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# Disease Vectors and SuDS

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A disease vector is a living organism that can transmit infection to a succession of hosts. Most disease vectors are insects, for example the mosquito which is responsible for causing the most human illnesses in the world. Intermediary animals often serve as a host or a reservoir for the pathogens, until susceptible humans are exposed, and then transmission can occur through these animals in their function as a vector.

Vector-borne diseases are prevalent in tropical and subtropical countries. The burden of these diseases is highest in tropical and subtropical areas and they disproportionately affect the poorest populations. Since 2014, major outbreaks of dengue, malaria, chikungunya, yellow fever and Zika have afflicted populations, claimed lives, and overwhelmed health systems in many countries. Other diseases such as Chikungunya, leishmaniasis and lymphatic filariasis cause chronic suffering, life-long morbidity, disability, and occasional stigmatisation.

**Disease Vectors in the United Kingdom**
The UK has both native and non-native vectors that are distributed across the country. There are many different vectors capable of spreading disease, however ticks and mosquitoes are the vectors of most concern in the UK. The UK has 36 native mosquito species, and most do not transmit disease. However, some Culex mosquitoes can transmit disease within the UK.

For tick vectors, Ixodes Ricinus is the greatest public health concern for the UK, as it is the vector for the Borrelia bacteria that causes Lyme disease. This tick is found across the UK and can also act as a vector for tick-borne encephalitis (TBE). However, TBE is not currently present in the UK although it has been recorded in several European countries including Switzerland and the Netherlands.

The UK has a Tick Surveillance Scheme (2005), run by Public Health England (PHE), to record and provide information about native and non-native invasive tick species. PHE also run a mosquito reporting system and the public is also encouraged to submit mosquitoes for identification.

Vector establishment does not always mean spread of the diseases they can carry, as other factors such as vector biting behaviour, affects their capacity to transmit disease. Currently there are no mosquito-borne diseases of humans are circulating in the UK. Vector distribution is complex and affected by a variety of factors including globalisation and socio-economic factors. Climate change is also thought to be a main contributory factor.

**Breeding Grounds and Transmission**

Water acts as a breeding-site for many disease vectors (insects, sometimes copepods, snails) that play a key role in the spread of pathogens (viruses, protozoa, parasitic worms). This is due to bacteria thriving in moist and warm places. Water resources development projects (dams, irrigation schemes) in rural areas or open water collections in urban areas promote spread of vectors. The stagnation of water occurs when it is unable to flow or drain somewhere, when this occurs it becomes an extremely volatile breeding ground for some carriers of air and water borne diseases such as distinct species of mosquitoes.

As mosquitoes can breed in shallow water it is possible for almost any concaved surface that can collect/store water to be a risk of populating mosquitoes of any amount. This may include a bowl left out in the back garden to a poorly designed footway that pools in a low point without being drained somewhere.

The risk of water stagnation can occur in as little as 12 to 24 hours whereas bacteria can begin to form within the 48to 72 hour mark, later developing into a full colonisation of mould in under 2 weeks which is why it is so important to have a proper drainage system in place. Here in the UK, it is a lesser risk due to our current climate.

**Effect of UK Climate Change**

Currently there are differing opinions as to the effects of sustainable drainage features (open waters) and climate change on the spread of vectors. Vectors are usually geographically restricted, because of climate conditions, limiting diseases to certain countries or regions. Human-caused climate change has led to seasonal variations and increases in mean temperatures. This has led to consequent global changes in vector distributions. Although climate change will affect all vector travel, the extent as to which it does so is vector, host and disease dependent.

The effects of climate change are interlinked with globalisation, land use and socio-economic factors, distinguishing between these can prove challenging. In the UK invasive mosquito species have been identified by PHE that were previously restricted to warmer, more tropical environments. This is due to several factors, including increased international trade and travel.

As the climate changes in the UK, permanent invasive species populations are likely to become established, particularly mosquito species. Higher temperatures typically decrease the time it takes for mosquitoes to become infectious, potentially allowing more opportunities for transmission when feeding.

The current UK climate is already suitable for certain breeds of infectious mosquitoes, but further rises in temperature could increase the months and areas in which these mosquitoes can be active. Current models suggest a 1$^{o}$C average rise in mean temperature by 2030-2050 could lead to an approximate 1–2-week extension of adult mosquito activity in Southern England. According to PHE and models from the Met Office, other UK climate variables such as humidity and rainfall, will also change leading to altered water availability influencing mosquito breeding levels.

**Impact of Sustainable Drainage on Disease Vectors**

Sustainable drainage systems, by definition, are a contributing factor to the increase in disease vectors. The design strategy to retain water on a site and release it gradually invites standing and held water in certain areas. With the promotion of open green structures to convey and attenuate water, this further increases the potential for breeding grounds for disease vectors. It is critical that sustainable drainage design counters this by not producing more habitat for these creatures. But how can this be done without compromising on the sustainable approach to design?

The straightforward way to minimise disease vectors is to have all the water underground in conventional drainage systems and underground tanks. Although this is in direct contradiction to the approach to implement the four pillars of sustainable drainage design, that must consider amenity, water quality and biodiversity.

**Biodiversity**

At first glance, it appears there is a direct contradiction between increasing biodiversity and habitat through sustainable (green/blue) drainage infrastructure and the increase in disease vector breeding grounds. Control of human infectious disease has been promoted as a valuable ecosystem service arising from the conservation of biodiversity.

There are two commonly discussed mechanisms by which biodiversity gain could decrease rates of infectious disease in a landscape. Firstly, increase of competitors or predators could facilitate a decrease in the abundance of competent reservoir hosts. Secondly, biodiversity gain could disproportionately affect non-competent, or less competent reservoir hosts, which would otherwise interfere with pathogen transmission to human populations.

Biodiversity has little net effect on most human infectious diseases, but when it does have an effect observation and basic logic suggest that biodiversity will be more likely to increase than to decrease infectious disease risk.

**Vector Control Methods**
There are four main methods of vector control:

- **Habitat and environmental control:** Removing or reducing areas where vectors can easily breed can help limit their growth. For example, stagnant water removal, destruction of old tyres and cans which serve as mosquito breeding environments, and good management of used water can reduce areas of excessive vector incidence.

- **Reducing contact:** Limiting exposure to insects or animals that are known disease vectors can reduce infection risks significantly. For example bed nets, window screens on homes, or protective clothing can help reduce the likelihood of contact with vectors. To be effective this requires education and promotion of methods among the population to raise the awareness of vector threats.

- **Chemical control:** Insecticides, larvicides, rodenticides, Lethal Ovi traps and repellents can be used to control vectors. For example, larvicides can be used in mosquito breeding zones; insecticides can be applied to house walls or bed nets, and use of personal repellents can reduce incidence of insect bites and thus infection. The use of pesticides for vector control is promoted by the World Health Organization (WHO) and has proven to be highly effective.

- **Biological control:** The use of natural vector predators, such as bacterial toxins or botanical compounds, can help control vector populations.

Reducing contact is not achievable within the drainage design scope and chemical control is an unwanted solution if habitat is being promoted, so this indicates the best way to control vector populations on a site is through habitat and biological control.

**Sustainable Drainage Design Considerations**
The following design techniques have been considered within this article and may have a positive impact on the control of disease vectors though drainage design in a changing climate:

1. Removing stagnant water. Design drainage systems to ensure that there is either a natural water body or that any attenuation feature has a nominal flow to reduce the chance of stagnation.

2. Increase the blue/green corridor. The increased green vegetation on a site will help with urban cooling and prevent a heat island effect in densely populated areas. The addition of a green space could prevent temperatures from increasing to the point where they create a viable habitat for vectors.

3. Design with habitat and wildlife population in mind. Introducing species that predate vectors or their eggs, or to deliberately introduce a sterilising species can all be part of the planting and habitat design. For example, catfish are known to eat mosquito larvae and so the generation of an attenuation pond that acts as a habitat for catfish would be a boon for VBD control.
4. Design biodiversity correctly. Collaboration between the drainage design and the landscape / habitat design is more critical now than ever. The disciplines rarely cross each other but, with the emphasis on creating a suitable ecosystem on a site for potential climate change, this will come to the forefront of people's minds.

**Summary**

The potential for increase in disease vectors within the UK is something that is looming ever closer on the horizon. As good engineers, we are responsible for considering the habitat we create in our designs and whether this is beneficial for wildlife in general, but also if it promotes disease transmission. While it may be easier to introduce chemical or biological controls on a site-by-site basis, it is not a sustainable approach, and it is better to design out risk of potential disease spread as much as practical. There are simple solutions to drainage system design that can be implemented to reduce heat islands and to promote flowing water / reduce stagnation, which can all be considered by the designer as part of a sustainable strategy for the scheme.

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