

The legacy of dumping chemicals including mustard gas in the sea routinely affects local fishermen who if they dredge it up then have to discard their catches.

Costs of clean-up

What has become starkly apparent is the high cost of cleaning this coastline to a reasonable standard each year - even using job creation scheme staff. This has been made possible by the involvement of the County Employment Board who operate 'Opportunity Schemes'. Approximately 100 people have been employed for 4-5 months cleaning up the coast each (approx. 9,000 working days). Further costs are incurred from supervision costs, administration, transport & disposal of litter. The total cost amounted to approximately 10.7 million SEK (£937,000) in 1993. Since the volume of litter collected was 6000 cubic metres this worked out at a cost of 1,800 SEK / cubic metre (£156). Since the amount collected in 1994 from the same area was larger than in 1993 one can conclude that the situation is not improving.

Recommendations

1. Every ship should develop and follow an on board waste management plan.
2. A 'garbage record book' should be made mandatory on all ships in order to control the ship's operations. The record book to be readily available to inspection.
3. In order to minimise the volume of litter, excessive packaging not required for the protection of food etc. should be removed ashore prior to loading on to the vessel.
4. The motivation and qualification of crew members should be enhanced.
5. Due to different disposal strategies of different kinds of litter, separation into agreed categories should be made on board ship prior to delivery to the port reception facility.
6. Waste stream management plans, from reception facility to final disposal, should be developed in every harbour.
7. The development and implementation of new techniques for waste treatment on board ships and on land should be promoted.
8. The Port Authority should jointly agree on common fees for litter treatment. This will restrain any prolonged storing of litter on board or illegal dumping into the sea for financial reasons.
9. Both regulations themselves and the system for checking that they have been complied with should be improved. Offenders of the regulations should be prosecuted.

10. Co-ordinated beach cleaning operations should be carried out and types and amounts of litter as well as the costs assessed.
11. More information should be given to the public on existing regulations and environmental effects in order to increase their awareness of the problem.
12. The issue of marine litter should be addressed at the North Sea conference.

[* This article was compiled by the editor from material provided by the contributors, in particular the text of Anon, 1994]

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2.6 Sources and Sinks of Litter

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Introduction

Water borne debris can be classified as either having a land or ocean source. Major contributors of the latter are merchant and military ships, commercial fishing ships, cruise ships and recreational vessels. Debris can be blown, washed or discharged into water from land, some of the sources being recreational beach users, manufacturers, solid waste disposal facilities, combined sewer outfalls, fly-tipping. It is apparent that much of the above can

enter the marine system via the riverine environment, and this is the ultimate sink. Temporary sinks exist along river banks and sheltered bays, but eventually material either degrades and/or remains for some years at one location.

a) Marine

One of the earliest qualitative investigations on persistent marine debris in the UK was carried out by Scott (1972), who looked at two inaccessible shoreline stretches in northern Scotland. He found a preponderance of plastics which could be classified into three main types - domestic and industrial waste, agricultural and packaging and maritime waste. He showed that tourism had a very small role to play. Similar observations were made by other workers (Cundell, 1973; Dixon and Cooke, 1977; Simmons and Williams, 1992). Pruter (1987) showed that the major input of plastics to oceans came from ships, rivers and municipal drainage systems and beach visitors. However, all observations are site dependent and Williams and Markos (in press) have shown the huge visitor litter beach discards that can accrue on, for example Greek holiday beaches. These can be viewed as land based.

Dixon and Cooke's (1977) study on discarded containers was one of the first to set out a methodological framework for marine litter. Their classic study encompassed types and relative abundance, the range and geographical origins, shore retention rates and persistence of litter. Sufficient evidence was found to indicate a global scale of manufacturing sites with a decreasing numerical relationship decreasing with distance from the study area, which indirectly implicated shipping in the distribution and disposal of containers. Numerous workers have characterised plastic debris found on local beaches and attempted to determine origins e.g. Merrell (1984) for Alaska; Morris (1980) for the Mediterranean; Vauk and Shrey (1987) for Heligoland; Simmons and Williams (1992), Williams et al (1993), Simmons et al (1993) for Wales; and the NUCS (1993) studies for the UK. Vauk and Shrey (1987) specifically investigated wind direction and showed that most litter items were deposited during winds deriving from the direction of main shipping lanes. How much is inputted from these sources is open to question but Dixon and Dixon (1981) commented that estimations were susceptible to error due to assumptions and interpolations, concluding that beach surveys were the best approach to tackle the source problem as they are essentially the sink point for the litter. Hazardous debris is also included in marine litter. Dixon and Dixon (1981) reported a metre long explosives canister found on the shores

of southern England; four dozen packets of Phosphine and over 3,500 chemical packages of which > 95% were hazardous, all being washed ashore over a 6 month period, the most hazardous being 32 canisters of arsenic. Currently, concern is being expressed regarding medical waste which in 1988 caused beach closures along the USA Great Lakes coastline. Similarly, offshore sinks of sewage derived material in the Inner Bristol Channel (Williams et al, 1993) probably derived from coastal discharges is a cause for anxiety. Over 100 Combined Sewer Outflows (CSO) exist in the Swansea Bay area and this has probably given rise to submerged marine litter sinks - one such being at the White Oyster Ledge where analysis was carried out on some 3670 items of sewage litter entangled in fishermen's gill nets (Simmons et al, 1993).

b) Land based

The main sources of litter in these systems are fly tipping and sewerage derived mainly via storm water riverine discharges (Simmons and Williams, 1994). A pilot study at 50m sites on the River Taff in South Wales, which was assessed on two occasions using three five metre transects gave 8687 items of litter, resulting in an average of 584 items per 100 metre of bank length. Litter from beach visitors -see earlier section-could also be classified under this heading.

i) Fly tipping

Land use, road network and vehicular access categories are important with respect to fly tipping (Coggins *et al.*, 1991). Table 1 gives results found from such sites in the Taff valley in South Wales according to land use categories.

Household-type waste was the most common form of litter tipped in the Taff catchment, and an inference could be that residential land use areas would show the highest preponderance of tipping. This is not the case as although industrial areas are more commonly tipped, the bulk of the material is household derived (Table 1). It is plausible that members of the public wanting to tip waste would employ a 'NIMBY' attitude, and these areas show seclusion and are aesthetically unpleasant. Additionally household type waste is collected within these premises. However, problems exist in determining waste origins in these sites (Coggins *et al.*, 1991). The predominance of such waste in the Taff area could indicate shortcomings in public waste disposal services, and/or low public awareness. Unpublished studies by the authors, on the 'willingness to pay', have shown that there is very little support for increased council taxes ((equivalent to £20/annum for the total Taff valley catchment population), but significant support for

Land Use	TYPE OF TIPPING			
	None	Indus/Comm	Household	Combination
Residential	52%	4%	32%	12%
Industrial	25%	25%	38%	12%
Open Space	55%	14%	24%	7%
Commercial	38%	12%	50%	0%

Table 1. Tipping Types and Uses.

either voluntary donations or payment per visit equivalent to £16,000 pa for the population. Additionally, locals were prepared to contribute 2,800 hours of time to help maintain river banks free of litter. This includes fly tipping sites and the river bank areas covered by 'the Christmas tree effect' of mainly sewage derived material.

ii) Sewage

Combined Sewer Overflows (CSO) were constructed 'for the purpose of relieving the system of flows in excess of a selected rate, the excess flow being discharged to a convenient watercourse' (Jeger, 1970, p65). The selected rate is a multiple of the dry weather flow (DWF). When flows exceed 6 times the DWF, the CSO operate but in fact they can discharge outside of storm events. The Technical Committee on Storm Overflows and Disposal of Storm Sewage (1970) took into account proportions of industrial and domestic elements such that:

$$Q = DWF + 1360P + 2E$$

where

Q = Overflow setting (litres /day) ; DWF = Dry Weather Flow

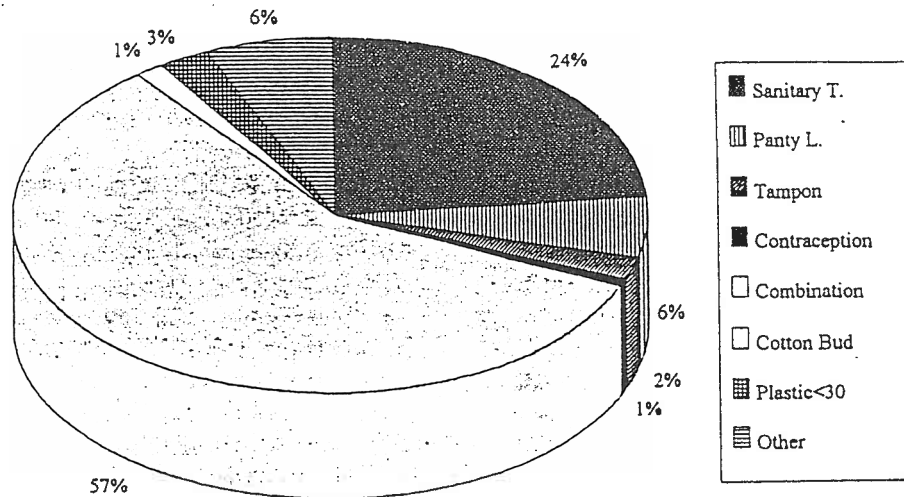
P = Population ; E = Volume of industrial effluent discharge in 24 hours (litres).

The majority of CSO are unscreened and over 3000 exist in Wales alone. New CSO incorporate some storage facilities to hold the 'first flush'. Others can involve the removal of floaters and sinkers (material with a specific gravity higher or lower than water) by slowing the flow to allow settlement and removal, neutrally buoyant materials such as many feminine hygiene products are much more difficult to remove. Screens with > 15mm mesh are ineffective gross solid removers (Welsh Water & WRc, 1989); smaller screens run the risk of blinding. The optimum size appears to be 6 mm but is a function of the modelling of the system. Mechanical screening involves labour; rotating drum screening power. New design technology has culminated in dynamic separation overflows based on the principles that at low velocities, the centre of a

spinning column of liquid rotates slower than the remaining liquid. Their efficiency is undergoing investigation. Investigation of COPASAC - sacs designed to retain gross solids from sewer systems - contents on many CSO in the Taff catchment gave results depicted in Fig 1.

The dominance of sanitary towels as the most numerous CSO discharge component highlights the need to tackle this particular source (Fig.1). Unfortunately CSO form an integral part of combined sewer systems of the UK. Alternatives are landfill, recycling and composting. Pressure groups such as Surfers against Sewage (SAS) and the Women's Environmental Network (WEN) have gained high media profiles with their 'bag it and bin it' campaigns. Confusion has existed until recently as to whether these products are clinical waste. Incineration is the key to this aspect of litter. Prosser (1990) considered them as such i.e. 'any waste which consists wholly or partly of human or animal tissue, blood or other bodily fluids, excretions, drugs or other pharmaceutical products, swabs or dressings, syringes, needles or other sharp instruments, being waste which unless rendered safe may prove hazardous to any person coming into contact with it' (CDWR, 1988). Currently, some 60-79% of hospital incinerators (NAWS, 1991) are incapable of reaching the standards set down by the Secretary of State's Guidance note PG5/1/1(91). Municipal waste incineration costs are some £50 per tonne (compared to £250 per tonne for hospitals) and they handle some 150,000 tonnes/annum - as opposed to some 10,000 tonnes/annum for clinical waste. These are the ultimate sinks. In the Netherlands, incineration of 100 tonnes of sewage per day yields 4 tonnes of ash which is used to make bricks. Techniques developed in the oil industry have resulted in a 1000 metre pipe in the ground, where some 22,000 tonnes of material per year is incinerated at 280°C. The cost of the installation is some £20 million.

Figure 1 Sewage Litter Composition: Percentage Volume



However, the main sinks within the system can be thought of as:

Marine:

Land based:-

- burial in the beach/dune systems
- movement to other marine areas or marine sinks.

Offshore:-

- movement by currents to oceanic sinks.
- eventual deposition on a coastline.

Riverine:-

- partial bank burial, e.g. cloth in particular exhibits this trait.
- movement to the sea.
- degradation (this can occur in all the other areas)

Anthropogenic:-

- municipal waste dumps.
- incineration.

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2.7 Resort Management

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Woodspring has 22 miles of Bristol Channel coastline between Portishead in the North, to Weston-super-Mare in the South. A busy shipping estuary; the docks of Royal Portbury, the port and heavy industry at Avonmouth; a coast with its share of water-borne litter problems.

The district has designated bathing beaches at Clevedon, Sandbay, and Weston-super-Mare. I shall concentrate on Weston-super-Mare. Made popular by the Victorians and introduced to the masses by the railway, the resort has suffered with the decline in domestic tourism combined with the cost of maintaining (and the difficulty in adapting) many of its Victorian buildings. Weston has come through the recession with some questions unanswered but with all its hotels and attractions still in business and visitor numbers increasing. Decline was arrested before it became irreversible; confidence together with investment is returning.

The Henley Centre categorises Weston as a prosperous market town; it enjoys a strong manufacturing base, growing service and commercial sectors and good retailing opportunities. Twenty per cent of its working population - around 4,000 people are employed in the tourism industry. Tourism contributes some £75 million per annum to the local economy. The town provides 10,000 bed spaces in the hotel, guest house, self-catering and caravan sectors. Tourism is also significant in terms of infrastructure and buildings. It is difficult to know what would happen to those large nineteenth century buildings that line Weston sea front, if they were not used as hotels, nor to the many public buildings and places of entertainment that reply upon the visitors' spending for their viability.

Weston-super-Mare's attraction has always been and will remain its beach - 2 miles of wide golden sand of a consistency ideal for sand castles, donkeys, beach football, cricket and relaxing. The sea front attractions, Museum, theatre, conference centre, cockle sellers, special events, all add value - but it is the beach that attracts.

The sea - or bathing in it has never been Weston's strong point with the second highest rise and fall in the World that is not surprising. Nevertheless, it does wash the beach twice a day and its shallow nature makes paddling, and splashing safe and fun. Swimming can occasionally be seen - but visitors do not choose Weston for sea swimming.

The resort receives around 2½ million day visitors per year, in addition to 300,000 staying visitors. A sunny Sunday or August holiday will see very large numbers descend upon Weston's sandy beach. The litter generated is equally substantial! Weston's litter comes from two sources - the greatest bulk from its land visitors - but the more worrying and at times detrimental litter, from the sea. Once litter is on the beach there is only one solution. Pick it up and dispose of it. The responsibility for that rests with the District Councils and the majority of Councils, are effective in dealing with it.

In Weston the beach is mechanically raked/swept every day and when tide times make it desirable, twice each day in summer. The tide line is also raked and cleared regularly during winter. Hand litter pickers operate along the beach through the day and hand sweepers operate along the promenade. Litter bins line the promenade and others - though decidedly unattractive in form - are placed on the beach.

We have a mile of beach at Sand Bay but it's a quite different beach. From a mid tide line upward, the beach is constructed of imported sand and pebbles set at a stable but steep angle to serve as a flood defence. The imported sand comes from a mile or so out at sea. The size of grains varies from fine golden sand up to pebbles the size of a fist. The raking machine cannot be used - it would remove bigger aggregate and make the constructed beach less stable. Cleaning is carried out manually on a regular basis and mechanically during the highest part of the monthly tidal cycle. A JCB is used and about a hundred tons plus of litter, seaweed, flotsam and jetsam is removed each month from Sandbay and Weston - most of it from Sandbay.

The cost of managing litter and sand on these two beaches is £100,000 a year. The beaches are recreational areas and the standard must match that of the best recreational areas. Beaches, like parks, are a showcase for the town. Litter is not acceptable. Tide washed litter is even less acceptable. We do have a water quality problem at Weston-super-Mare but a good management regime ensures that possible problems are observed and tackled before they become visible problems.