6. Stormwater treatment approaches

6.2 Other Pollutant Removal Processes

Whilst sedimentation is typically the contaminant removal mechanism targeted by stormwater quality initiatives, it is by no means the only one. In those parts of the country discharging into lakes or other systems susceptible to nutrient related effects, other mechanisms may be more important, although nutrient related contaminants from roads are unlikely to be the dominant contaminant (refer to **Section 4.3**).

Other treatment processes and mechanisms, as alternatives to sedimentation to address nutrient related effects, can include:

- Physical removal / **skimming**;
- **Filtration**;
- **Infiltration**;
- **Flocculation**;
- Chemical **complexes**, **dissociation**, **chelation**, **volatilisation**, **precipitation**;
- **Bioturbation, biological uptake**, **metabolism**, **mortality**; and
- **Photodegradation**.

Each of these is discussed briefly below, with stress on the importance of biological systems as part of any engineering approach. Whilst many of the processes listed below are not viewed as the primary treatment mechanism, they can be beneficial and result in a more robust and resilient treatment process.

Physical removal / skimming

Litter and floatable materials can be a significant component of stormwater (refer to **Section 4.2**). Consequently, the physical skimming and removal of such material can be a valuable and intrinsic part of any treatment approach for heavily urbanised catchments.

Litter trap
Source: Mersey Basin Campaign

Floating booms or baffles for the retention of hydrocarbons are also another means of simply extracting a contaminant from the system. However, wind, the ability of the contaminant to mix with water, volatilisation and other processes may limit the effectiveness of this treatment strategy if used on its own. Care is required in relying on baffles if petrol and diesel are the expected / predominant hydrocarbons of concern. Whilst baffle systems and plate separators are well established, these tend to be effective for removing spills rather than for trace amounts that may be required by statutory or environmental criteria. Not only would petrol or diesel evaporate quickly, these mixtures are also partially **miscible**. Consequently it is recommended that hydrocarbon baffles be used in conjunction with a bioretention system (e.g. wetland) or a filtration device (e.g. sand filter). Baffles are, however, a common sense inclusion within a pond or sand filter; less for ongoing treatment or containment and more to provide some buffering in the event of a spill.

Should baffles be included within the stormwater system, it is recommended that the RCA liaise with local emergency services so that they are aware of the containment capacity and so that they can manage any vapour related hazards that might arise. Appropriate management strategies would similarly need to be adopted by the RCA.

Filtration

Peat and Sand Filter
Source: Wikipedia

Filtration is the process of separating solids from liquid; large solids are simply trapped and entrained within the **filtration medium**. Whilst sand is the most common medium used, compost, peat, sphagnum, zeolite[8], pumice, lime, fly ash, steel slag, and other substances may be used (Auckland Council has tested crushed mussel shell; Auckland University has suggested using banana skins). Filters can be effective at removing a wide range of contaminants, including sediment, heavy metals, hydrocarbons, and phosphorus (NZTA, 2009; Landcare, 2008). Care is required, however, when using 'active' media (e.g. peat and compost) rather than an inert substance (e.g. sand) to determine the appropriateness and chemical outcomes of the media choice. For example, peat can have a low pH and many heavy metals are mobilised in acid conditions, so peaty materials may be inappropriate.

As with most treatment processes, filtration does not need to occur in a specifically designed SQID. In gravelly or other permeable soils, filtration may occur in roadside ditches and areas where flows are impounded. Contaminants may 'naturally' build up in these areas and provide some benefit to a down gradient receiving environment or to an underlying shallow groundwater system. The 'mucking out' of these areas therefore needs to account for any contaminant build-up, so that effects can be appropriately avoided, remedied, or mitigated.

Flocculation

Flocculation is the process of taking solid material out of suspension by the clumping together of the particles. This is distinct from precipitation, overviewed below, which is the process of settling a substance out of solution. The flocculation process is useful to stormwater treatment as **colloidal** or very fine particles may either be too light or have insufficient **residence time** within a SQID to settle.

Flocculation is an important natural process and can be seen in many estuarine and soft shore environments where the effect of the cationic (positively charged) saltwater causes fine sediments that tend to be anionic or negatively charged to flocculate and deposit within **accretion** zones (as first described by Hall and Morison in 1907). It is in part because of this natural process that erosion and sediment control practices are particularly important; accelerated sediment accretion within estuaries and soft shore environments can result in smothering or other changes to an ecosystem.

Changes in mangrove distribution are a common indicator of ecosystem change arising from sediment accretion. Whilst mangroves do not necessarily need soft sediments for growth, they will tend to establish more readily in accretion zones because currents tend to be slower and seed establishment is improved. Once established, the mangroves themselves are effective at trapping sediment and may therefore add to accretion rates.

8 The granular material used in "kitty litter".

The use of flocculation in long term stormwater treatment is not commonly used, but is effective (and often necessary) during earthworks. A range of flocculent and coagulating chemicals have been used, the most common of which is polyaluminium chloride (PAC). Where discharges are directly to a marine environment, however, saline solution has also proved effective (Winter and Blom, 2003).

Sediment Runoff into the Whangarei Harbour
Source: Northland Regional Council

Chelation, dissociation, volatilisation, precipitation

A range of chemical processes can be found within biologically based treatment systems such as wetlands. Processes include the formation of metal ion compounds or **chelation**, **dissociation**, **oxidation** and **reduction**, and natural **precipitation**. In this regard, Mays (2001) notes:

> "*Chemical adsorption onto surfaces within wetlands can result in water column reductions of phosphorous, bacteria and viruses, and heavy metals. Chelation reactions also impact phosphorous concentrations, but are a primary mechanism for heavy metal removal. Chemical oxidation / reduction (redox) reactions are a primary removal mechanism for BOD and heavy metals, and can also have an impact on TSS. Certain heavy metal species can be bound as metal sulfides under appropriate redox conditions. If reducing conditions can be maintained these compounds can become buried and essentially immobile…Chemical precipitation reactions can be a primary removal mechanism for phosphorous.*"

Bioturbation, biological uptake, metabolism, mortality

The role and potential benefits of biological processes in stormwater treatment are also well reported (Mays, 2001; ARC, 2009). Processes such as the mixing of sediments by earthworms or marine species such as crabs (bioturbation) can assist with sediment mixing and biological and chemical processes (refer to Figure 6.2.1).

Mechanisms such as algal or plant uptake are more widely recognised. Where biological uptake is involved (whether by a plant or animal), this will vary over the life cycle of the organism and typically only be of benefit where materials are removed from the system over time, either by 'harvesting' (the collection of dead plant growth) or the migration of animals through the system. This is where strategies such as the collection of grass after the mowing of swales or plant choice are important.

Species such as Raupo, which die off en masse during the year, are generally considered to be inappropriate (at least as the primary species) within stormwater treatment devices. This mass die off will release nutrients and other contaminants during this period as well has give rise to other effects such as reduced oxygen levels. Whilst the removal of plants or dead material would not occur in a natural system, it is important to manage SQIDs for what they are, a stormwater treatment device, even if they do include natural systems.

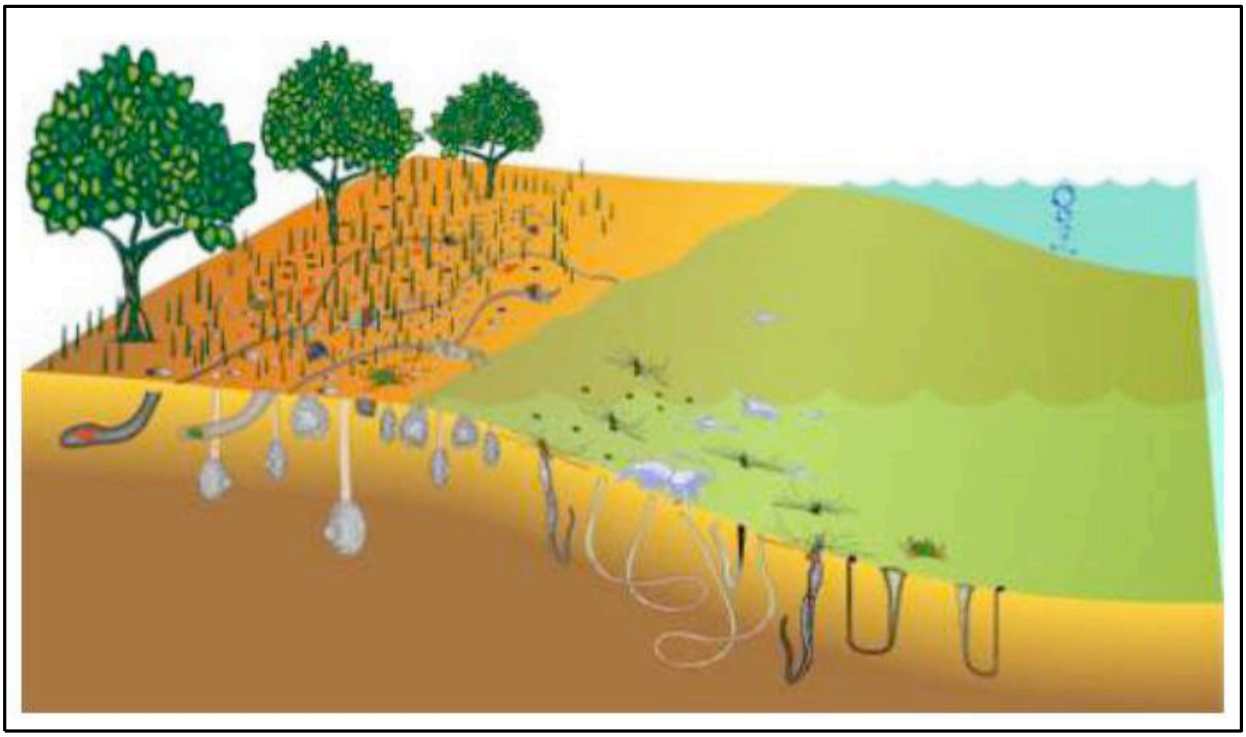

Figure 6.2.1: Biological, chemical, and physical processes arising from the burrowing and feeding of animals
Source: ARC, 2009a.

Bacteria can also play an important role in contaminant reduction. Aerobic bacteria can assist in reducing BOD and suspended solids, oxidise ammonia to form nitrites, and nitrites to form nitrates, and absorb phosphorous. Anaerobic bacteria can convert nitrate to nitrogen gas, thereby denitrifying a system (Mays, 2001; NZTA, 2009). Anaerobic conditions within a SQID may not be optimal in many instances, as this can lower pH and mobilise other contaminants, such as heavy metals. However, in environments where nutrients are the primary contaminant of environmental concern, the establishment of an anaerobic zone may be appropriate.

Photodegradation

The process of solar radiation breaking down chemicals can affect a wide range of contaminants; from hydrocarbons through to plastics in litter. Whilst some investigations have been carried out in relation to stormwater (Pitt et al., 1995; Burton and Pitt, 2001) photodegradation is more often used in wastewater treatment processes. As such, photodegradation tends to be a passive ‘benefit’ derived from open treatment systems, such as ponds, rather than an active treatment method per se.