaged communities. A collaborative research programme on improving the quality of the built environment in urban squatter settlements in Indian through effective waste recycling led to the development of several ingenious building products from solid wastes (Commonwealth Human Ecology Council et al, 2006). These products include tiles and blocks made from various wastes by using organic polymer, geo-polymer and phosphate binders; sandwich panels made from cardboard, jute and bamboo; and translucent panes manufactured from such wastes as polyethylene terephthalate (PET) bottles, woven fabric, polypropylene, glass, jute and polyester (Figures 7, 8 and 9).

Fig. 7 Translucent panes from various waste products manufactured from municipal solid waste in India

Discussion: constraints and opportunities

Time and distance to waste sources; the expense of separation; and the ready access to cheap building stone and aggregates restrict the sustainable reuse of C&DW as primary raw materials. The cost of transporting high mass, low value materials means

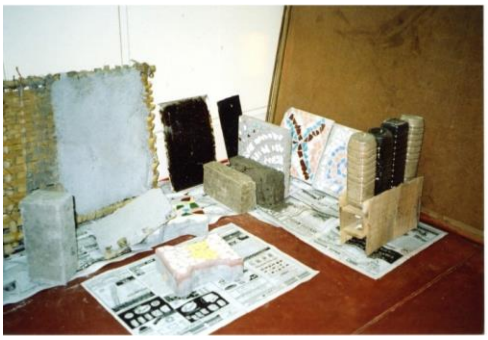


Figure 8 Tiles, blocks, sandwich panels and various building products manufactured from municipal solid waste in India.

that the sustainable recycling of C&DW depends on the waste sources being close to the location where they can be reused as an alternative to primary raw materials. In the UK, waste legislation applies to all types of waste including C&DW. The charges for testing C&DW to meet EU End of Waste criteria can be prohibitive. Some products such as asbestos- based insulation and fibres in mineral based ceiling tiles may have health implications.

Closing the C&DW resource cycle requires innovative solutions. In the UK the imposition of a landfill tax has resulted in the greater use of recycled aggregates. Quality protocols for inert waste provide a thorough methodology to establish when C&DW ceases to become waste and is able to meet the End of Waste Criteria Act allowing it to be re-used. Initiatives such as the Building Research Establishment's Environmental Assessment Methodology (BREEAM) for master-planning projects and the use of site waste management plans provide a framework for waste reduction.

Much more needs to be done to ensure that C&DW becomes a valuable resource. There is a need for waste treatment facilities geared to the recycling and storage of C&DW to be strategically located on or near ring roads adjacent to expanding urban areas. The use of composite materials in insulation panels and timber products are becoming more prevalent and architects should be encouraged to design buildings with their ultimate deconstruction in view, enabling materials to be separated without cross-contamination. Behavioural change could be achieved if, in lieu of contractors having to pay to dispose of waste, they were recompensed for depositing well separated waste products at designated sites. Such a move would also discourage fly tipping. In developing world squatter settlements discarded materials become valuable building commodities and more economically developed societies can also learn from solutions such as those being used by people in the developing world without easy access to natural resources.

Fig. 9 Manufacturing sandwich panels in a settlement in Ahmedabad, India

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2. E-waste

Ian Douglas and Ripin Kalra
Commonwealth Human Ecology Council

Introduction

Our increased reliance on continually upgraded personal technology, such as laptop computers and cell phones, has much old equipment being deposited in landfills and incinerators rather than being reused or recycled. Electrical gadgets, with plugs or batteries, on which we have now depend so much, are difficult to repair, re-use and recycle, due largely to their sheer numbers, component complexity, and the hazardous substances that they contain. This waste (Table 1) has many valuable components, particularly precious metals, which make some dismantling and recycling economically viable. In this article we seek to examine the magnitude of the problem, what is being done now and what needs to be improved in the future.

Table 1. Categories of e-waste

No.	Category	Examples
1	Large household appliances	refrigerators, cookers, washing machines
2	Small household appliances	vacuum cleaners, irons, toasters
3	IT and telecoms equipment	computers, photocopiers, telephones
4	Lighting equipment	fluorescent tubes and high intensity discharge lamps
5	Toys, leisure & sports equipment	electric trains, games consoles, running machines
6	Electrical & electronic tools including	drills, saws, sewing machines, electric lawnmowers
7	Medical devices	dialysis machines, medical freezers, cardiology equipment
8	Monitoring & control equipment	smoke detectors, thermostats, heating regulators
9	Automatic dispensers	hot drink vending & automatic teller machines
10	Electrical waste	switches, relays, connectors,
11	Electronic Waste	metal waste, printed circuit boards, sockets, connectors
12	Cable waste	pre-insulated copper, PVC, & aluminium waste
13	Chemical waste	chemical sludge and residue

Valuable metals contained in e-waste are, in many countries, extracted at informal recycling sites where health and safety provision is minimal. Circuit boards of mobile phones can contain copper, gold, zinc, beryllium, and tantalum. Their coatings are typically made of lead; whole phone makers are now increasingly using lithium batteries. Beryllium and tantalum are only found a few localities in nature. The failure to recycle them will lead to shortages of them for future manufacturing.

Components of electronic devices also contain toxic heavy metals, such as lead, mercury, cadmium, arsenic, and also hazardous chemicals such as flame retardants and leaching agents such as cyanide.

For example, an old-style cathode ray tube computer screen may contain up to 3kg of lead. During informal recycling, after valuable metals such as copper and aluminium have been removed, the remains of the item are often burnt, releasing toxic chemicals that can affect the workers, some of whom may be children. For example, the radioactive source in smoke alarms, Americium, is a known carcinogenic. Sulphur in batteries can cause liver damage, kidney damage, heart damage, eye and throat irritation.

A typical example of the problems associated with e-waste treatment is provided by flat panel TV and computer screens. Estimates that suggest that over 145,000 tonnes of flat panel displays will be in the waste stream for the treatment and recovery of discarded flat panels. Mercury-containing fluorescent backlights are used to illuminate television, laptop and desk top monitor screens from behind. Manufacturers declare an average of 3.5 mg of mercury per backlight, with the average 37" television having up to 18 lamps; however there may be considerably this average figure suggests. The current main treatment option is to manually remove the mercury-containing backlights for specialist treatment and then separate other re-usable materials. This has both high labour costs and potential health and safety implications.

The rapid growth of e-waste

The mountain of so-called e-waste is growing by the day. In 2014, nearly 42 million tonnes of e-waste were generated, about 7 kg for every person on the planet, with the trade in e-waste possibly being worth as much as US$18.8 billion a year (UNEP, 2015). Most of this waste was generated in Asia (16 Mt), followed by Europe (11.6 MT), North America (7.9 Mt), Latin America and Caribbean (3.8 Mt), Africa (1.9 Mt) and Oceania (0.6 Mt). However, in e-waste generation per capita, Europe has the highest figure (15.6 kg/person) and Africa the lowest (1.7 kg/person) (UNEP, 2015). Individual national generation rates range from 0.2 kg in poor countries, such as Malawi, to 29.5 kg in the USA (see Table 2 for data on some Commonwealth countries). The global volume of electronic waste is expected to grow by 33% in the next four years, when it will weigh the equivalent of eight of the great Egyptian pyramids, according to the UN's Step Initiative (http://www.step-initiative.org/), established to tackle the world's growing e-waste crisis. Few countries understand the true scale of the problem, because no track is kept of all e-waste, according to the European Environment Agency, which estimates that between 0.25 and 1.3 million tonnes of used electrical products are shipped out of the EU every year, mostly to West Africa and Asia (Fig 1).

Fig. 1 e-waste in Ghana
(Sourca: GL Brain)

Table 2: Estimated e-waste generation in Commonwealth countries (data from Baldé et al., 2015) e-waste generation

Country	Kg per capita	Total kt	Country	Kg per capita	Total kt
UK	23.50	1511.00	St. Vincent & the Grenadines	9.70	1.00
Canada	20.40	725.00	Mauritius	9.30	12.00
Australia	20.00	468.00	Trinidad & Tobago	9.00	12.00
Singapore	19.60	110.00	Botswana	8.30	16.00
Bahamas	19.10	7.00	Malaysia	7.60	232.00
New Zealand	19.00	86.00	South Africa	6.60	346.00
Brunei Darussalam	18.30	7.00	Belize	6.50	1.00
Cyprus	16.30	14.00	Maldives	6.30	2.00
Malta	14.60	6.00	Guyana	6.10	5.00
Barbados	13.20	4.00	Jamaica	5.80	16.00
Antigua and Barbuda	11.60	1.00	Tonga	5.40	0.57
Seychelles	10.90	1.00	Namibia	5.00	11.00
St.Kitts & Nevis	10.10	1.00	Sri Lanka	4.20	87.00
Grenada	10.00	1.00	Swaziland	4.00	4.00
St. Lucia	9.90	2.00	Samoa	4.00	0.76
Dominica	9.70	1.00	Kenya	1.00	44.00
Vanuatu	3.90	0.78	Uganda	0.90	33.00
Kiribati	3.90	0.45	Cameroon	0.90	9.00
Fiji	3.30	3.00	Lesotho	0.90	2.00
Tuvalu	1.70	0.02	Zambia	0.90	13.00
Solomon Islands	1.60	0.95	Bangladesh	0.80	126.00
Ghana	1.40	38.00	Mozambique	0.70	16.00
Pakistan	1.40	266.00	Rwanda	0.60	6.00
Nigeria	1.30	239.00	Tanzania	0.50	13.00
India	1.30	1641.00	Sierra Leone	0.40	2.00
Gambia	1.20	2.00	Malawi	0.20	4.00
Papua New Guinea	1.10	8.00			

The e-waste hierarchy: recycling, disassembly and disposal

Advice on the disposal of e-waste in the UK suggests 1) returning the product to the manufacturer; 2) taking the item to a professional waste disposal facility; or 3) donating the goods to a non-profit organization. Manufacturers, such as Dell and Hewlett Packard, now incorporate e-waste management into their environmental policies and operate consumer recycling schemes. Such schemes reduce dumping in landfills, lower demands for raw materials, and make recycling convenient for the consumer.

In well-regulated countries, licensed waste carriers may collect and dispose of e-waste, but even a UK government website warns that “There are quite a few waste disposal cowboys out there” and suggests checking that any company complies with the relevant legislation and can provide details of their waste carrier’s licence.

Several non-profit organizations collect electronic equipment including computers and printers, either for re-use or for disassembly and recycling. Recipients are either given the equipment, or buy it for a nominal amount. Although most such equipment goes to developing countries, some is used by local community groups. Press reports and electronic media writers have questioned the sending of used electronic goods to developing countries, saying that the United Nations is accusing the relatively rich countries of dumping the waste on those less developed.

Export of e-waste

Data on the export of e-waste are difficult to obtain, so many scholars have used sophisticated methods to obtain reasonable estimates (Duan et al., 2014). Used electronics, including around one million used laptops per year, have been shipped from the USA to all parts of the world, but the majority of the used laptops went to Asia (48% of the total) and Latin American and Caribbean countries (25%) that are within the high income or upper middle income categories. Only 4% went to African countries. It is important to remember, however, that it is unclear whether these countries were the final destinations for the exported products. Indeed, some of the destinations may simply be transfer points for re-export activities (Duan et al., 2014).

Broad analysis of where e-waste is traded reveal that the global trade in e-waste is largely organized intra-regionally, with the Americas, Asia and Europe representing the largest volumes of trade. Inter-regional trade, though smaller in volume than intra-regional trade, evolved after 2001 into a distinct orientation of e-waste flows to Asia from all other regions. There is some support for the pollution haven hypothesis (that richer countries export e-waste to poorer countries where disassembly cost are lower) in that as GDP per capita declines, the likelihood of a given country being a net importer of e-waste increases (Lepawsky & McNabb, 2010). E-waste trade transactions tend to occur between trade partners where the importer has a lower GDP per capita than the exporter. However, while e-waste is traded inter-regionally, moving from developed to developing countries, there is a substantial trade in e-waste between developing countries.

The materials disposed of as e-waste in one place become sources of value elsewhere when they are reused, repurposed and/or broken down as feedstocks of experienced resource inputs to new manufactured goods, not necessarily in the electronics sector. Separation of e-waste component materials occurs in situations ranging from well-run modern factories to informal activities by impoverished people on the edges of waste dumps or among the shacks of squatter communities in deprived urban areas. Many accounts of such informal places describe the high risks faced by workers and residents, particularly by the young people and children involved.

One location of informal e-waste processing adjoins the 31 ha Old Fadama informal settlement in Accra, Ghana, on the floodplain of the Odawa River and Korle Lagoon. Close to Accra's flourishing Agbogbloshie wholesale market, 1.5 km from the city centre (Farouk & Owusu, 2012), Old Fadama comprises densely packed self-built kiosks and shacks, with inadequate water supplies and but a few hundred toilets for around 80,000 people (Afenah, 2012). The Odaw River carries untreated sewage from parts of the Greater Accra area upstream, as well as contaminants from nearby electronic waste dumps and scavenging areas (Huang et al., 2014; Monney et al., 2013).

Over 72% of Old Fadama's inhabitants are migrants from northern Ghana and most male residents work informally in recycling e-waste. Now a centre for the dissembling of discarded electronic equipment, Ghana receives waste from Africa, Europe and North America (Grant & Obeng-Ababio, 2012). This informal recycling is a key part of the metals recovery process and thus of the Ghanaian economy and its global links (Box. 1). Here, informality has become normalized within global-urban dynamics (Grant & Obeng-Ababio, 2012). However, today most of the e-waste handled in Agbogbloshie is derived from other parts of Africa.

For a decade, Agbogbloshie has been the site most synonymous with e-waste dumping in the eyes of the world's media, including the New York Times, Al Jazeera and the Guardian. Journalists describe how 7- to 25-year-old boys smash stones and simple tools against TVs and PCs to get to the metals, especially copper. Earning approximately $2.50 per day, most of them suffer injuries like burns, untreated wounds, lung problems, eye damage, and back problems together with chronic nausea, anorexia, debilitating headaches and respiratory problems. Almost everyone suffers from insomnia. Smoke and invisible toxins (especially cadmium) harm the workers because they often are unaware the risks and have not protective clothing. Nevertheless, the work is part of a well-organised trading system, with the reclaimed metals and components being marketed by middlemen.

Box 1. The Human Ecology of Coastal ACCRA & E-Waste

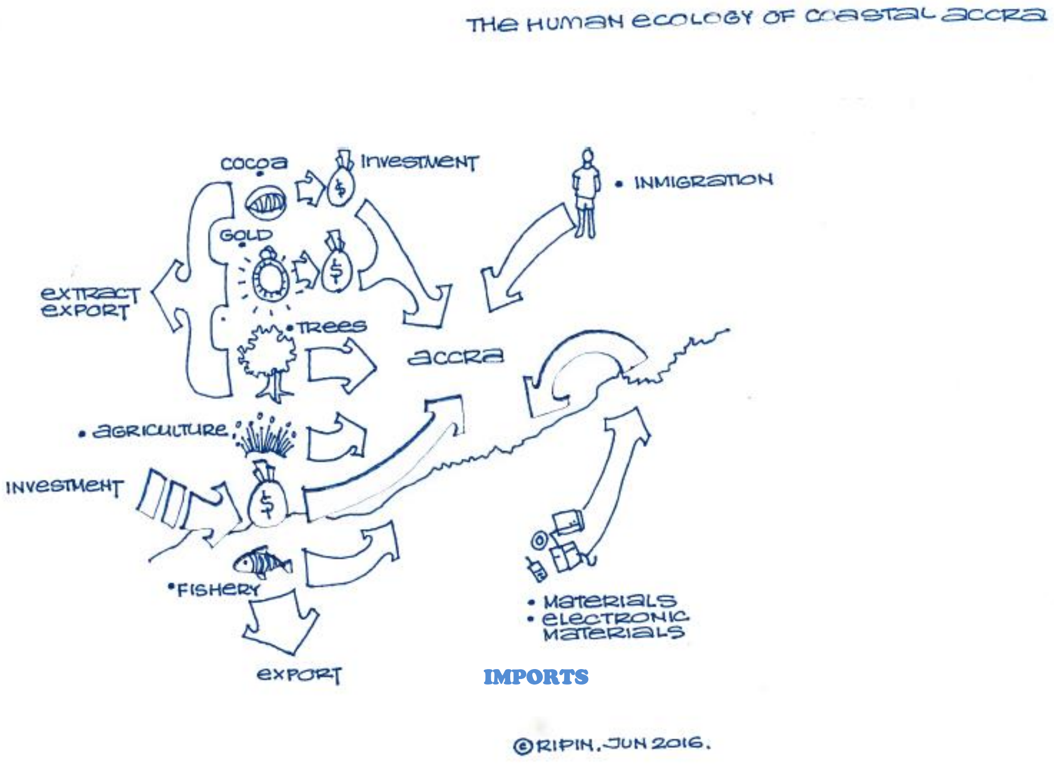
Ripin Kalra *Commonwealth Human Ecology Council*

Rapid environmental change in Coastal Ghana (Accra) has coincided with evolving economic practices. Most of the last 500 years saw the area dominated by subsistence fishing and farming. Many households within the area continue to rely on resources 'given by nature'. The resource extraction and export practices (cocoa, gold, timber) that followed led to significant environmental changes at a wider scale. Their environmental consequences have been difficult to mitigate, even though in the late 20th century there were efforts to control the decimation of hardwood forests.

In the post-colonial period, particularly since 2000, investment (or expectation of investment) in real estate has led to rapid expansion of built-up urban land. Developers have contributed heavily to this and as a result vast areas of green cover have been permanently lost. Inward investment in real-estate and services has required the setting-up of supply chains for building material. It is believed that the Greater Accra Metropolitan Area (GAMA) now imports (into the country) 70% of its building materials: a staggering proportion of building material demand to be met from imports.

In the last two decades we have witnessed an alarming growth in the dumping of e-waste in the GAMA area, some of which is on sites that are both ecologically sensitive and important for subsistence (water and land for fisheries or food crop production for local communities). Other than crude extraction of material from electronic components, the facilities and skills available locally are inadequate to return this e-waste into usable and economically re-usable and recyclable products.

Urbanisation in recent years has led to both environmental pollution and depletion in the GAMA. The financial cost of this is enormous and much of the damage is irreparable. This puts the entire human ecology, the social and environmental aspects of the urban ecosystem, at risk.



Regulating e-waste trade

International trade in hazardous materials is banned under the Basel Convention, which came into force in 1992, and bans the export of hazardous waste including e-waste from developed countries to developing ones for "final disposal, recovery or recycling".

The collection and management of e-waste depends heavily on the legislation in each country. As e-waste could include end-of-life products, it is an obvious candidate for some form of extended producer responsibility (EPR) or product stewardship, with such schemes being either voluntary or mandatory. Although various forms of take-back systems are being implemented in both developed and developing countries, the amount of e-waste treated under such systems is reported to be lower than 50% of the total amount generated (40% in Europe, 24 to 30% in China and Japan, 12% in the U.S. and 1% in Australia). The e-waste not collected under these take-back systems might end up discarded into the general waste stream, or it might be collected by individual dealers or companies who trade the e-waste either for reuse or disassembly and resale of usable components and valuable metals. (UNEP, 2015).

In Europe, the updated EU *Waste Electrical and Electronic Equipment (WEEE)* directive which became law in 2014 obliges large shops selling electrical goods to accept small e-waste items from customers, such as mobile phones, even if the customers do not buy a replacement. With big items such as washing machines, the manufacturers will be responsible for the recycling. The law also requires exporters to provide proper documentation for goods being shipped for repair or re-use. The aim is to prevent illegal shipments of e-waste to poorly equipped developing countries. The Commission says that such illegal shipments, used to evade EU regulations, are a serious problem in the EU.

From 2016 EU member states will have to collect 45 tonnes of e-waste for every 100 tonnes of electronic goods put on sale during the previous three years. By 2019 the target must rise to 65 tonnes, or member states can opt to collect 85% of total e-waste generated. EU officials say only about one-third of e-waste is treated appropriately.

Sadly, in May 2015, a UN Environment Programme (UNEP) report estimated that 60 to 90% of the world's electronic waste is illegally dumped (Fig 2). "Many shipments of e-waste are disguised as second-hand goods," the UNEP report says. The big problem is that we do not know the quantities of e-waste involved in: 1) collection outside official take-back systems in developed countries; 2) transboundary movements; and 3) informal collection systems in developing countries (Baldé et al., 2015).

> The United States and China generated the most waste. However, countries that regard themselves as environmentally conscious topped the list for per-capita waste, leading with Norway and followed by Switzerland, Iceland, Denmark and Britain.
>
> 2014 GLOBE-Net c/o GLOBE Foundation of Canada
> (Accessed at: http://globe-net.com/global-e-waste-volume-hits-new-peak-in-2014/)

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Fig 2. Trucks carrying waste into an open municipal waste dump in Phnom Penh, Cambodia, 2007 (Ian Douglas)

3. The Ganges: Holy, Deadly River

Victor Mallet

FT MAGAZINE
Victor Mallet was the FT's South Asia bureau chief.

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The Ganges is venerated and relied upon by half-a-billion people. But its waters are also a lethal cocktail, poisoned by industrial pollution and human waste. Victor Mallet travels the river's length to find out whether the sacred waters can still be saved.

Nearly 13,000ft up in the foothills of the Himalayas Amod Panwar, an Indian hotel owner and devout Hindu, reverently places offerings of almonds, sultanas and a coconut into the water cascading from an icy cavern known as Gaumukh, the "cow's mouth".

As dusk falls over the snow-capped peaks, a block of ice the size of a house breaks from the glacier and plunges into the stream with a roar, sending me scurrying for safety across the grey stones of the riverbank. Panwar, my guide for the gruelling high-altitude trek from Gangotri in northern India, is undeterred. He continues his devotions, strips off his clothes and immerses -himself in water flecked with shards of ice. Only when we have filled plastic bottles with the holy liquid to take home in our backpacks do we walk downhill to the isolated ashram where we will take sweet tea and shelter in the cold October night.

Gaumukh, the source of the River Ganges, is one of the most sacred places in Hinduism. But in truth the entire river, flowing for more than 2,500km across north India from the mountainous haunts of the snow leopard (we see prints on the way down) to the tiger-infested mangrove swamps of the Bay of Bengal, is holy. Ma Ganga or Mother Ganges, described by Harvard religious scholar Diana Eck as "the archetype of sacred waters", is worshipped as a goddess by Hindus worldwide. Her water has even been ceremonially poured into a well built on the orders of a generous 19th-century maharajah for the English villagers of Stoke Row, near Reading.

Reverence for the river should come as no surprise. Descending rapidly from the Himalayas before winding across its fertile and densely populated floodplain in north India and Bangladesh, the Ganges has helped to sustain a tenth or more of the world's population with food, water and fish for millennia.

Like many non-Indians, I was vaguely aware of the sanctity and the economic and social importance of the river before I came to live in India three years ago. In his famous travel book Slowly Down the Ganges (1966), Eric Newby lists translations for 108 of the sacred Sanskrit names for the river, among them "eternally pure" and "alight amid the darkness of ignorance". Legend has it that Shiva protected the world from Ganga's destructive power when the cosmic waters fell to earth by releasing the streams gently through his hair. One Sanskrit hymn calls the river the "sublime wine of immortality".
What I had not expected was to find the Ganges so polluted by untreated sewage, industrial waste and pesticides that parts of the river and its tributaries are not only filthy and unsightly but disease-bearing, toxic and carcinogenic.

The crisis afflicting their emblematic river has not escaped Indians themselves. Narenda Modi, the Hindu nationalist leader who swept to power in last year's election, abandoned his constituency back home in Gujarat and chose the ancient city of Varanasi (Benares) on the Ganges as his parliamentary seat. He called the river his mother and promised a clean-up. Hundreds of millions of dollars’ worth of projects since the 1980s have failed in this aim, and when Modi met President Barack Obama for an informal White House dinner last September, the talk turned almost immediately to climate change and the new effort to clean the polluted Ganges. Obama told Modi that the river in his native Chicago, once so filthy it used to catch fire, was now a place where fish were caught and eaten. "That's exactly what I want for the Ganga," said Modi.

By then, piqued by 1970s photographs showing weekend dinghy sailing in Delhi on a Ganges tributary that is now a foetid open sewer, I had already made it a mission to discover what ailed the river and why, and had decided to see as much of it as I could from source to mouth. Good scientific data, especially on industrial pollution, are scarce in India. But the conclusions of official measurements, academic papers and the evidence of one's own eyes are alarming for anyone who cares about human health or the environment.

Delhi's Yamuna River, one of the great tributaries of the Ganges, is a good place to start. Portrayed in Indian legend as a natural paradise of lilies, turtles and fish enjoyed by the flute-playing Krishna and his adoring gopis, almost all its waters are now diverted above the capital for irrigation. In the dry season before the monsoon, what flows from greater Delhi's 25million inhabitants towards Agra and the Taj Mahal is a toxic mixture of sewage and industrial waste, foaming hideously into windblown heaps of spume as it passes the Okhla barrage (Fig. 1).

Fig. 1 Yamuna River (Credit: Ian Douglas)

First, the sewage. At its worst - according to the 2011 water quality statistics published by the Central Pollution Control Board (CPCB) - the Yamuna's water at Okhla contains 1.1billion faecal coliform bacteria per 100ml, nearly half-a-million times the (Indian) recommended bathing limit of 2,500. The reason is clear. Half of India's 1.3billion inhabitants lack toilets; if they have them, they may not be connected to drains; if they are, there may be no sewage treatment plant; and if there is, it may not be working. The CPCB says only a tenth of the sewage produced along the main stream of the Ganges is treated at all. It is small wonder that those who can afford it use high-tech water filters to ensure the cleanliness of their drinking water, or that more than 300,000 Indian children under five die each year from diarrhoea, many of them in the Ganges basin.

Equally sinister are the findings of scientists investigating the rapid, sewage-borne spread of genes known as NDM-1 and NDM-4 (NDM stands for New Delhi metallo-beta-lactamase) that associate themselves with bacteria to form "superbugs" highly resistant to most kinds of antibiotics. NDM-1 was first detected in Delhi drinking water in 2010, and David Graham, a Canadian environmental engineering professor at Newcastle University , told me that he, as a visitor to India, and I, as a resident of Delhi, were both likely to be harbouring NDM-1 in our guts. A research paper he co-authored last year found that concentrations of NDM-1 in the relatively clean waters of the upper Ganges multiplied greatly when Hindu pilgrims from India's big cities visited holy sites such as Rishikesh and Haridwar in the early summer. The rise was correlated with increases in faecal bacteria, too, suggesting that poor sanitation was once again the cause of the contamination. It is a grim irony that urban Indians who come to pay homage to the Ganges end up dirtying the river and spreading exposure to life-threatening diseases across the country. The second problem is industry. A recent sampling of the Yamuna's sediments, where many of the capital's vegetables are grown when the river is not in spate, found the riverbed to be "highly contaminated" with carcinogenic and poisonous heavy metals, including lead, cadmium, chromium, mercury and arsenic - all except the naturally occurring arsenic being largely the product of India's rapid industrialisation. "This is alarming," says Prashant Rajankar of Toxics Link, the environmental group that published the study. He adds that more research is needed now into the vegetables themselves. Even for the main stem of the Ganges, there is little information about the scale of the crisis. The CPCB merely mentions 764 "grossly polluting industries" and says how much wastewater they produce - but not what is in it.

One obvious way to grasp the effects of human waste and industrial toxins is to compare locations upstream and downstream. So, with the help of the World Wide Fund for Nature (WWF), I visited stretches of another important Ganges - tributary, the Ram Ganga. The contrast was startling.

In the hills near Marchula, the Ram Ganga flows clear and fast, home to fish eagles and otters. Stand on the bank and you can see golden and silver - mahseer fish swimming in the pools and hear the harsh bark of the sambar, a type of deer, from among the trees. Anil Kumar, a guide and ornithologist from the village of Bakhroti, perched high on a hillside, points to tiger footprints, the dung of wild -elephants and a pool where he caught a 68 kg catfish two years ago. I jump in for a swim and wash off the grime of the long journey by car and on foot from Delhi. In a village above the river, Basanti Devi - who thinks she might be about 50 years old - complains that wildlife is too abundant, with elephants destroying the vegetable crops and tigers occasionally eating a cow. "I saw a tiger right here two months back," she says.

Fig.2 Bihar, India (Credit Eva Ekehorn)

The descent to the plains of Uttar Pradesh (at 200million, the state has as many inhabitants as Brazil) is a shock. By Indian standards, Moradabad is not a particularly large city - just one million people - but there is no sewage treatment and there are scores of paper mills, sugar plants, brass foundries and plastics factories nearby that spew waste into the Ram Ganga and its tributaries. Downstream of the city centre, the sandy banks and the exposed riverbed present an apocalyptic scene of filth and garbage, of dead dogs, plastic bags, nullahs (drains) spewing pink dye and pigs rootling through the muck. All the while, men with tractors and bullock carts are mining sand for construction, while dhobi-wallahs (washermen) ply their trade in the dirty water and a boy forlornly casts his net for fish. In the Lal Bagh district, men and women squat in the shallows swirling the waste ash from the foundries in deep bowls to recover tiny remnants of metal. We had been told that the panning of incinerated electronic waste is done here at the dead of night - it is illegal because of the known toxicity of many of the components - but at least one boy is openly panning his e-waste in the daylight to extract wire and other valuables.

"When I was young this river was very clean and we could even see the riverbed," says Mairaj Uddin, a Moradabad dentist who has become a Ram Ganga Mitra (crusader), one of a group of anti-pollution volunteers formed by WWF-India. As he speaks, someone hurls a plastic bag of rubbish from the walls of the nearby Ganga Mandir, a Hindu temple, straight into the river. "Now it's dead. All the sewage from the city comes into the river. But things should change once the sewer line is laid... And I really hope that I'm going to help make this river go back to its original state. Maybe I'll be too old to bathe in it. But I want my children to bathe in it."

The same pattern - cleaner water upstream, filth downstream (faecal contamination is "off the charts, ridiculously high", says one World Bank (official) - is repeated around all the great pilgrimage sites and cities along the Ganges.

Near the Hastinapur wildlife sanctuary, between Haridwar and Kanpur, it is almost possible to -imagine what the Ganges was like in its stately progress across the north Indian plains before the industrial revolution, the building of dams and the population explosion. We encounter a cheerful crowd of pilgrims, waving flags, blowing trumpets and carrying brass pots of river water as they return from their prayers to Ma Ganga. Ducks and waders feed in the shallows while river turtles and endangered gharials, the thin-snouted crocodiles of the Indian subcontinent, bask on the sandbanks.

The industrial town of Kanpur is another story. So vile is the effluent from its 400 tanneries - including dyes, salts, acids and chromium -compounds - that the government temporarily shut them down for the 2013 Kumbh Mela downstream in Allahabad. I was among the tens of millions who bathed in the Ganges at this Hindu festival, reputed to be the largest gathering of humans on earth. Rakesh Jaiswal, a Kanpur environmentalist, calls the tannery waste a "toxic cocktail" of chemicals that afflicts farmers using the water with rashes, boils and numbness in the limbs. A few years back he helped the Blacksmith Institute, a non-profit group that tackles pollution, to protect a Kanpur community of 30,000 from hexavalent chromium - Cr(VI) - in their groundwater. Known to cause lung cancer, liver failure and premature dementia, Cr(VI) had been found at a concentration more than 100 times the Indian government limit.

Move still further downstream and you reach Varanasi. I assume that this - the cultural heart of India and of Hinduism and, it is said, the world's oldest living city - must be the place to understand what is being done to the Ganges and why Indians so abuse the river they worship. At dawn near the ghats (the riverside steps) and funeral pyres, holy men meditate and pilgrims bathe. A pair of dogs fight over charred human remains on the muddy shore (one scientist has calculated that 32,000 human corpses are cremated here each year, with 200 tonnes of half-burnt human flesh discharged into the Ganges). The rotting remains of a monkey, its face distorted in a watery rictus, is caught on a boat's mooring line. A rotund man snorts like a hippopotamus as he swims across to the far bank and a yoga lesson broadcast by loudspeaker punctuates the subdued roar of awakened humanity.

Even here, in a seat of ancient learning and religion, there is little scientific data on the Ganges, but the anecdotal evidence and the facts that do exist are scarcely comforting. Atul Gawande, the Indian-American surgeon and writer, describes in Being Mortal - his book on ageing and death - how he came to Varanasi to commit his father's ashes to the Ganges. Knowing both the ritual and the unhygienic state of the river, he carefully dosed himself with antibiotics, hoping to avoid illness from the three spoonfuls of bacteria-filled river water he would be made to drink by the pandit presiding over the ceremony. Instead, he caught Giardia, a parasitic infection resistant to the antibiotics.

Few residents are aware of such dangers, and even if they are, they are unsure what to do about them. "I still bathe in the river on major Hindu festivals because that's what everybody here does," says Rina Verma, a 17-year-old student who lives at nearby Assi Ghat. "I feel really offended when outsiders come here and say they will not touch the river because the water's very dirty," she adds. Some locals say they learnt to swim in the Ganges but have now stopped and keep their children away. "My son asks me, 'You all had so much fun in your time going to the river, what about us?'" says Govind Sharma, a small trader of 43 with a 10-year-old son. "I have no answer. I feel sad and guilty."

As in the Yamuna, the pollution is not just from sewage. Scientists Anand Singh and Jitendra Pandey at the city's Banaras Hindu University (BHU) last year published one of the first detailed studies of heavy metals in the Ganges. They found concentrations increasing steadily as they moved downstream past Varanasi, suggesting that its own waste was the main contributor. After the city, concentrations of both lead and cadmium were typically about three times the World Health Organisation’s "maximum admissible concentrations". Noting the resultant risk of everything from birth defects to cancer, Pandey said the presence of the toxic metals was "a health -concern directly to human beings".

It has been known for years that there are alarmingly high rates of certain cancers in the Gangetic plain. Women in Delhi show the highest rates of gall bladder cancer in the world. Indian scientists hesitate to say which heavy metals, if any, are the cause, although a preliminary Indo-Japanese joint study in 2012 found "significantly high" levels of chromium, lead, arsenic and zinc in the cancerous gall bladder tissues of Indian samples when compared with those of Japanese sufferers.

So why allow the pollution, then? It is not just that people are oblivious to the ugliness or ignorant of the dangers; that was true of most countries during their industrial revolutions and is changing fast. In India, there is an additional obstacle to change: so sacred is the Ganges that she is considered beyond harm. Her waters are pure, medicinal even, and she is the responsibility of the gods, not of humans.

Ilija Trojanow, the Bulgarian-German author of Along the Ganges, encountered this phenomenon more than a decade ago. On the Ganges in Varanasi, he observed "yellowish foam that stinks worse than a rotting carcase, boils of pus on the holy body" but found that true believers would not acknowledge the sacrilege or accept the warnings of environmentalists. "They love Ganga mata-ji [Mother Ganges], and their love does not permit them to speak ill of her." Varanasi environmental scientist BD Tripathi tells me his mother and other devotees were appalled when he started measuring the pollution 40 years ago. "They said: 'You are not a Hindu. The water of Ganga is the most pure.'"

Tripathi has not given up, and hopes Modi's plans - including sewage treatment plants, the deployment of 40 "eco-battalions" of soldiers and a project to make the river navigable again from the sea all the way to Kanpur - will achieve more than the lethargically pursued efforts of the past. "Why protect the Ganga?" asks Tripathi. "It's a question of survival, the survival of 450million people. It's not religious sentiment... Ganga is a life-support system. It provides water, it provides nutrients, it enhances fertility of soil in the basin."

Fig. 3 Village in Bihar, India (Credit Eva Ekehorn)

Later I meet Vishwambhar Nath Mishra, a mahant or high priest, as he holds court at the Sankat Mochan temple to Hanuman the monkey god in the heart of Varanasi. The temple is like a busy medieval cathedral but the mahant is anything but medieval. He is a professor of electronics engineering, heads a foundation to protect the Ganges and has an intimate understanding of sewage treatment and political will: both, he says, are sorely lacking when it comes to the Ganges. "We are actually expert in complicating a problem and not finding a solution," says Mishra, who is proud to have extracted a pre-election promise from Modi at the temple to save the river.

Like Mishra, I found the plight of the Ganges to be no mystery as I travelled along its length. It can be saved just as the Rhine and the Thames were. "We need to bring a transformation in our country," says Vinod Tare, an environmental engineer from Kanpur who leads an effort by the elite Indian Institutes of Technology to research and restore the Ganges. "The government is very serious - no doubt about it. But the problem is so huge; it's not going to change overnight. The Thames took 20 or 30 years and the Ganga is much bigger, so it's going to take time."

People are not the only victims of pollution. My next stop after Varanasi is Patna, a metropolis the size of Rome where I am astonished to see endangered Gangetic dolphins in the river in the city centre. It is good news that the dolphin, called the water-hog by the Mughal emperor Babur and known as susu for the breathy noise it makes on surfacing, is able to co-exist with humanity, although I am saddened to find them fishing amid the garbage of what smells like a sewer outfall and to hear that they are repositories of organo-chlorine pesticide residues. Nearby, a partly burned human corpse caught on some underwater obstruction twists in the current, jet-skiers amuse themselves by roaring in circles, and dogs gnaw at the ribcage of a dead cow.

After Kolkata - formerly Calcutta, the old capital of the British Raj and the last great city, along with Dhaka in neighbouring Bangladesh, to pour its filth into the Ganges - the journey down India's sacred river draws to a close. In its parting gift to the land, the river spews millions of tonnes of fertile silt on to the rice fields and mangrove swamps of the Sundarbans at the Ganges delta.

On the far side of India from Gaumukh and with the air 35°C warmer, boat skipper Tapan Das is as much in awe of the Ganges at its mouth as Amod Panwar was at its source. Two years ago, Panwar's new hotel on the upper reaches was left teetering on the bank when the river tore out a new course after a monsoon cloudburst that swept 6,000 pilgrims to their deaths. Das was just nine when his father drowned in a storm on the delta, leaving him to support his four younger siblings, and he recalls the destruction wrought by Cyclone Aila in 2009.

Panwar and Das will welcome any action to mitigate climate change, protect the Ganges watershed and cleanse its waters of the waste that exposes them and their families to the risk of death by disease. What is not clear, however, is whether such Indians in their twenties and thirties will live long enough to see the benefits of the enormous clean-up task announced but barely begun by Modi. As Harvard 's Diana Eck has written, a river seen as a source of salvation by the millions who include it in their daily rituals is now itself in need of saving. The issue is not just environmental, "it is a cultural and theological crisis." Even the secular Jawaharlal Nehru, first prime minister of India, asked for his ashes to be thrown in the Ganges, which he called "a symbol of India's age-long culture and civilisation, ever-changing, ever flowing, and yet ever the same Ganga".

Das is no philosopher, but he knows the vagaries of the river as well as anyone. He points to a spot where he watched a Bengal tiger on a mudbank a month ago. "Storms and cyclones are happening more often than before," he says as silt surges from the depths in thick brown eddies of warm water around the boat. "The current is faster and stronger." Ahead of him, in the distance, the turbulent waters of the holy Ganges finally meet the Bay of Bengal and the open sea.

Comparisons of great river clean-ups with that of the Ganges

The Thames, 346km

In the 19th century, the Thames was so thick with sewage and industrial waste that cholera broke out and sittings of the Commons were abandoned because of the "Great Stink" of 1858. Today, fish and water birds have returned to the river. This was a subject of discussion between Nick Clegg, UK deputy prime minister, and Narendra Modi when they met last year. Clegg commented afterwards: "Cleaning up the Ganges is of course a challenge on a much, much bigger scale."

The Rhine, 1,232km

The World Bank's India chief, Onno Ruhl , who is helping oversee $1bn of planned aid to clean up the Ganges, compares the task to that of restoring the Rhine in the 1980s. "It cost about Є 40bn to get to a sustainable outcome," said Ruhl. "You would not expect cleaning the Ganges to be cheaper than cleaning the Rhine was."

The Chicago River, 251km

When Narendra Modi discussed environmental issues at the White House last year, Barack Obama told him that the river in his native Chicago, once prone to fires as a result of oil residues and other filth, was now so clean that you could eat its fish.

4. The Quest for the Source – a Systematic Approach to Marine Debris in Australia

Angelika Volz *Tangaroa Blue Foundation*

The solution to marine debris is as diverse as the items washed up on the beaches around the world. The Australian non-profit organisation Tangaroa Blue Foundation aims to tackle the issue in a scientific way. Whilst is it necessary to analyse the problem first in order to solve it, it is also pivotal to stop finger-pointing, start acting at different levels and accept that a throw-away-society is a one-way lane downhill.

I am standing on a remote windswept beach on Australia's Cape York Peninsula in the far north east of the continent. It took two long dusty days to drive the 1,000 km from the nearest city, Cairns. First the road was sealed, then unsealed and corrugated, and in the end a rough bush track lead us down to the beach. This land is so empty that I can confidently look along the beach and assume that at this very moment there may be no more than a handful of people on the next 1,500 km of coastline. Yet, in my hand I am holding one out of millions of similar man-made items scattered along the beach: a broken bit of plastic. My feet stand in a pile of plastic bottles, rubber sandals, plastic remnants and bottle tops, and further down the beach over 3 tons of debris (equalling about a ton per kilometre of beach) are already piling up in rubbish bags, waiting for recycling (Fig. 1). I am part of a non-profit organisation that tackles marine debris – the Tangaroa Blue Foundation - and for several weeks a year we travel through this remote area and pull tons of mainly plastics off the beaches. What we

Figure 1. Tonnes of plastics were collected on just 550 m of this beach in north-east Australia after tropical Cyclone Nathan in 2015. Credit: Angelika Volz

find can hardly come from the sparse population here. It rather is the durable portion of marine debris that has floated here from other parts of Australia and overseas. And since plastic never decomposes, but just breaks up into smaller pieces, the most common items in this remote area are plastic remnants.

Tangaroa Blue operates Australia wide, and the very same moment we are collecting mainly hard plastics in Cape York, our colleagues might be picking up cigarette butts from Sydney's Bondi Beach, fishing gear in Australia's southwest or plastic resin pellets in Melbourne. The type and amount of debris greatly varies with the proximity to its sources. In populated areas, street litter and household rubbish dominate, plastic resin pellets stem from plastic factories and fishing gear can come from recreational or commercial operators. Cleaning up the beaches is an important step to reduce the environmental, economic and safety impacts that are already occurring, but does not address the causes and sources of the problem. If we don't stop the flow of litter into the ocean we will never break the cycle. But to solve the issue, it is pivotal to understand it first.

From a Database to Tailored Action

Therefore, Tangaroa Blue Foundation started the Australian Marine Debris Initiative (AMDI) in 2004. All items removed from the beaches are recorded and classified into over 140 categories and their gross weight and volume are written down. With over 6 million items logged to date from more than 1,800 sites around the country, the Australian Marine Debris Database has become the most detailed and comprehensive of its kind in Australia. The people submitting the data for this citizen science project are almost 60,000 volunteers from all walks of life. With all the information and training material available online from which to learn about the methodology of the AMDI, individuals, schools, Indigenous rangers and community groups enter the data of the debris they remove either directly into the database or by sending the tally sheets back to Tangaroa Blue Foundation (Fig. 2). Some beaches have been monitored monthly or quarterly for up to 12 years. These long term data sets give invaluable information of trends over time.

Fig. 2. Tangaroa Blue crew and community members tally what they found after a beach clean-up.
Credit: Angelika Volz

A detailed picture of the quality and quantity of rubbish found in a specific area can thus be established and hard evidence of the issue provided. This is used on a local level to run source reduction plans with affected communities. From the information gained from the data collection, particular items or item groups that pose a problem are identified and an action plan can be established to solve the issue in partnership with local stakeholders and government. To combat littered cigarette butts, collaboration with the council might be necessary to install butt bins near beach access points and to run an education campaign. To reduce the influx of local fishing gear into the ocean, a deposit scheme for bait bags might be initiated when the bags are returned to the tackle shop. A campaign with local businesses can help reduce the use of plastic shopping bags and perhaps the beach café down the road can be convinced to cease using single use plastic cutlery or replace it with natural fibre (wood) alternatives. Once the action plan is in place, continuous monitoring of the debris at the targeted site then reveals whether the plan worked or if it needs to be amended.

Whilst some issues can be solved locally, others like the ban of plastic shopping bags, the introduction of a container deposit scheme, or regulations regarding shipping and commercial fishing need to be tackled at a state or federal level to achieve a change in legislation. Again, having the data provides the necessary evidence of the magnitude of the problem when explaining it to decision makers. The Tangaroa Blue Foundation has been involved in reviews of nationwide management plans and has given evidence of the marine debris issue to representatives of the federal government.

Stop talking, start acting!

The Australian and global proof of the marine debris problem is overwhelming. With an estimated eight million tons of plastic entering the oceans every year, marine debris is a major pollution problem. Even now the full impact of microplastics in the environment and the toxins attached to them are not yet fully understood. However, the scientific evidence we have so far already shows that beyond the sheer volume of plastics floating in the ocean, the health of the entire ecosystem is at risk and that with the ingestion of plastics and the associated chemical pollutants across all levels of the food chain - from plankton to whales - human health is also affected. However, a lot of emphasis is still put on the potential, not fully researched hazards. What if the problem eventually turns out to be just as bad as predicted? What, if it turns out to be worse? The longer we wait to take action the more irreversible the issue becomes. Even if we don't understand the full extent of the problem yet, everybody collecting water bottles or styrofoam from a beach will admit that the issue is rapidly growing. Therefore it is essential to start acting before we reach or even pass the tipping point.

There is no one-size-fits-all-solution to marine debris. It is crucial for success to work at all levels of the problem. However, the further upstream we operate the more effective the outcome will be. Beach clean-ups are the most cost efficient solution to remove the rubbish that has already ended up in the ocean and got washed back up on land (Figs 3). But cleaning up the environment is of little use if we fail to mitigate the flow of litter into the waterways.

This is done in many places through pollution traps that catch debris floating down a river before entering the ocean, but it can also be done by providing more rubbish bins and running an education campaign that addresses littering and illegal dumping. Container deposit schemes are a form of retrieving waste and providing an incentive to pick up littered items. In some countries (e.g. Germany) those drink bottles are not just retrieved for recycling, but are washed and refilled.

Recycling is a great way to get more out of your raw product, but we have to keep in mind that it also uses energy, and in many cases – particularly with plastics – the material loses value during this process and is rather "down-cycled" into an inferior item. After only one or two cycles the product is still thrown out and in this case, the process of sending material to landfill through recycling is delayed rather than prevented.

Fig. 3. Tangaroa Blue volunteers collect marine debris on the remote Cape York Peninsula. Credit: Angelika Volz

To change the fate of the environment we must change our lifestyle

Since even properly disposed of rubbish can get dispersed by wind or animals and end up in the environment, the best solution overall is decreasing the amount of waste we produce. Rubbish that doesn't exist cannot become a problem, and fewer resources would be wasted if items were not deliberately created to be thrown away after a single use. Marine debris consists of everyday products from everyday people. Whilst it is easy to state "I didn't litter", it is everyone's rubbish and thus everyone has a responsibility to prevent the pollution.

The best way to minimise the amount of waste we create is to use less and to design products for more long-lasting sustainable use.

Using less addresses not only the single-use products like food packaging, plastic bottles, takeaway containers or plastic shopping bags, but also our tendency to purchase faster and more of just about everything under the sun - clothing, electronics, household appliances, toys and almost everything else you can possibly think of. Replace single-use products with durable alternatives: refill your own water bottle instead of buying throw-away ones, purchase products with minimal packaging or chose items with a long warranty and the option of being repaired, instead of reaching for the latest and greatest device that will die tomorrow. Investing more money in quality products frequently pays out in the long run. Using less also incorporates reusing worn out items for other purposes and can be as simple as using an old T-shirt as a cleaning rag. It can mean participating in second hand bazaars, cloths swaps, or book and tool libraries, or using vinegar and multipurpose liquid soap to clean everything in your house instead of having an army of cleaning products under your kitchen sink.

Using sustainable products means replacing plastic items with materials that are not based on crude oil. This is particularly important for single-use products. The options range from bamboo toothbrushes to corn starch, wooden or edible takeaway containers to even reusable baby nappies or hygiene products. For inspiration, remember the "good old times" before the era of plastic and single-use products. Go back 20 years or to the childhood of your parents. Recall a time when the per capita consumption rate was a fraction of what it is nowadays, but still with the population living fulfilled and prosperous lives. With no plastic shopping bags people brought baskets, and food was wrapped in paper. Pencils and crayons preceded felt pens and whiteboard markers, and pens were refillable. Cleaning rags got washed and reused, and families had one TV per house, not per room. Life was not any less enjoyable just because it was less plastic than nowadays.

Even though reducing our consumption is the only long term solution for many problems, this approach contradicts the idea of an ever growing economy. What if items suddenly lasted - as they did in the past - and you didn't need to buy a new phone, toaster, or printer every year anymore? Could it be an economic disaster? Therefore, we are "greenwashed" by the media: we are told to use eco-friendly products to soothe our guilt as long as we just keep consuming. We are lulled into believing that degradable plastic bags are a smart option without being told that they are worse than conventional plastic bags since they fall apart even faster releasing toxins into the environment more quickly. The smartest choice would be to not use any of them. We are urged to switch to alternative energy at the same time that we are made to believe that every toddler needs an iPad. The media conveniently forget to tell us that not buying a product in the first place would still be the best choice.

Marine debris is only one tile in the mosaic of pollution problems. If we were serious about change we would retreat from our throw-away society, reuse whatever we can and refuse plastics wherever possible whilst making sure that no waste is lost into the environment. Then, maybe, one day the Tangaroa Blue volunteers can visit the beaches in Cape York and find corals and sand instead of bottles and flip flops.

For more information visit www.tangaroablue.org
To learn more about marine debris and waste free alternatives follow "Resources > Fact Sheets" on the Tangaroa Blue Foundation website.

5. The Great Canadian Shoreline Cleanup

Kate Le Souef, *Manager, Great Canadian Shoreline Cleanup, Vancouver, Canada*

Canadians love being around the water. With the longest coastline in the world and thousands of lakes and rivers, every Canadian lives near a shoreline. So, since 1994, the Great Canadian Shoreline Cleanup has been encouraging Canadians to protect their waterways, and their local wildlife, by coordinating shoreline cleanups. A joint initiative of the Vancouver Aquarium and WWF-Canada and presented by Loblaw Companies Limited, the Shoreline Cleanup celebrated the most cleanups in one year in 2015, with more than 2,000 cleanups registered across Canada.

More than 20 years of history

Our mission is to promote understanding and awareness of shoreline litter issues by engaging Canadians to rehabilitate shoreline areas through cleanups. We envision a fully engaged and committed public keeping all Canadian shorelines free from litter.

The Shoreline Cleanup began in 1994, when volunteers from the Vancouver Aquarium decided to take action against litter by coordinating a cleanup on the shorelines of Stanley Park in Vancouver, Canada. The program expanded to shorelines throughout the province of British Columbia and became a national initiative in 2002. Since 2010, the Vancouver Aquarium has partnered with WWF-Canada to deliver the program. The Shoreline Cleanup is one of the largest national contributors to Ocean Conservancy's International Coastal Cleanup.

Fig. 1. A cleanup on the west coast of Vancouver Island, Canada

In 2015, more than 2,000 volunteer-led cleanups were registered with the Shoreline Cleanup, with events in every province and territory, and more than 59,000 registrants in total. Together, this team of volunteers contributed to healthy shorelines and waterways for everyone (Fig.1)..

Our team loves to support new and returning cleanup coordinators. We provide ongoing support to our returning coordinators, many of whom have been coordinating cleanups for more than 10 years. We have developed education guides for teachers, written specifically to match provincial curriculum requirements. By partnering with groups like youth organisations, federal and regional parks agencies, and key municipalities, we are constantly reaching out to new audiences who share our mission to activate volunteers and keep Canada's beautiful shorelines free of litter.

Our data

Every cleanup group that participates in our program records data about the litter they collected, contributing to our national litter database which is shared with the International Coastal Cleanup. Year after year, the top items are cigarette butts and single use disposable items. Some of our most unusual items include a rainbow clown wig, a piano, yoga pants and a fire extinguisher!

Cleanup summary data for all our cleanups in 2015 are presented below, including our 'Dirty Dozen', which are the most common items picked up by our volunteers. Every year, single use disposable plastic items dominate the top 12 items found on shorelines. Much of this litter could be avoided by using reusable drink bottles, coffee mugs, shopping bags and other items.

Table 1: Summary data from cleanups across Canada in 2015

	Total
Number of registered cleanups	2,016
Number of registered participants	59,136
Weight of litter removed (kg)	175,932
Distance of shoreline cleaned (km)	3,211
Trash bags filled	11,910
Recycling bags filled	3,866

Table 2: The ‘Dirty Dozen’, the most common items collected on cleanups throughout Canada in 2015

	Litter item	Quantity
1	Cigarette Butts	409,417
2	Food Wrappers	93,129
3	Plastic Bottle Caps	50,904
4	Plastic Beverage Bottles	37,769
5	Beverage Cans	27,814
6	Other Plastic & Foam	27,110
7	Straws & Stirrers	27,047
8	Other Plastic Bags	25,047
9	Metal Bottle Caps	22,093
10	Plastic Grocery Bags	20,492
11	Plastic Lids	19,365
12	Paper Cups & Plates	17,819

Where does litter come from?

Shoreline litter comes from many sources, but it’s always the result of human activities. At popular shorelines close to cities and towns, litter may be accidentally or deliberately dumped right at the shoreline. At other shorelines, wind, rain and currents may have carried litter huge distances from where it was originally generated.

Most shoreline litter comes from recreational activities, including food wrappers, drink containers, plastic bags, caps, lids and cans (Fig. 2). Smoking also generates litter, and every year, cigarette butts are the most common litter item found on our shorelines. Fishing and shipping can also contribute litter to our shorelines, including particularly harmful items such as fishing line, nets, oil bottles, rope, crab/lobster traps and sinkers.

Many shorelines such as river beds also become a dumping ground for large items that should be disposed at a dump. This garbage can include building and construction materials, household appliances, tires, batteries and even car parts. Natural disasters such as typhoons, hurricanes and tsunamis can wash huge volumes of debris into waterways in a short period of time. The 2011 tsunami in Japan is a tragic example. Tonnes of debris from Japan washed up on Canada’s western shores in the months and years following the disaster.

What’s the threat?

Litter poses a number of direct threats to wildlife. Items such as rope, plastic strapping bands, six pack rings and wire can entangle aquatic animals. Once entangled, animals may be unable to swim or find food and they may slowly starve. In some cases, animals cannot surface to breathe, resulting in suffocation. For example, estimates from the west coast of Vancouver Island suggest that hundreds of sea lions are currently suffering from entanglement.

Abandoned fishing gear such as lines, nets, traps and pots pose a threat to wildlife in the form of ghost fishing. These items are specifically designed to trap and catch animals, so they continue to catch and trap fish, mammals, turtles, and seabirds long after they’ve been discarded or lost.

Scientists are also finding a growing number of freshwater and marine animals that have eaten litter by accident. Ingesting litter can affect an animal’s ability to eat, breathe and move, leading to starvation, choking or fatal poisoning.

Many shoreline litter items contain dangerous chemicals that degrade water quality. Paint cans, oil cans and batteries are a few examples that can easily leak toxic chemicals.

A pervasive and emerging threat, microplastics are being found in shorelines and waterways across Canada. Microplastics include deliberately manufactured items such as microbeads and pellets, as well as microplastics that break down from larger pieces of plastic. Recent research by Dr. Peter Ross at the Vancouver Aquarium shows that zooplankton, the smallest animals in the food chain, is eating these tiny pieces of plastic. Microplastics may even be transferred up the food chain, from zooplankton to fish to birds and mammals.

Fig. 2 A shoreline cleanup at a beach near the Vancouver Aquarium

Anytime, anywhere, anyone

Every season is ‘litter season’, so our volunteers can coordinate a shoreline cleanup in Canada any time of year, in all seasons (Fig. 2 & 3). Our volunteers cleaned snowy waterways in Edmonton in May, misty beaches in Tofino in July, rainy beaches in Taloyoak in August and sunny shores in St. Johns in October, as well as thousands of shorelines in between.

All waterways are connected so we encourage our volunteers to clean any place where land connects with water. Teams can remove litter from rivers, streams, wetlands, marshes, parks, lakes, storm drains and beaches. Nearly two thirds of our volunteers’ cleanups in 2015 took place at freshwater shorelines.

Fig.3. A snowy shoreline cleanup in Edmonton, Alberta

Our huge volunteer base shows that anyone can coordinate a cleanup, from businesses to community groups to schools to concerned citizens. Collaborating with groups such as Girl Guides of Canada, key municipalities and Parks Canada allows us to reach new audiences across the country. The Shoreline Cleanup team is constantly reaching out to new audiences by building relationships with regional and national organizations that share our mission, through earned media coverage, and in-person at events.

Education across Canada

Together with the Education team at the Vancouver Aquarium, we have developed elementary curriculum guides about the Great Canadian Shoreline Cleanup for teachers in each province, including in French. These guides can be downloaded for free from our website, and include lesson plans and resources to teach about marine debris, ocean currents and recycling. We have also expanded our cleanup locations to include schoolyards, so that teachers who may not be able to coordinate a field trip can still participate with their students.

Educational material about the Shoreline Cleanup, recycling and marine debris is incorporated into schools, camps and clubs programs delivered onsite at the Vancouver Aquarium and offsite by the AquaVan team. Information is also shared through WWF's Schools for a Living Planet program, which engages thousands of teachers across Canada.

The challenge

We know that a cleanup can be the first step in aquatic conservation for an individual or team, and many of our volunteers go on to take meaningful action to reduce their personal waste, influence their friends and family, or introduce new policies at their school or workplace.

However, cleanups alone cannot solve the problem of litter and plastic in our waterways. Cleanups are just one part of the overall strategy needed to address this global issue. Ultimately, changing consumer behaviour to refuse single use plastic items, providing incentives for industry to use plastic alternatives, and properly collecting, disposing and recycling of waste is needed to ensure a lasting reduction of plastic pollution in our oceans and waterways. oceans and waterways. ensure a lasting reduction of plastic pollution in our oceans and waterways. disposing and recycling of waste is needed to ensure a lasting reduction of plastic pollution in our oceans and waterways.

Until we reach that point, we will continue to engage the Canadian public using the best tool we have: direct action through shoreline cleanups.

Kate Le Souef, Manager, Great Canadian Shoreline Cleanup
A conservation initiative of Vancouver Aquarium and WWF
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Site: www.shorelinecleanup.ca
Blog: www.aquablog.ca/category/shoreline-cleanup
Twitter @cleanshorelines

GREAT CANADIAN Shoreline Cleanup™ VANCOUVER AQUARIUM & WWF

6. SeaCleaner Project: Monitoring Marine Litter on Beaches around the "Pelagos Sanctuary".

Silvia Merlino, *Instituto di Scienze Marine del CNR (ISMAR-CNR), Forte Santa Teresa, Pozzuolo di Lerici, La Spezia, Italy*

Once upon a time there was a piece of plastic, which, in some way, arrived to the sea. For 1000 years it travelled again, ended on distant beaches, often nibbled by fish and turtles, warmed by the sun of other seas …

Although this sentence could be the start of a children's story in the distant future, it is absolutely realistic. Plastic fragments that currently end up in our seas take from 200 to 1000 years to degrade, and are carried by ocean currents to places extremely far from where they were dumped. They often accumulate along coastlines or are swept into great oceanic swirls, such as the famous Pacific Ocean plastic gyre, an "island" of floating plastic. This "marine litter problem is now indicator number three in importance among those defined by the EU Marine Strategy Framework Directive (2008/56/EC). The Directive defines litter as: "Marine litter is any persistent, manufactured or processed solid material discarded, disposed of or abandoned in the marine and coastal environment".

The damage caused by this plastic waste across the world's oceans, particularly to animals as dolphins and sea birds, has long been known. The garbage in the oceans is formed, not only by plastic, but also by a variety of materials that take long and differing times to decompose, that often enter the seas close to harbours, river mouths, or from illegal landfills and sewers, almost always located in highly populated coastal areas. These materials, known as *macrolitter*, initially subjected to mechanical and physical fragmentation, generate *mesolitter*, from 5 millimetres up to 2 cm long, and finally the *microlitter*, even smaller fragments. Among them, the *microplastics* are the most harmful part, and which are also directly released to the environment in the form of *micropellets*, i.e. microscopic spheres which are the primary input to the production of all plastic objects. In recent years, many research Institutions and universities have helped to increase our knowledge about the concentration and typology of macro, meso and microplastics floating in our seas. However, we still do not have enough quantitative data to evaluate either the status of our beaches and coasts, or the role of beaches and coastlines as possible source areas for the release microplastics to the sea. Macroplastics washed on to beaches that are exposed to direct sunlight for a long time, are easily photo-degraded into ever smaller pieces, which become mixed with sand and carried into the sea. These pieces, though invisible to our eyes, represent a great danger to marine life as they can be ingested by filter feeders, both as large as whales and other cetaceans or small, such as sponges, molluscs and corals, that live attached to cliffs, among floating algae, or move around in the near surface layers of sea water, where they form the base of the marine food chain.

Since 2013, the Institute of Marine Sciences of the CNR (Consiglio Nazionale delle Ricerche) in Italy has therefore undertaken the SeaCleaner project that aims to gather as much data as possible on the presence, type and amount of marine litter in the coastal area around the "Pelagos Sanctuary ", a particularly sensitive marine area in Mediterranean sea, where different kinds of cetaceans, such as the Mediterranean whale, live. It is important to establish standardised protocols for marine litter surveys, to be able to proceed with the analysis of these artefacts, their classification and their comparison with similar material collected in other countries, both within Europe and beyond. Following these protocols, researchers initially removed from the beaches macrolitter, then took high-resolution photos that will permit estimation of the distribution of mesolitter remaining on the beach. Finally, the collection and sieving of the sand, was followed by microscopic analysis, to count and catalogue the smallest fragments.

The SeaCleaner project involves several marine protected areas and marine parks in Liguria and Tuscany. The reasons are many: from the importance of monitoring the degradation of places where there are endangered species or ecosystems of community interest, to the fact that marine protected areas often have, within them, some areas to which the public does not have access, which thus allow researchers to

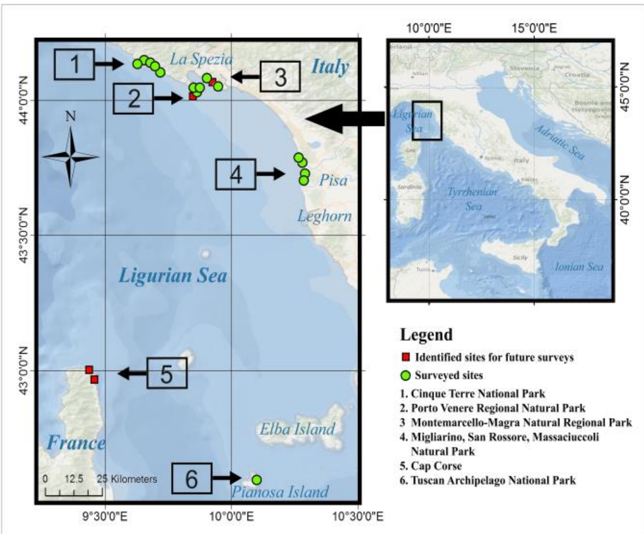

Fig 1. The surveyed sites within the Pelagos Sanctuary Marine Protected Area.

estimate the rate of marine debris accumulation on the beach, without contamination by local tourism.

A particularly interesting output of our monitoring program is the evidence for the existence of a relationship between litter accumulation zones and proximity of ports and especially river mouths.

A case study is the Marine Protected Area (MPA) in San Rossore regional park, which extends for 12 km to the north of the Arno River, the most important river of Tuscany (Fig. 1 & 2). On these protected beaches we noticed the presence of particular materials that are clearly transported from the river and coming from inland highly populated and industrialized parts of the Arno River basin. In particular, objects were found which had been used in the processing of yarns and footwear and also many hospital items, such as syringes and vials. Moreover, we found a huge quantity of cotton swab remnants, i.e. plastic sticks that are supposed to float in the seas for 14 years, an item the sale of which has been prohibited by Italian law since 2002 (Fig. 3).

On the San Rossore beaches polystyrene was also found, probably coming from packaging and fishing industries (Fig. 3). Polystyrene is a material that crumbles easily to form very thin pellets, which therefore can be mistaken for plankton and thus ingested by marine animals.

As in the San Rossore Park (Tuscany), the protected marine area of National 5 Terre Parks (Liguria), a particularly important area for the protection of marine mammals, had much material, probably of fluvial origin, but in smaller amounts. The biggest river near the 5 Terre area is the Magra River, which has a mainly torrential regime. In contrast to the Arno River, it does not drain heavily populated and industrialized areas, and it does not flow directly into the south of the Marine Protected Area (MPA), as in the case of San Rossore, but enters the sea several kilometres away. In the 5 Terre area, located to the north of the Gulf of La Spezia, and characterized by pebble beaches lying under high rocky cliffs, there is a significant abundance of plastic bottles and polystyrene, clearly derived from fishing activities, as well as small plastic ropes used for the breeding of mussels, one of the typical activities of the nearby areas of Portovenere and Palmaria island (Fig. 4). In

Fig 2. One of the beaches along the Tuscan coast in the Migliarino, San Rossore and Massaciuccoli Regional Park, a protected area of about 24,000 hectares (without public access)

Fig 3. Cotton swab sticks. Their sale has been forbidden in 2002; current law states that they should be manufactured with biodegradable materials

Fig. 4. High and middle school students during the cataloguing phase of the collected material, on Monterosso beach, 5 Terre National Park (left)) and in the "2 Giugno" middle school of La Spezia (right).

addition, some of the 5 Terre beaches, which were affected by severe floods in 2011, had many rusty metal fragments, electric cables and other objects clearly conveyed by the floods from overflowing streams, and not by the marine currents.

Our analysis has therefore revealed the importance of the outflows of rivers or torrents as the main entry points of litter, leading immediately to another question: once placed in water, how far may any floating object travel? Marine currents play an important role in this sense, but at present the relevant data are still lacking. A possible solution can lay in the use, in the near future, of "High frequency ground radar" (HF); small antennae that can easily be installed in different parts of the coast, allowing researchers to investigate mass displacements of surface water. The high-resolution knowledge of both spatial and temporal surface circulation is potentially very important for monitoring the plastic circulation in sea; by matching radar HF data with beached litter data we can try to obtain information such as the life cycle of waste floating in the sea; or to detect if there are storage areas where this waste remains for a very long time; or even to try to reconstruct the route that this waste performs before beaching; and to identify areas where this form of pollution may have originated.

Another major issue is the problem of the residence time of macroplastics on the beach. As already said: "secondary type" microplastics (i.e. not pellets for plastic production) originate from macro and mesoplastics that, if left "to rest" on the beach, undergo a progressive photo-oxidative deterioration which gradually, over several years, transforms them into microplastics. Moreover, a linear relationship between the degree of degradation and the length of exposure to irradiation has been well-established. Many of MPAs in our programme have in the past experimented with long periods of litter deposition without any sort of cleaning on the coast of San Rossore Park and the beach of Pianosa Island, in the National Parks of the Arcipelago Toscano. Pianosa Island has been used as maximum security prison for many years, and was only opened to a "controlled" tourism a few years ago. We have sampled microplastics, from 1 mm to 5 mm in diameter, from the sandy sediments of both places, and have compared the results with the microplastics contents of "urban beaches" located just at the northern extremity of San Rossore Park. The latter (beaches regularly cleaned by the administration, because they host bathing facilities during the summer season) have a microplastics content well below that found in

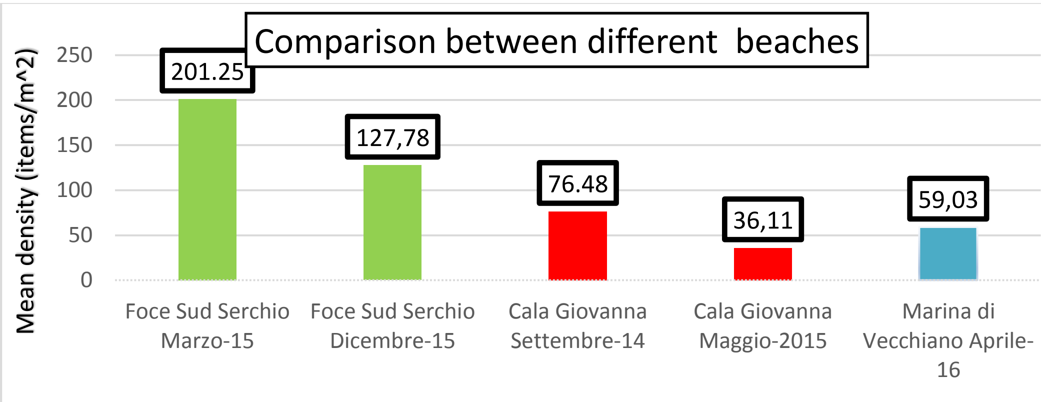

Fig 5. Graph of the first results obtained, by high school students, of microplastic abundance on several monitored beaches: an example the educational activities.

San Rossore Park, and comparable with that found in the Pianosa beaches. This fact is interesting, especially if we think that Pianosa is a long way from any harbour or river mouth, and has remained outside the tourist flow for many years. Moreover, the macrolitter accumulation rate we calculated for Pianosa beach is much lower than that of Marina di Vecchiano beach. The explanation is that the waste that accumulated in this island and was not removed over many years had time to degrade and fragment, generating the great amount of microplastics now present in the sandy substrate. This indicates the importance of continuously removing of macroplastics from the beaches, not just the touristic ones but even those inaccessible to the public and particularly those located in protected marine areas.

Within the project SeaCleaner, synergies have been established with voluntary associations and educational institutions, in order to promote citizen participation in environmental monitoring projects. This approach is called "citizen science". The citizen-science approach permits the collection of large amounts of data that would otherwise be impossible to obtain for such an extensive area.

SeaCleaner involves both students and volunteers in projects that accompany science education. Through the participation in internships in research centres, students learn what researchers actually do, and collaborate with them in developing and analysing the data (Fig. 5). Students collaborated also in other activities, as educational/awareness events, acting as scientific mentors for younger learners, or creating the SeaCleaner Logo and building the web page of the SeaCleaner internet site.

The emotional involvement of students who took part in these internships has been a very important factor. The fact to touch (in this case in the literal sense of the word!) this serious environmental problem has led them to develop a greater awareness of it and the will to commit themselves to change things. (Fig. 6)

In the near future it will be extremely important to undertake research on new technologies and materials, such as bioplastics, but it will be equally important to raise awareness of new generations concerning the issue of waste and their disposal.

For more information, contact (silvia.merlino@sp.ismar.cnr.it)

Fig 6. Public awareness activities especially devoted to school children. SeaCleaner high school students participated as "scientific mentors".

7. Postcard from the Brink – Belize in Crisis

Pam Longobardi, *Distinguished University Professor and Professor of Art, Georgia State University and Founder, Drifters Project,*

Fig. 1 Blackbird Caye, Oceanic Society's research outpost atop the coral encrusted Turneffe Atoll (picture curtesy of Pam Longobardi)

Drifters Project is a global, collaborative artist research project focused on ocean plastic pollution that I founded in 2006 after seeing first-hand the massive uncontrolled mountains of drifting plastic the ocean was vomiting out on remote Hawaiian shores. Now in its 10th year, Drifters Project has worked by cleaning beaches, making art and engaging with communities including: Beijing, China, cities across the US, coastal zones in Costa Rica, Greece, Monaco, Panama, Virgin Islands, Taiwan, and on nautical expeditions in Alaska and Indonesia. In 2011, I began a project called Plastic Free Island in Kefalonia, Greece and developed over 5 years with Dianna Cohen, artist and CEO of Plastic Pollution Coalition. Plastic Free Island is developing an exportable template model to measurably reduce an island's plastic footprint through behaviour change and switching from plastic disposables to sustainable natural alternatives. Plastic Free Island Export/Belize occurred in summer 2015.

Dropping into Belize City, the former capital of the Central American nation of Belize, you feel strangely like being on the edge: of climate change, plastic invasion, simmering violence and economic crisis. But Belize also harbours a lot of hope, and a small army of soulful people working to make change in a desperate situation. A country of natural wonders beyond compare, it is also, like any low-lying coast, a place on the brink.

Within 24 hours, I was transported from the Atlanta airport to the tiny pinprick of Blackbird Caye, the Oceanic Society's research outpost atop the coral encrusted Turneffe Atoll (Fig. 1). Very windy, very small and very beautiful, the first impression we had was of ploughing through a dark rainbow on the rim of the island. And secondly, we were hit by the stench and sulphurous fumes wafting from the entire bay. In an unprecedented phenomenon, never before witnessed by even the oldest islanders to whom we spoke, sargassum seaweed, common throughout the entire Gulf of Mexico, has been inundating shores from Texas to Trinidad._This invasion is caused by a combination of factors resulting from climate change. It is so extensive; it had been declared a natural and economic disaster in some parts of the Caribbean. A normal and essential part of the oceanic ecosystem, this beautiful and rugged sea plant is the reason for the Sargasso Sea, an area of over 5 million km^2 of the Gulf and N. Atlantic that feeds turtles and fish, protects young, and is the oasis of the deep ocean desert. Now however, in the quantities it is pounding Blackbird Caye, the sargassum seaweed is a death trap

Fig. 2. Sargassum seaweed on the beach of Blackbird Cave

(Fig. 2). All inshore life in the 50- yard wide coastal rim of the windward side of the island is being smothered.

The decomposing lives, along with the sulphurous fumes of the rotting sargassum were strong enough to burn our eyes and even blacken my silver jewellery. This impenetrable wall of seaweed also compounded and condensed the ocean-borne plastic washing in from the open sea; pre-chewed microplastic most likely came from macerators on cruise ships that dumped the tiny particles at sea. As Emory student researcher and collaborator, Paulita Bennet-Martin, and I made our first survey of the site, we were both moved to tears by the grimness of the situation, and named the area "Hell Bay". National Geographic runs one of its excellent student expedition programs at Oceanic's station, and by good fortune, 19 bright, energetic and tough students were on the island for the 4 days we were there. We invited them to collaborate on our work: Paulita is making a scientific study of coastal plastic, and I, with my intrepid assistant Susan, am making 'Ocean Messages' from the vagrant sea plastic to broadcast the dire condition in the form of S.O.S. signs. Together we mobilized citizens in 3 different locations as the first extension of the Plastic Free Island concept.

This is particularly disgusting and difficult work that the students powered through. The decomposing matter and stench were compounded by sand fleas, mosquitos and the infamous 'Docta Fly' a stealthy and hard-biting horsefly whose name must have arisen from the feeling that you are being operated on as they bite. Susan and I had scores of these bites after 4 days, mine alone numbered 39 and they itched like the devil.

The five student groups counted plastic particles coming up with the shocking density of **400-900 pieces per sq. meter of microplastic**. Paulita extrapolated for the length of the bay and arrived at the grim estimate of **nearly 240,000 small pieces of plastic on that one beach alone.** The students then took their microplastic collection and made small thoughtful and potent Ocean Messages of their own.

The invading plastic is not merely an inconvenience or eyesore, it infiltrates the very life of beach itself: I saw several of the thousands of hermit crabs on the island living in plastic bottle caps, a home so poor that the smallest disturbance or territorial battle results in a vulnerable soft-bodied crab ready to be eaten by a predator or cannibalized by its neighbours. One over-large fellow in the shallow clear cap cover of a water bottle actually bailed out of his bereft home as I moved twigs to take his photo. I felt horrible as I saw him scrambling naked for cover, and looked desperately for a suitable shell nearby. I saw none, but of course there were multitudes of other plastic fragments, so I left in sadness and wished him the best.

Ocean message

Our work on Blackbird Caye and Caye Caulker culminated in the creation of several large Ocean Messages, each site taking on a slightly different tone. On three different locations, we made 3 ocean messages (Fig 3, 4 & 5).

With the support of Oceanic Society and OS Research Station staff, Susan and I assembled a mass of plastic from all sides of the island, and constructed the 12 ft. tall letters of the word MASS from the disgusting plastic 'mass' we encountered on the inundated

Fig. 3 & 4 The Ocean messages from Belize

island. Eric Angel Ramos, a dolphin researcher from CUNY, who is an experienced drone operator, lent his skills to help document the public art message broadcasts. From the air you could really see how small and remote the island really is.

Oceana Belize was invited to a summit between Oceanic Society, National Geographic Field School and Drifters Project. The Belize support team of 4, including Oceana Belize Director Janelle Chanona, all physically lay down in the sand to create Ocean Message from Blackbird Caye: 'MASS Extinction' on the Beach Camp. The spooky concurrences of this message are as follows:

On June 22, 2015 is the official notice that the **6th mass extinction** event has begun (from Dr. Paul Ehrlich and colleagues, Stanford.) This study revealed that the *entire species die out is 100x faster than normal, most conservative, background extinction rate.* This unprecedented increase has not occurred since the extinction of the dinosaurs, **66 million years ago** (Ceballos et al., 2015)**.**

July 30, 2015, the day of our public art message to fight plastic pollution and mobilize collective action to save our oceans, also had a most beautiful BLUE Moon, the second full moon of July, in the sign of Aquarius, for the water planet, part of our transformation.

Onward to Caye Caulker, a tinier, more inhabited narrow strip of an island to the northwest of Turneff Atoll. Paulita, our student researcher, spent several weeks investigating there and energizing a dedicated group of locals who did regular cleanups of the beaches and mangroves of the caye. After a few days working there myself, I got to know many of the locals: naturalists, sanitation workers, city council members, artists and twin mermaids all joined by the action of cleaning up plastic. We had a big job: it was more than depressing to see whole fresh sacks of garbage tossed right on the beach or into the delicate mangrove nurseries dumped by locals, and of course, the ongoing plastic cup and straw siege. Here the sargassum invasion is raked daily by sanitation workers to clean the beaches of Caye Caulker, a fun laidback, creative, nature-loving tourist destination. We raked sargassum with the sanitation workers to incorporate into the final Ocean Message, this time with the trifecta of materials: plastic, people and sargassum, broadcasting another S.O.S and an apology as we took responsibility for our collective plastic impact. The Oceana team arrived from Belize City to support us with another drone, expertly flown for the very first time by the brilliant Mose Hyde of top Belizean news media Amandala and KREM TV. We thank them for our images and capturing an artwork that turned into a citizen rally of raised fists and "Fight the Power!"

Citizen rally

Revolutions begin in creative space. After 2 weeks on the ground, with fully mobilized actions involving hundreds of citizens and visitors; motivated beautiful soulful people; a research station outpost struggling to continue its important work; collective and creative will; and support of international organisations working to save the rare and precious gem of Belize, Plastic Free Belize was born. As an example of social evolution, change-makers everywhere can take on this challenge of social revolution against a plastic future.

Fig 5 Ocean message

Reference

Gerardo Ceballos, Paul R. Ehrlich, Anthony D. Barnosky, Andrés García, Robert M. Pringle, & Todd M. Palmer 2015, Accelerated modern human–induced species losses: Entering the sixth mass extinction, *Science Advances, 1 (5):* e1400253, DOI: 10.1126/sciadv.1400253

Further information:

George Leonard 2015, *Saving the Oceans from Plastic: A Field Report from Belize* http://blog.oceanconservancy.org/2015/05/20/saving-the-oceans-from-plastic-a-field-report-from-belize/ (another account of the beach litter problem from the Ocean Conservancy)

Mercedes Lu, Mark Chernaik & Heidi Weiskel 2013, *Ocean Waste in the Gulf of Honduras: Where it goes and what to do about it*, Eugene, OR: Environmental Law Alliance Worldwide (ELAW) http://www.elaw.org/system/files/ELAW_Solid_Waste_and_Transport_Report.pdf (a good well-illustrated article showing why the beach litter problem occurs and suggesting what can be done about it).

Pictures: http://driftersproject.net/blog/2015/08/15/postcard-from-the-brink-belize-in-crisis

8. The Trashy Side of Marine Conservation

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Marine litter is an ever growing, internationally recognized environmental concern, reaching every corner of the globe including Antarctica. Synthetic organic polymers, commonly known as plastics, make up 60-80% of all the marine litter in the oceans (Derriak 2002), and pose a variety of serious risks to marine life of all forms. There are a multitude of sources of marine litter and various ways they enter the environment. The majority of marine litter is now known to be of a terrestrial origin and primarily made of types of plastics.

Plastics have revolutionized our way of life, improved public health and safety standards and enabled unimaginable technological advances with endless applications. However, it has also led to a convenience oriented consumer society in love with plastic disposables. Plastic production is increasing on a global scale with no plateau in sight with 299 million tons estimated in 2013 alone (Bergmann et al 2015). While some of these items are recycled or repurposed, the majority goes to a landfill and the rest makes its way into the environment.

The major plastics manufactured are divided into six major classes that are categorized by their chemical makeup. The most common polymer currently produced is polyethylene. This type of plastic is the most common type discarded by consumers and includes jugs, bottles, tubs, bags, and films used for packaging foods, beverages, and other household products (Piringer and Baner 2008). Polyethylene is also the most common type of plastic found ingested by wildlife (Derraik 2002). The United States alone uses 102 billion plastic (polyethylene) grocery bags every year and has an average usage time of twelve minutes (Bergmann et al 2015).

Identifying the sources of marine litter that have negative impacts on biota needs to be a research priority in the mitigation and prevention of those sources reaching the natural environment. A comprehensive analysis including the socio-economic sector would bridge the gap between where it is coming from, where is it ending up, and how can we prevent it.

The environmental and economic cost of many plastic products, especially single use plastic items far outweigh the convenience factors associated with the plastic throw away lifestyle we all live. The problem with plastics is that it never goes away or out of our environment. Plastics persist especially in the marine environment and break down very slowly into smaller and smaller pieces of plastic until no longer seen with the naked eye.

Logically and scientifically, the most effective way to combat marine litter is to prevent plastics getting into the marine environment in the first place. In addition, public outreach and education should also be prioritized to spread awareness of our marine litter issues. Marine litter is one of the few environmental threats that we can help with in our everyday lives. If we do not know that we are a part of the problem or what the problem is then we cannot be a part of the solution.

Solutions begin with reducing the amount of single use plastic that you use in your daily lifestyle (Fig.1.). These sociological solutions include using reusable bottles, bags and containers instead of those designed to be disposable among others listed here. Making small steps towards a more sustainable lifestyle can lead to big changes in how you impact the environment.

Fig. 1. A list of solutions on helping the environment by making small changes in your everyday lifestyle

The amount of plastic packaging used in the food and beverage industry and in a variety of our household products has caused a state of plastics accumulation on beaches all over the world. This is one of the reasons why end of life responsibility of common plastic products used in our everyday lives is an important mitigation factor in reducing marine litter and moving towards a circular economy. Currently in the United States, the responsibility of plastics disposal lies with the consumer and there is virtually no corporate end of life responsibility or corporate regulation of plastics usage from any government entity. The beach cleanups performed by the nonprofit Mission:Clean Beaches Inc. over the years have yielded an overwhelming majority of plastics, with intact and partially degraded plastics with evidence of a household origin (Figure 2).

Fig. 2. The variety of plastic items found in a beach surface sediment survey over a kilometre transect of sand after heavy onshore winds at Melbourne Beach, Florida, USA (photo Nikia Rice)

The costs of litter occur both where the litter is originally created (upstream) and where it finally ends up (downstream) Upstream issues include landfill mismanagement, land based littering into storm water systems, inadequate waste management protocols, and lack of awareness and education about marine litter. Downstream activities include accidental and purposeful littering by beachgoers (tourists and locals), single use plastics used in coastal restaurants, and various other recreational activities on and/or near the waterways. Providing adequate infrastructure (covered trash bins, recycling receptacles, monofilament containers) at the beaches would be an initial cost, but would benefit the economy monetarily in the long run by sustaining and/or increasing tourism on the beaches and around the area. Several case studies have shown that cleanliness of the beaches is an important factor in choosing which beaches and waterways to visit.

A multifaceted approach including stakeholders within the plastics industry, community leaders, politicians, scientists, economic sectors and other environmentally oriented organizations to create efficient and legitimate action plans to prevent marine litter. Some of these solutions include initial costs that require substantial funding with long timelines that include improving waste oriented facility infrastructure, mitigating landfill management, storm water management, and other regulatory protocols that prevent marine litter on a large scale. In the meantime I am an advocate of each person doing what they can now with knowledge and reverence.

Community outreach and education is key in bridging the gap between scientific research, technology, policies and the public. In addition, public outreach is a great way to engage beachgoers, reduce littering and encourage social change that would be of little to no cost, but rather fall on the responsibility of local environmentally oriented organizations (e.g. Mission:Clean Beaches). Community outreach programs such as beach cleanups are a good incentive for people to volunteer their time while providing a service to the local region that has an economic value.

It must be noted that this article focuses on household plastics, a major source of plastic pollution but other sources not mentioned here include commercial and industrial runoff along with sources from human activity outside of the household (e.g. derelict fishing gear). The take home message is that a multitude of stakeholders will be necessary to implement truly effective and preventative mitigation efforts against marine litter at all levels. However, it is important to understand that each stakeholder, including the lay person, must work together to form executable action plans and policies for combatting marine litter issue at the source.

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9. Nuclear Waste

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10. The Circular Economy

Ian Douglas *Commonwealth Human Ecology Council*

National and local governments and many enterprises have developed waste management policies in order to prevent the worst side-effects of waste disposal and to control the disposal of dangerous substances. Many governments are endeavouring to reduce the amount of waste being dumped in landfill sites and to increase the recycling and re-use of discarded materials. In Europe, such actions are now described as implementing the circular economy. First proposed in the 1970's, the circular economy is an alternative to the conventional and unsustainable linear manufacturing process, where the majority of products are made, used and then disposed of at the end of their life with few materials recycled or re-used. The circular economy keeps raw materials and products in use and recycling for as long as possible, with secondary (experienced) resources being employed rather than primary raw materials. A circular economy achieves this by emphasizing the use of the Waste Hierarchy: prevention, repair, re-use, recycling and recovery, rather than disposal (Fig. 1).

The recycling of used substances from cities is centuries-old, with the re-use of human and animal wastes as agricultural fertilizers having been an established practice in many civilizations. Detailed analysis of the nitrogen economy of Paris in the nineteenth century shows that at least a third of the nitrogen contained in food supplied to Paris found its way back on to farms as fertilizers (Fig. 2) (Barles, 2007). In the twentieth century, sewage

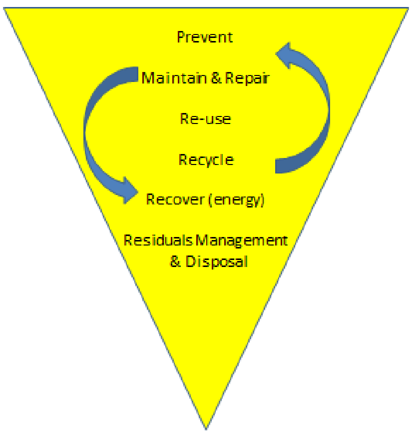

Fig.1. Key elements of the waste hierarchy

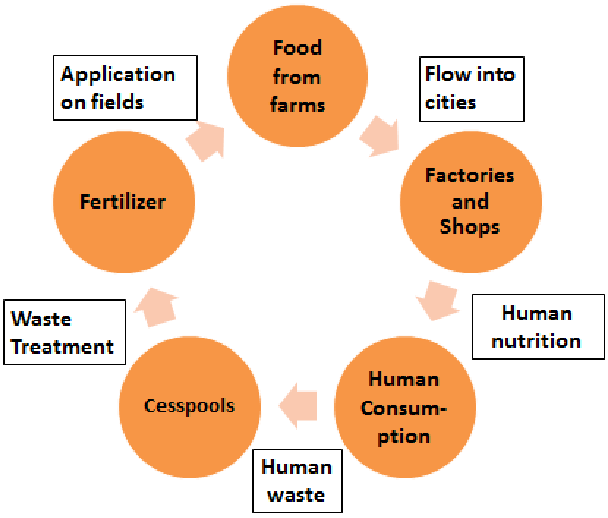

Fig. 2. Simplified circular economy of urban nitrogen in nineteenth century European cities

sludge was spread onto farmland in Europe until public health concerns led to it being stopped. Now it is recycled in the form of energy, through bio-digestion of organic waste.

Now, however, the problem is not simply one of the relationship between a city and its rural hinterland. It is an issue enmeshed and entwined with global trade and financial flows. Almost everywhere, flows of food involve long distance commerce, from Chilean grapes and New Zealand lamb reaching British supermarkets to tins of tuna being opened in remote longhouses in the interior of Borneo. The food we eat, the clothes we wear, the materials used in building our homes, office, factories and schools, the instruments in our hospitals, the electronic gadgets, and the motor vehicles and aircraft we use all comprise raw and recycled materials drawn from a wide variety of mines, quarries, forests, fields and factories from many different countries and oceans. The circular economy endeavours to cope the discarding of much of the used, broken, and wasted goods and materials that stems from these international flows.

The advantages of the circular economy include the reduction of the environmental impact of production and consumption; less waste; a more competitive economy; practical solutions to our resource problems; improved resilience to changing markets; and new job opportunities. The concept started to gain significant weight from 2010, when former sailor Dame Ellen MacArthur established the

Ellen MacArthur Foundation to champion an economy that is restorative and regenerative. Six years later, global corporations, world leaders and celebrities have now become vocal supporters of its principles.

The **circular economy** is an alternative model that anticipates and designs for biological and technical 'nutrients' to be continuously re-used at the same quality, dramatically reducing our dependency on sourcing new materials. Some international bodies and national governments have enacted legislation to implement the principles of the circular economy. China implemented its circular economy programme in 2008, based on the waste hierarchy (Navickas et al., 2015).

The EU action plan for the Circular Economy

The European Commission has adopted an ambitious *Circular Economy Package*, which includes revised legislative proposals on waste to stimulate Europe's transition towards a circular economy that will boost global competitiveness, foster sustainable economic growth and generate new jobs (European Commission, 2015). The Commission's general argument in favour of the Circular Economy is that it will boost the EU's competitiveness by protecting businesses against scarcity of resources and volatile prices, helping to create new business opportunities and innovative, more efficient ways of producing and consuming. It will create local jobs at all skills levels and opportunities for social integration and cohesion. At the same time, it will save energy and help avoid the irreversible damages caused by using up resources at a rate that exceeds the Earth's capacity to renew them in terms of climate and biodiversity, air, soil and water pollution. The Commission also acknowledges the wider benefits of the circular economy , including helping to lower current carbon dioxide emissions levels that were set out earlier in 2015 (Ellen MacArthur Foundation et al., 2015). The foreword to the MacArthur document emphasizes that the circular economy helps us to make better decisions about resource use, design out waste, provide added value for business, and work towards economic, social and environmental sustainability for future generations. Properly regulated and managed, the circular economy potentially changes economic activity in a way that creates more employment.

The proposed EU actions will contribute to *closing the loop*" of product lifecycles through greater recycling and re-use, and bring benefits for both the environment and the economy**.** They seek to establish a long-term strategy for waste management and recycling, with the following key elements:

- A common EU target for recycling 65% of municipal waste by 2030;
- A common EU target for recycling 75% of packaging waste by 2030;
- A binding landfill target to reduce landfill to maximum of 10% of municipal waste by 2030;
- A ban on landfilling of separately collected waste;
- Promotion of economic instruments to discourage landfilling ;
- Simplified and improved definitions and harmonized calculation methods for recycling rates throughout the EU;
- Concrete measures to promote re-use and stimulate industrial symbiosis - turning one industry's by-product into another industry's raw material;
- Economic incentives for producers to put greener products on the market and support recovery and recycling schemes (e.g. for packaging, batteries, electric and electronic equipment, vehicles).

Many Commonwealth countries, and their component states, provinces and regions, have plans for developing a circular economy. Scotland's plan (Scottish Government, 2016) emphasizes four particular aspects due to the resources that they use and their importance to the Scottish economy, tackling environmental and economic objectives in parallel:

Food and drink, and the broader bio-economy - A report on beer, whisky and fish production identified potential savings of between £500 million and £800 million per year.

Remanufacture – currently contributing £1.1 billion to annual economic activity with potential to add an additional £620 million by 2020.

Construction and the built environment - representing about 50% of all waste arising in Scotland; influencing the built environment has an impact on wider resource efficiency.

Energy infrastructure - with the recent growth in renewables and £30-35 billion of oil and gas decommissioning spend expected by 2040, the potential for added value is significant.

Some countries have so improved their domestic recycling that they can treat waste imported from other countries. Among them are Norway and Sweden who see a big potential in waste recycling. Their waste recycling rates are up to 99%. In 2016, Norwegian and Swedish waste recycling companies are able to process larger quantities of waste than now, and thus can import waste as a raw material to fulfil their potential recycling and energy production potential. In 2010, Sweden recycled over 550 thousand tons of imported waste but by 2014, it was

recycling over 800 thousand tons of such waste. At this moment, Oslo recycles over 410,000 tons of waste per year, 45,000 tons of which is imported from the United Kingdom (Navickas et al., 2015).
As European Union policy aims at reducing the number of landfills, opportunities for the recycling industries are expanding rapidly.

The variety of circumstances, sizes and locations of Commonwealth countries creates contrasting challenges in implementing the Circular Economy at national level. For example, Malta's Minister for Sustainable Development, the Environment and Climate Change, Dr Jose Herrera pointed out that the different starting points and the realities and challenges that EU Member States face in shifting towards a more circular economy should be duly taken into account at the European level (Malta News Agency, 2016). The Minister explained that Malta's particular geographical circumstances and lack of economies of scale makes it highly dependent on shipments of waste both within and outside the Union, which require complex logistical and market mechanisms to ensure Malta is able to contribute to a Circular Economy in an affordable manner. The Minister stated that Malta looks forward to future developments and work in this area on the basis of the Circular Economy Action Plan.

Commenting on the European Commission's "Circular Economy" proposal, in June 2016, the Cyprus Minister of Environment, Nicos Kougialis, welcomed the European Commission's "Circular Economy" proposal, saying that Cyprus gave great importance to water management, particularly water recycling, to the waste management hierarchy and creation of a market in secondary raw materials (Parikiaki, 2016). He also is stressed that European targets for recycling, landfill waste and the issue of non-EU waste exports, should be evaluated carefully.

This EU Circular Economy proposal is a "top-down" driver of change. However, one of its prime associates, and thus a driving force in the Ellen MacArthur Foundation. Such civil society promotion of the Circular Economy is found in many countries. In Australia, Circular Economy Australia is a network of professionals helping to drive awareness and adoption of circular economy principles. The network aims to expand by educating and inspiring businesses and individuals to change their behaviour. Their examples of what a circular economy might look like include, Giurco, which offers a cafe owner taking empty milk cartons – a resource – over the road to be fed into a 3D printer to produce bespoke tea cups they can sell the next day. Carpet company Desso and electronics giant Philips are releasing a light-emitting carpet, combining signage and furnishings. Australian firm Interface uses discarded fishing line from the Philippines for its Net Effect carpet range. H&M, Nike and Puma are using plastics and polyesters for clothing lines.

Another example from Australia is that dismantling rubbish is already bringing dividends for social enterprises such as Mission Australia's (MA) Soft Landing NSW mattress recycling program (White, 2015). It began in 2009, when people started dumping unwanted mattresses in the MA clothing bins following the introduction of a dump gate fee. They saw a business opportunity in the steel, and set up a recycling plant the year after with a grant. Since then 300 people have found full-time work extracting the steel (which is pressed and sold on), timber (helps build toys), foam (carpet underlay) and textile (used for their punching bags business). They returned $19 for each initial seed funding dollar, and report a $3 social return on each dollar invested – measured in terms of creating jobs for their workers, many of whom face barriers to getting work such as criminal records or mental health issues.

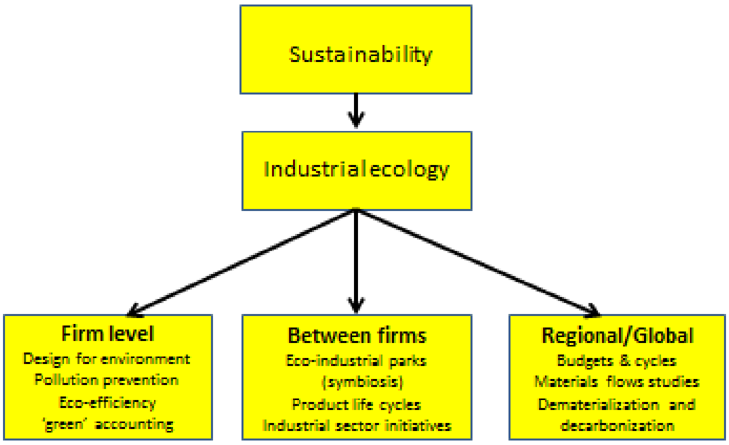

Fig. 3. The components of industrial ecology at different scales (after Lifset and Graedel, 2002)

Relationships between enterprises, in which the used or excess materials and objects of one business become the inputs to a second enterprise, have long been discussed in terms of industrial ecology. However they are now firmly seen as a key component of the circular economy.

Industrial ecology

From the outcomes of the 1992 Rio de Janeiro conference that stressed the importance of creating a sustainable global future emerged attention to the efficient use of resources by industries and consumers. A new concern for developing neighbouring industries that could use excess materials from each other led to the development of the concept of industrial ecology: a parallel with the recycling of nutrients in biological ecosystems. Actions can be taken at scales from the firm to the nation and continents to ensure that efficiency in materials use is increased (Fig.3.)

A fine example of industrial ecology at the between firms level exists in the seaside industrial of Kalundborg, Denmark (Ehrenfeld and Chertow, 2002). Here a network of materials interchange has developed between a power plant; a large oil refinery; a pharmaceutical factory; a biotechnology company; a plasterboard manufacturer; a soil remediation company; and the local municipality. By exporting some of its formerly wasted heat in warms the water in fish farms whose waste sludge is used by the biotechnology company from which treated sludge and yeast slurry is used as fertilizer by nearby farms. Steam from the power plant is also used for district heating by the municipality and by the pharmaceutical company. Many other similar links exist between the various enterprises involved: there is a potential user for the matter other factories discard.

Zero waste

Zero Waste is a philosophy that encourages the redesign of resource life cycles so that all products are reused. It promotes sustainable practices to emulate natural cycles, where all discarded materials are designed to become resources for others to use. Zero Waste involves designing and managing products and processes to systematically avoid and eliminate the volume and toxicity of waste and materials, conserve and recover all resources, and not burn or bury them. No trash is sent to landfills and incinerators.

Supported by the NGO Zero Waste International Alliance, national groups have actively encouraged their governments to act to promote resource recovery and eliminate waste. Zero Waste Scotland exists to create a society where resources are valued and nothing is wasted. It is funded to support delivery of the Scottish Government's circular economy strategy and the EU's Europe 2020 growth strategy. Their goal is to help Scotland reap the environmental, economic and social benefits of making best use of the world's limited natural resources. The National Zero Waste Council established in 2012 by Metro Vancouver and the Federation of Canadian Municipalities (FCM) has embarked on a multi-stakeholder initiative to engage industry for waste prevention changes upstream, and to change consumer behaviour downstream to generate less waste. Zero Waste Singapore manages an online business waste exchange platform called '*Waste is not Waste*'. It puts industrial ecological symbiosis into practice by facilitating the exchange of waste materials and unwanted items from companies and organizations that no longer need them to businesses, non-profit organizations, designers and schools that can use that waste. It is conducting waste matching and industrial symbiosis workshops to gather companies and find out what waste they are generating and whether there are opportunities to connect them to companies that want their waste.

Zero Waste SA is a South Australian state government organization, set up in 2003, which enables people to improve their recycling and waste avoidance practices, whether at home, at work or in industry. Through collaboration, advocacy, financial incentives and education, it works towards meeting the target to 'reduce waste by 35% by 2020'. Efforts made under South Australia's Waste Strategy 2005-2010 have reduced the amount of waste going to landfill in the State by 17.32% since 2003-04. In Queensland, Brisbane City Council set targets to help achieve its goal of Zero Waste, including reducing waste disposal to landfill by 25% by 2014; increasing recycling of municipal solid waste by 50% by 2014; increasing recycling of commercial and industrial waste by 40% by 2014; and reducing generation of waste by 15% by 2020. In New Zealand, Auckland Council has adopted the vision: "to become the most liveable eco city in the world, Auckland will aim for the long term, aspirational goal of Zero Waste by 2040, turning its waste into resources" (Auckland Council, 2011).

In Ahmedabad, India, almost 110,667 metric tonnes (Mt) of solid waste is generated from the city every month. Around 98 percent of this is collected by AMC. Of this, about 10,000 Mt is currently processed. About 90 percent of the generated waste is being dumped in the open at the Pirana landfill site. To develop a pathway to better waste management, Ahmedabad Municipal Corporation (AMC), sought technical assistance from the United Nations Centre for Regional Development (UNCRD) and help from Zero Waste SA to develop a "Road Map for Zero Waste Ahmedabad – 2031" (UNCRD & AMC, 2012). Ahmedabad has become one of the first metropolitan cities from the developing world to adopt a Zero Waste goal.

In India the term "Zero Waste" is used by various organizations and businesses, mainly concerned with dealing with discarded materials rather than in applying the whole of the waste hierarchy. A company called Zero Waste sells incinerators that can be installed by business or organizations to deal on site with discarded matter. The city of Kochi has a Zero Waste project that will promote an eco–friendly garbage management system to help west Kochi residents treat organic waste and also to have plastic waste collected and taken to a plastic shredding facility in Ravipuram.

Plastics in the Circular Economy

As in Kochi, India, much can be done readily in any municipality to deal with plastics waste, but if the flow of plastic debris into the oceans and the impacts of plastic debris on ecosystems are to be reduced, then a new approach is required. The Ellen MacArthur Foundation has made the case for a "New Plastics Economy" driven collaboratively across industry, cities, governments and NGOs (World Economic Forum et al., 2016). Businesses supplying consumer goods and plastic packaging together with plastics manufacturers would play a critical role, because they control the use of plastics in their products. Cities control the collection and recycling, if any, of discarded plastic, and often find innovative solutions. Businesses involved in collection, sorting and reprocessing make an equally important contribution. Politicians and all levels and their advisers can incentivize and regulate through standards, fiscal and innovation measures. NGOs can encourage community involvement and ensure that broader social and environmental considerations are taken into account. Achieving such systemic change will require major collaboration efforts between all stakeholders across the global plastics value chain – consumer goods companies, plastic packaging producers and plastics manufacturers, businesses involved in collection, sorting and reprocessing, cities, policymakers and NGOs.

The key components of the new plastics economy would be:

- Create an effective after-use plastics economy
- Drastically reduce the leakage of plastics into natural systems and other negative externalities
- Decouple plastics from fossil feedstocks

Today only 5% of plastics in circulation are recycled. The remainder is discarded. Possibly, ways could be found to recycle some 53% of all plastic now being produced. Plastics can be recyclable and thus keep materials in circulation (as do "lifetime" shopping bags) or compostable, as are bags for food waste issued by municipalities such as Milan, Italy and Trafford (Greater Manchester, UK). After the introduction of compostable bags for organic waste in Milan, collection of food waste rose from 28kg to 95kg per inhabitant per year. In Greater Manchester, the food waste is combined with garden waste for composting and bio-digestion, producing both fertilizers and energy.

The importance of preventing the leakage of plastics into the oceans is well documented in other contributions to this issue of the journal. The concern is that if plastics continue to be used at the rate they are today, and we rely only on efforts to re-use and recycle plastic, the leakage will merely be contained at its present level. Alternative materials will have to be designed and put into circulation. Paper, providing it does not have damaging inks, is biodegradable and is widely used instead of plastic bags in many countries. Innovation is required in the field of packaging to find alternative solutions.

Plastics are manufactured from unsustainable hydrocarbon-based fossil fuel resources. Potentially these virgin feedstocks could be replaced by renewable sources, either by directly converting greenhouse gases like methane and carbon dioxide (GHG-based sources) or by using biomass (bio-based sources). Innovators claim that production of GHG-based plastics is already cost competitive to current fossil based plastics for certain applications (World Economic Forum et al., 2016). In 2011, 3.5 million tons of bio-based polymers were produced worldwide, compared to 235 million tons of traditional, fossil-based plastics. Current producers of bio-based polymers estimate that production capacity will reach nearly 12 million tonnes by 2020. With an expected total polymer production of about 400 million tonnes in 2020, the bio-based share should increase from 1.5% in 2011 to 3% in 2020. Much depends on political support for sustainable production.

Europe lacks a policy framework to support bio-based polymers, whereas biofuels receive strong and ongoing support during commercial production. Most bio-based polymer production is in Asia, which has stronger political support as do the USA and South America (Nova Institute, 2015). Overall, the message is that appropriate technologies exist, solutions to plastics recycling and discard management are available, but political action and community and business behaviour have to adapt and change.

Construction and demolition waste in the circular Economy

Plaster board manufacturers had a three-year project, called Gypsum-to-Gypsum or GtoG, which showed that a circular economy can be achieved through a collaborative approach and a change of mind-set on the supply side as well as the demand side of the industry. Significantly higher rates of plasterboard recycling can be achieved where buildings have been selectively deconstructed and demolition made profitable. Product design is a key strategy in which a best practice in construction has buildings designed for disassembly. Experienced resources have long been used in construction. In southern Europe, Greek temples were used as building stone sources by subsequent Roman, Byzantine Arab and Norman civilizations. Concrete is a 100% recyclable material: at the end of its life, it can be recycled either back into concrete (closed loop) or into other applications such as a road base (open loop). It is essential that we maximise both open and closed loop recycling. Major building repairs, renovation, adaptation and redevelopment are increasing in many countries so using fewer resources and gaining new uses for old infrastructure.

E-waste and the circular economy

E-waste is notorious for the complexity, diversity and value of the materials of which it is composed. Innovation in product design could greatly help WEEE recycling if it assisted in making the design of equipment less complex. For example, if something is bolted, screwed and soldered together it is going to be considerably harder to recycle. These companies could also potentially also keep ownership and simply license out their products for periods of time. This means that afterwards the technical and biological materials will come back to the company and they can reuse it efficiently. Manufacturers can also help extend their product's lifespan by making information about repairing it more freely available.

Users of electronic items (WEEE) could reuse them or redistribute them to other people so they are not wasted. WEEE could potentially also be refurbished and repaired but if we have no need for them anymore, perhaps they could be upcycled or recycled to create something new. Disassembly can be profitable, but end use thinking about design could make it even more effective.

The shared responsibilities for building and maintain the circular economy

As in all aspects of human ecology, individual responsibility plays a significant role in implanting and supporting the circular economy. Individuals and households can engage in repair, reuse, recycle to save resources and money. If they have a garden they can compost food waste and other organic waste, including shredded paper, so returning nutrients to the soil. If they do not, they can place organic matter in green waste recycling bins. They can ensure that everything, for which there is another possible use from cardboard to scrap metals, goes to the appropriate recycling facility. In their shopping they can avoid plastic bags as far as possible.

Businesses and organizations can engage in similar good practices, particularly in purchasing materials and in their operations, by using recycled products and by passing items they have finished with to other potential users, rather than sending them to waste collection services. NGOs can actively promote the circular economy and set good examples by their own office and travel practices.

Municipal governments already are innovating good practices and improving waste collections services. The best now have separation at households into green waste; glass, recyclable plastic and metals; paper and cardboard; and non-cycleable materials (which are largely plastic packaging). They provide much more refined recycling opportunities at domestic waste recycling facilities. Specialist waste collections firms can assist businesses and manufacturers in dealing with their individual waste problems. However, in many countries, the municipalities are so poorly supported by central governments and have such weak local tax bases, that they cannot maintain adequate waste collection facilities. Such a situation is a global concern and needs attention by international agencies.

National governments can introduce policies that change individual and organizational behaviour. Sometimes the implantation of such policies is triggered by international conventions or directives, with the Waste Directive of the European Union being a prime example. The UK landfill tax has been a major driver of a great increase in the recycling by municipalities, action originally prompted by the EU.

International measures, such as the Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter of 1972, known as the London Convention, one of the first international agreements for the protection of the marine environment from human activities, help to reduce hazards associated with waste and thus potentially support the circular economy. However, there is potential for more international action, particularly for the proposed global plastics protocol, advocated by the Ellen MacArthur Foundation, providing a core set of standards as the basis for action to redesign and convert materials, formats and after-use systems and to avoid plastics leakage to the oceans. We can all do something about this, through our own actions, lobbying our politicians, and working together towards a more sustainable future for our grandchildren's children.

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"A circular economy is restorative and regenerative by design and aims to keep products, components, and materials at their highest utility and value at all times. The concept distinguishes between technical and biological cycles."

Ellen MacArthur Foundation

Waste – uncovering the global food scandal, *by Tristam Stuart* – Penguin Books 2009, ISBN 978-0-141-03634-2

Per Ekehorn

The author spent many years investigating how the international community treats organic and prepared food, and the unbelievable amount of perfectly eatable food that is thoughtlessly trashed. Although published some years ago, this remarkable book is still highly relevant. Fortunately there are signs that food producers and manufacturers, supermarkets and regulatory authorities are now beginning to face this squandering and taking steps to mitigate it.

Discarding food does not only mean loss of that particular piece of food, it may also mean that a part of a farm has been worked on unnecessarily, and that corresponding water, fertilisers, pesticides and fuel could have been saved; all of which are important issues in these days of worrying climate change.

One example is the use of “best before” (quality) dates and “use before” (safety) dates. In addition to the true meaning of these dates being often misunderstood by the public, in order to have an adequate safety margin (food may be transported from the supermarket to the customer’s fridge after hours in a hot car boot, and the customer’s fridge may be a few degrees warmer than it should be, etc.) the dates are often set several days before the food would actually go off, if it were handled properly. Also “best before” does not mean that it is uneatable directly after. Most people can decide for themselves if the condition of the food is acceptable or not (p. 65).

> On one hand manufacturers assume everyone is an idiot;
> and on the other, the public are very stupid to take these dates seriously.
> (p 65)

The New Plastics Economy: Rethinking the Future of Plastics.

Peter Lockwood

> This year the Ellen MacArthur Foundation released a new report entitled ‘The New plastic Economy: Rethinking the Future of Plastics’. The situation with regards to the proliferation of hydrocarbons is often painted as a bleak one, but we draw attention to the achievements of this report, how it charts a way forward in which the world community can manage plastic, and create a more sustainable future. The report can be accessed at: http://bit.ly/1XYm3Ue

Overview

In The New Plastics Economy, the authors emphasise that plastics are an irreplaceable aspect of the world’s human ecology - the global use of plastics is expected to increase twofold over the next twenty years. With this in mind, they draw attention to the way plastic packaging escapes collection systems – a loss of value to the ‘plastic economy’ equally damaging for natural systems. Initiatives to reduce the impact of the plastic industry on greenhouse gases and the environment are far too fragmented, they argue. Collection systems have made great improvements in industrialised nations, but are often piecemeal, bottom-up initiatives disconnected from the distribution chains of plastic-producers.

Concepts

The ‘New Plastics Economy’ builds on the concept of the circular economy and its emphasis on a systematic overview of human economic-ecological systems as interconnected. One of the major problems with the plastics economy, the authors suggest, is the way plastics effectively ‘leak’ out of after-use collection systems, resulting in the degradation of eco-systems, particularly the ocean. Approximately 8 million tonnes of plastics leak into the ocean every year, a staggering amount. And, after all, these eco-systems are integral to the production of plastic in the first place. Plastic is not the problem itself, but rather its management. Since so much value is lost for companies when plastics escape the chains of distribution and re-use, why not work to close that gap?

Intervention Points

The report suggests a few major areas for intervention:

- *An effective after-use plastics economy*
  Recognising that existing efforts to re-use plastic are far too fragmented, the authors recommend radically increasing the uptake of recycling, and creating *global* protocols for the collection and reprocessing of plastics. This would also entail a larger scale uptake of reusable packaging and compostable plastic packaging.

- *Reducing leakage of plastics into natural systems*
  This is a key logistical point made by the authors: that after-use collecton, storage and reprocessing infrastructure needs to be scaled up and improved, as well as introducing economic incentives for keeping plastics circulating in the system. Clearly, they note, such initiatives should be tailored to particular countries but the upshot is that a globally integrated circular plastics economy-ecology that keeps plastics in the system. A related point is the introduction of economic incentives to make the reprocessing of plastics more attractive, although such measures would require significant government and international intervention to bolster the 'new plastics economy' (see below). Along with this would be developing innovations in packaging design and material, such as the widespread rolling-out of 'bio-benign' packaging that would be less harmful to ecosystems when leaked. The warning in the report stark, 'Today's biodegradable plastics rarely measure up to that ambition, as they are typically compostable only under controlled conditions (e.g. in industrial composters). Further research and game-changing innovation are needed.'

A New Approach

Finally, the report sets out its vision for a global, integrated plastics economy, one with the management infrastructure to avoid heavy leakage of materials into nature and that bolstered after-use programmes.

- *Global protocols on plastic coordination and demonstration projects*
  In this section, the authors emphasise the need for global discussion and material collaboration on the creation of international standards and innovation in packaging. Further details on this can be found in the report, but significantly, the authors recommend that after-use systems ought to be developed and coordinated at a much larger scale than ever before.

- *Innovation*
  Investment in innovation, particularly the development bio-benign materials is seen as a major step in mitigating the impact of materials that are nonetheless likely to leak into the ocean.

- *Further insights and scientific study*
  Further investigation is recommended into the socio-economic impact of ocean plastic waste and the potential outcomes of recommendations recommended by the report itself.

- *Engaging Policymakers*
  The onus is on innovators like the Ellen MacArthur Foundation to bring possibly policies and management toolkits to the attention of policymakers.

The number of plastic bags used in shops in England dropped well over 80% over the six months since a charge of 5 p per bag was introduced; from over 7bn bags before the charge.

BBC News, 30 July 2016

Highlights from

What a Waste: A Global Review of Solid Waste Management; Report from World Bank, 2012; Daniel Hoornweg and Perinaz Bhada-Tata, March 2012, No. 15

Eva Ekehorn

This report is part of the World Bank Series aiming to explore and delve more substantively into the core issues affecting a world that is becoming increasingly urbanized. The major issue for most local governments is the treatment of the municipal solid waste (MSW), and the cost of which is increasing. The report recognises that now over half of the world's people (some 3.5 million) live in urban areas. The report provides worldwide statistics on the collection and treatment of waste. Some countries lack data, but the report uses in depth studies of the Caribbean, Latin America and South and East Asia. It is estimates that today about 3 billion residents are generating 1.2 kg per person per day (1.3 billion tonnes per year). By 2025 this will likely increase to 4.3 billion urban residents generating about 1.42 kg/capita/day of municipal solid waste. Nearly half the waste is generated by the OECD countries, with a fifth coming from East Asia and the Pacific.

Waste quantities numbers vary greatly between countries and between rural and urban areas. Over most of the world average waste generated is around 1 kg per capita per day, but in rich OECD countries it is more than 2 kg. Intraregional totals vary, with islands often generating more waste, frequently partly due to their on the tourist industry.

Greenhouse gas emissions from MSW have emerged as a major concern as post-consumer waste is estimated to account for almost 5% (1,460 mt CO2 equivalent) of total greenhouse gas emissions.

Waste collection is a major task for municipalities. It is often their biggest budget item and also the largest component of their workforce. It is important to collect waste from its sources and to work on the key issues of reducing, reusing and recycling waste, particularly because of health concerns, increased pollution and contributions to carbon emissions. Municipal solid waste managers are charged with an enormous task: to get the waste out from underfoot and do so in the most economically, socially, and environmentally optimal manner possible.' (p17)

The general finding is that the composition, collection and treatment of waste are usually strongly associated with income and urbanisation. Low income countries generate a higher percentage of organic waste, such as food scraps, garden waste and processed residues. In richer countries much more other material enters the waste stream, making organic waste usually less than 30% of the total. On average globally the organic waste is roughly half of all waste. The second largest waste source is paper of all kinds, again with a larger share from richer countries.

With regard to collection of waste, the local government is usually the main provider of the service. Depending on culture and social norms, waste is collected from three times a day to once a week. Low income countries spend most of their municipal budgets on collecting waste, but even so, collection is sporadic and inefficient. Only a fraction of the waste is picked up, often mostly from rich or high visibility areas. Medium income and richer economies use modern collection vehicles and more efficient methods, thus the collection is a relatively small part of the budget for waste management. Some 90% of all waste is collected in rich countries.

The sorting of the waste from source to disposal varies widely. Waste in low income countries is usually a mixture of various objects and materials that is difficult to sort. Recycling is often highly effective. However, the informal sector still collects, sorts, and sells on recyclable materials such as wood, metals and cardboard. Some of these countries also import waste from other parts of the world, including hazardous waste such as e-waste and ships to be dismantled.

The informal sector is involved even in mid income countries and recycling is still fairly high. Materials are often imported for recycling and there is some control and regulation.

Organic material ought to be composted, but in low income countries, this is rarely done, in spite of the fact that most of the waste is organic. In rich countries composting is becoming more popular and as material is often separated at source or early on, composting is easier. Anaerobic digestion is increasingly used in middle to income countries for both sewage waste and organic material from domestic and commercial sources, often with biogas as a by-product.

The final destinations of waste are unfortunately still dominated by dumps and landfills, especially in low and medium income countries. Liquid residues from landfills contaminate aquifers and rivers. The compostable material, which dominates the waste, can become mixed with medicines; an input that is a health hazard, both to those working on the dumps and the neighbouring villages. Sometimes the dumps are on fire continuously, creating serious air pollution. Incinerating the waste is expensive and there has to be control over emissions from the material that is burnt. In rich countries the heat is often used to generate electricity and combined heat and power generation.

There is an emerging trend towards a global market in recycling goods. The volatility of secondary materials prices has increased, making planning more difficult. The price paid per tonne of waste paper in New York City is often based on what the purchase price is in China. The majority of waste recycled in Buenos Aires, for example, is shipped to China.

The Report's conclusion on waste management suggests an integrated solid waste management system that reflects the need to approach solid waste in a comprehensive manner with careful selection and sustained application of appropriate technology, working conditions, and establishment of a "social license" between the community and designated waste management authorities based on both a high degree of professionalism on behalf of waste managers; and on the appreciation of the critical role that the community, employees, and local (and increasingly global) ecosystems have in effective solid waste management. MSW can represent a considerable potential resource. In recent years, the global market for recyclables has increased significantly.

'The waste management sector follows a generally accepted hierarchy. The earliest known usage of the "waste management hierarchy" appears to be Ontario's Pollution Probe in the early 1970s. The hierarchy started as the "three Rs" — reduce, reuse, recycle — but now a fourth R is frequently added — recovery. The hierarchy responds to financial, environmental, social and management considerations. The hierarchy also encourages minimization of GHG emissions.' (p27)

The whole Report can be found at:

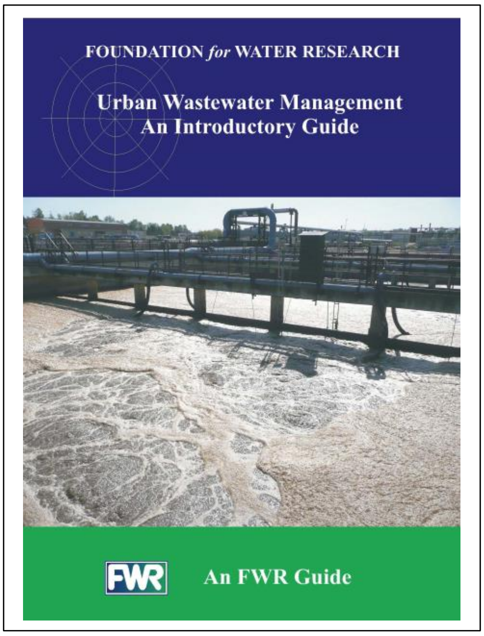
http://documents.worldbank.org/curated/en/2012/03/20213522/waste-global-review-solid-waste-management

The Global City Indicators Program (GCIP) is a decentralized, city-led initiative that enables cities to measure, report, and improve their performance and quality of life, facilitate capacity building, and share best practices through an easy-to-use web portal. GCIP assists cities in providing support to decision makers in making informed policy decisions; in addition to enhancing government accountability to the public. GCIP has been providing many data for this World Bank report. (www.cityindicators.org)

Highlights from

Foundation for Water Research - FWR

Waste water section. http://www.fwr.org/wransom1.html



The Wastewater Forum was established by FWR in 1995 and, at that time, its main concern was the integrated management of wastewater systems and receiving water quality. The remit of the Forum has been expanded to include all aspects of wastewater (re-use, transport, treatment and discharge (including all by-products), together with related environmental and public perception issues). The Forum is an integral component of FWR's activities.

Managing wastewater and the resources it contains are hugely important in the water cycle. There are many complications of which the science needs to be understood and shared. That is the role that FWR's wastewater section undertakes.
For further information see: www.fwr.org

Websites for Journal 27 'Waste' & References

Ocean Conservatory

http://www.oceanicsociety.org/?gclid=CMmdsNuQls0CFYEy0wodxawE4g

Through our conservation travel programs, marine research, and investments in conservation, we are inspiring and empowering people at all levels of society to become better stewards of ocean ecosystems.
Our mission is to conserve marine wildlife and habitats by deepening the connections between people and nature.

Sierra Club Marine Action Team

https://content.sierraclub.org/grassrootsnetwork/teams/marine-action-team

The Marine Action Team (MAT) is a Grassroots Network National Issue Team, authorized to act on behalf of the Sierra Club on issues that typically involve federal legislation, rules, or proposed actions by federal agencies affecting more than one Chapter.

Race for Water Foundation

http://www.raceforwater.com/home

The Race for Water Foundation is a charity dedicated to water preservation. This indispensable resource is under massive threat from plastic pollution and must be protected. The Foundation aims to identify, promote and help implement solutions that give end-of-life plastics a value and therefore prevent the plastic pollution of our waterways. Using an innovative approach inspired by the principles of a circular economy and social entrepreneurship, the foundation seeks to create new sources of income for the people most affected by pollution by giving an economic value to plastic waste.

Institute of Marine Sciences - National Research Council

http://www.ismar.cnr.it/organization/geographic-units/ancona?set_language=en&cl=en

ISMAR conducts research in Mediterranean, oceanic and polar regions

Ellen MacArthur Foundation

https://www.ellenmacarthurfoundation.org/circular-economy

The Ellen MacArthur Foundation was established in 2010 with the aim of accelerating the transition to the circular economy. Since its creation the charity has emerged as a global thought leader, establishing circular economy on the agenda of decision makers across business, government and academia.

Eunomia

http://www.eunomia.co.uk/

Eunomia is one of the foremost waste, recycling and resource efficiency consultancies in the UK, in the vanguard of efforts to establish a circular economy

Back cover: Remote clean-ups are often done in collaboration with Indigenous Rangers and communities. Here, the next generation learn how to look after their natural heritage. Credit: Christian Miller

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