ON-SITE DISPOSAL : CATCHMENT MANAGEMENT AND PUBLIC HEALTH ISSUES

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Abstract

Disposing of wastewater on-site, requires the operator to have a working knowledge of the basic principles of catchment management. This includes an understanding of natural attenuation and facilitated bioattenuation of contaminated sites such as those used for the on-site disposal of wastewater. There is also a need for an appreciation of the microbiology of wastewater, coupled with an elementary understanding of the sources and fates of the chemicals which pervade our everyday existence. This paper briefly reviews the distribution and fate of microbes in wastewater, their potential impact on catchments, the microbiological processes and health risks associated with on-site disposal.

Key Words

bioattenuation, biogeochemical cycle, catchment management, denitrifying bacteria, pathogens, xenobiotics.

1 Introduction

The purpose of this presentation is to provide a brief overview of the main principles and practices which are the underlying fabric to maintaining good environmental and public health within a catchment. Catchment management principles should be considered in the design and management of on-site systems. A Total Catchment Management (TCM) approach allows for the holistic management of human development because it encapsulates the water cycle within a defined biogeographical region in which biogeochemical cycles occur, thus allowing us to view human settlement, and the on-site disposal of human waste as an integral part of nature. Within a catchment one can identify biogeochemical cycles and define a number of chemical and biological principles which are intimately related to the water cycle.

2 Public Health

The water cycle is an integral part of human inhabitance. Therefore, in harvesting water from the environment for human settlement and disposing of wastewaters into the environment, the first priority is to protect human health. All other priorities and efforts must be directed towards sustainable development.

The wastewater stream generated by humans must be treated to a level suitable to be re-released into the environment. The water supply and disposal industries are regulated by government standards and guidelines to minimise pollution and its impacts on public health.

In relation to on-site disposal it would be unwise to approve any form of **surface** disposal of wastewater in areas where it is known that waterborne illness is endemic. Care must also be exercised in approving new on-site treatment systems where elderly or frail people will live on the site. Added care must be taken where cystic fibrosis sufferers or young children are at risk of exposure.

3 Water Supply

Residents are usually rated on water supply and treatment. Water supply authorities have become corporatised and are responsible for supplying quality potable water. Water for on-site treatment is often collected on the site (eg groundwater, rainwater) before being released back into the environment. Groundwater for household use is increasing as are the risks associated with its contamination as population density increases in rural areas.

A reticulated water supply with on-site disposal, will lead to hydraulic problems if treated on-site, unless the water usage is regulated and pressure minimised. Hydraulic problems lead to the problems of failing systems due to "carry over" of solids into the disposal field and wet areas or "soaks" which result from an inability of the disposal field to absorb or transpire the volume of water being disposed. These problems represent a point source of pollution which are covered by legislation enacted by the Environmental Protection Authority (EPA) and local council authorities. Conflicts over water pollution caused by on-site disposal failure will arise and may have to be resolved through litigation. Situations where hydraulic problems are the cause and exist due to high water pressure, can be regulated by the water supply authority or by the owners of on-site systems installing their own pressure regulating valves on their water supply. On-site systems will perform best when pressure and flow are regulated.

4 Microbiology Of Wastewater

4.1 Microbes and disease

Microbes (ie bacteria, fungi, virus and protozoa) are endemic in our environment. The vast majority of these organisms are harmless to humans and helpful to the environment. A small percentage of microbes are pathogenic (disease causing) in man and other warm blooded animals.

When humans become infected with a pathogenic organism the body responds by activating the immune system to control the disease. Sometimes pathogen levels override the immune system causing an illness that requires drug treatment. During the course of the illness the body sheds live disease causing organisms into the environment. The more virulent organisms appear in human waste for several weeks following infection. Typhoid is an example of a condition where a human becomes a **carrier** of the pathogenic microbe which is continually shed into the surrounding environment. A carrier status occurs with other illnesses such as hepatitis A, some protozoan illnesses (eg giardiasis and cryptosporidosis), nematode and fluke related disease. At any one time approximately 1-2% of the population are secreting infectious organisms in their waste stream and into the greater environment.

4.2 Health concerns regarding surface disposal of wastewater

1. Aerosolization and direct human exposure from sprinkler systems.

2. Contamination of subsurface waters by leaching and surface waters through run-off.

3. Adherence to foliage, fruits and roots of crops for consumption.

4. Infection of grazing animals.

5 The long survival time of some pathogens (up to a few years) eg., nematode eggs in shallow soils.

4.3 Pathogens in wastewater

An understanding of the presence of pathogens in wastewater streams is important because of the risks they pose to public health. Municipal wastes and wastewater, farm animal wastes, some

industrial wastes (eg meat packing and poultry processing) all possess organisms capable of causing disease or opportunistic infection in man.
The degree of risk is dependant upon the nature of the wastewater stream, its treatment, the infectious dose of any pathogen present and the human hosts' ability to fend off the organism via serological and non specific defences.

4.3.1 Virus

The dominant virus associated with wastewater is hepatitis A which is usually referred to as infectious hepatitis. It can cause widespread illness in epidemic proportions. It is associated with eating shellfish but exposure to contaminated water can also transmit the disease.

There are also numerous gastroenteric viruses which cause illness.

4.3.2 Bacteria

Bacteria are an integral part of the wastewater treatment processes.

There are many infectious bacteria which transmit disease amongst humans. Some of these are pathogenic and many are closely related to human commensal bacteria. Exposure to infectious doses of disease causing bacteria in wastewater can lead to severe debilitation and death in susceptible individuals, particularly the immunocompromised , young and elderly.

Typhoid and cholera are the main bacterial diseases which are spread through direct contact with waste or with poorly treated wastewater and these organisms can, because of the low infective dose needed to cause serious disease, generate epidemics which are difficult to control. The most common disease associated with faecal contaminated wastewater is bacillary dysentery. This disease is rapidly spread via the faeces, flies, fingers food and fomite associations.

There are, however, other bacteria in the environment which are beneficial to the wastewater treatment process. The denitrifying bacteria, for example, are involved in a critical part of the nitrogen cycle, which is the return of nitrogen back to the atmosphere.

4.3.3 Protozoa.

Parasitic diseases of humans caused by more complex organisms, such as protozoa often have a zoonose existence meaning they can complete their life cycle in other animal hosts including pets, wild animals and farmed animals. There are two dominant protozoan parasites of concern in the on-site treatment of wastewater:

Cryptosporidium is a zoonose, infecting a wide range of animals including humans. *Cryptosporidium parvum* can cause chronic illness. Part of the life cycle is completed as an intracellular cyst which leads to an inflammation of the bowel lining causing a loss of water and electrolytes into the bowel, leading to illness and a watery diarrhoea. The immunocompromised, young and elderly are at risk. There is a high morbidity in infected individuals. Cryptosporidium is known to contaminate relatively clean water and the oocysts can survive chlorination.

Giardia is a zoonose and the organism is common in warm and or wet coastal environments. A number of species of giardia infect humans with one species, *Giardia lamblia* causing the most illness. *Giardia lamblia* is widespread and occurs commonly in rural areas. Like cryptosporidium, children and young animals are mainly affected with adults developing a certain immunity to the organism allowing a 'carrier' state to exist. This makes these organisms endemic in rural environments.

4.3.4 Nematodes and Helminths

Nematodes are a common parasitic infection in pets and native animals in rural areas. Several roundworms and helminths (flatworms) are endemic on the Australian mainland and are capable of infecting humans. The eggs from these organisms are robust and adapted for transmission through the

digestive system. The eggs can withstand chlorination and can remain viable in the soil for up to two years (Safton, 1993).
The relatively large number of human pathogenic and opportunistic micro-organisms transferred to humans through contact with contaminated wastewater, contaminated soils or foods, can be grouped according to their portal of entry. This includes the gastrointestinal tract, the skin, eyes, ears and the respiratory tract.

5. Mechanisms Of Pathogen Die-Off In Wastewater

The following processes are regarded as the main mechanisms for controlling pathogens:

1. Desiccation (ineffective against spore forming organisms and nematode eggs).
2. Exposure to sunlight (varies with depth of light penetration through water column).
3. Environmental (temperature, pH, toxins) and nutrient conditions may be unfavourable for survival.
4. Entrapment (mechanical straining/adsorption) in surface soils.
5. Predation by, or competition with other microorganisms in the natural environment (eg., secondary treatment, biofilters).

6. Management To Reduce Pathogen Hazard

The following principles apply to all domestic wastewater for on-site treatment. Particular attention must be given to the use of spray irrigation systems as the method of disinfection may be unreliable:

1. Pre-application treatment of wastes (stabilisation of waste).
2. Design sites to control runoff, erosion, and provide for buffer zones.
3. Restrictions on grazing of animals especially pets around disposal sites.
4. Avoid use of sprayed food crops for direct human consumption (fruits, vegetables, small grains).

Both humans and animals can pollute water with disease causing micro-organisms. The presence of organic matter in water will promote the growth of bacteria, whereas sanitising chemicals such as chlorine, bromine and ozone, as well as ultraviolet light, many chemical cleaning agents and antibiotics will destroy or inactivate the bacteria and other micro-organisms. Cleaning agents and antibiotics when present in the wastewater will have a marked impact on the distribution and abundance of both beneficial and pathogenic micro-organisms.

7. Chlorine

Chlorine or lime is often used to sanitise waste for protection from these pathogenic organisms. Chlorine can be ineffective against some human parasites, particularly *Cryptosporidium* and other cyst forming or egg laying parasites. Lime is sometimes used as an alternative sanitiser/ disinfectant, but to be effective, it is required in relatively large amounts.

Chlorine reacts with organic (carbon rich) molecules, many of which have been shown to be carcinogenic or mutagenic. In a domestic wastewater stream the chlorination process would create a myriad of chlorinated organics (xenobiotics). These chemicals are regarded as man-made or xenobiotic. Xenobiotics follow a variety of biogeochemical pathways in the environment though many are linked to the carbon cycle. Some chlorinated organics (eg., DDT, Chlordane, 2,4,5T and

Dioxins) are toxic and chemically very stable, they are also persistent in the environment and bioaccumulate in living tissue.
Humans are an integral part of the carbon cycle and the health risks due to exposure to chlorinated organics (as for example, would be derived from the widespread use of organochlorine insecticide) are present, but these risks are unknown. There may be links to high rates of cancer between chlorinated organics being dispersed into the environment in pesticides and through the chlorination of wastewater. This mechanism may be contributing to the significant high rates of cancers in the human population with unknown aetiology. An exposure to chlorinated wastewaters would increase the theoretical risks to health in a number of ways.

There is a problem with the widespread use of chlorine and other halogens, for disinfection, in on-site treatment, in terms of catchment management. The use of chlorine in aerated wastewater treatment systems (AWTS), increases the probability of the creation and dissemination of organochlorine molecules into the environment. This dispersal of chlorinated organic compounds into the environment is a cause for public concern.

8. Total Catchment Management (TCM)

In summary, wherever there is human settlement, there is the potential presence of pathogens in the wastewater stream. In the household, infectious illness can occur at any time. There are many chemicals, in addition to cleaning agents, entering the wastewater stream. Consumable commodities such as medications (prescribed and unprescribed) and consumed food (often imported from outside the catchment) contribute to the inevitable generation of a household wastewater stream which is rich in plant and microbial nutrients such as calcium, iron, phosphate and nitrate.

The hydrology of the area will determine the extent to which problems will arise. With poor flushing, such as in areas west of the Great Dividing Range, the problems become largely obvious (eg, severe algae blooms in the Darling River) and can result in economic devastation. These large inland catchments depend on a relatively smaller water budget and are reliant on irrigation from slow flowing rivers. Coastal areas tend to flush faster, more frequently and fare better because of the relatively short length of rivers and the higher average rainfalls, however, they are not without their problems. In coastal catchments, there are many more non flowing water bodies, such as farm dams and swamps. The relatively higher rainfall in coastal catchments attract a more intensive approach to farming and cropping techniques, carry larger herds of grazing animals (and sources for zoonose based pathogens) per hectare and are generally subject to greater fertiliser application rates.

Management of any site in terms of water pollution must reflect the principles of Total Catchment Management. Any on-site wastewater treatment method will contribute pathogens and opportunistic microbes as well as phosphate and nitrate to local waterways, unless the site is managed to reduce and **contain** these organisms and nutrients. The presence of water pollution due to plant nutrients will support the survival of some pathogens in the environment.

A site owner must be encouraged to adopt an active holistic plan of wastewater management take an active interest in the disposal of wastewater from the site. As part of a holistic wastewater treatment plan for on-site disposal, a thorough site inspection and soil analysis is required as prerequisite to the design and construction of a geotechnical disposal field. A biological treatment and wastewater management plan aimed at *insitu enhancement* (Lenzo, 1999) would include the application of bacterial cultures into the wastewater stream, such as denitrifying bacteria in addition to an awareness of those chemicals, such as antibiotics and cleaners detrimental to the performance of on-site wastewater disposal systems. Cyclic dosing of cultured denitrifying bacteria would boost the systems denitrifying capability. A holistic plan could include the application of inorganic chemicals, such as lime, which may assist rate limiting chemical processes. It would also include the adoption of the use of chemicals known to be low in phosphate as recently illustrated in a study conducted in Albury, by the Co-operative Research Centre for Freshwater Ecology (Morgan 1999).

9. Conclusion

Used and polluted upstream water becomes the water, for which others are reliant on for their livelihood and survival. Groundwater contamination through poorly designed on-site wastewater treatment systems is a major problem in all areas where on-site disposal is a common occurrence. By actively managing hydraulics, treatment and disposal of effluent on-site, there is the potential to create a scientifically aware and controlled wastewater disposal practise. This will lead to a well managed catchment with minimal surface water and groundwater contamination. If biological or chemical management does not occur, the uncontrolled release of nutrient and excess flows into the environment will increase the potential for the presence and spread of disease causing organisms.

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