The urban cooling effect of canals in cities shown to exceed 1 degree centigrade in summer

Canals, Cooling and Replicable Models - Summary Report to the Canal and River Trust

September, 2019, School of Environment, Education and Development, The University of Manchester

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Executive summary

This summary paper sets out an innovative approach to assessing the level of cooling offered by urban canals, prompted by a request from the late Professor Walter Menzies of the Canal and River Trust (CRT) to help prove the hypothesis that canals contributed to urban cooling, an area of increasing concern given climate change. The paper is based on research conducted by a team of researchers at The University of Manchester, working with the CRT and Cirkadia. towards developing a model of thermal cooling.

The model developed shows that there is likely to be a cooling effect between 0.3°C and 1.6°C within a 100 metre wide corridor of the canal during the hottest hours of the day (the variation is from differing orientations of the canals tested and the configuration of the surrounding buildings). The research provides a case study of the Rochdale Canal in Greater Manchester, followed up by verification tests in Birmingham and London. As well as demonstrating the positive impact canals can have on cooling urban areas, as the model shows how building height and distance from the canal can have an impact on this cooling.

The model also shows that whilst the canal can contribute to urban cooling when needed during warmer summer temperatures, the cooling effects during the colder winter periods are far less significant. The model provides a novel and valuable contribution to understanding the important role that blue infrastructure, such as canals, can play in cooling cities (with the caveat that further field verification is needed to fully test the model). The model was designed to be transferable and used with readily available data, to maximise its potential value for calculating the urban cooling potential of urban canals.

The team would like to extend a special thanks to the CRT for funding the University researchers to carry out the additional testing of the model at the London and Birmingham locations, the late Professor Walter Menzies for the inspiration for this project, David Baldaccchino of the Canal and River Trust for his input and to Dr. Olutayo Adebowale of Cirkadia for her role in project management between two research projects to help make the most of this innovation.

Introduction

Despite advances in architecture, planning and engineering, as well as notable efforts towards increasing the 'sustainability' of urban environments, cities continue to both contribute to, and be affected by, worldwide climate change (Stoper and Scott 2009). One of the major impacts of climate change is that of increasing temperatures, which have proven to be a challenge for many urban conurbations across the world (Revi *et al.,* 2014). Continuous urbanisation has meant that tackling the issue of urban heating has become increasingly pertinent. Dubbed the urban heat island (UHI) effect, many urban areas still suffer from the impacts of higher temperatures. Whilst cities have approached tackling the UHI in a variety of manners, including creating green spaces (Oliveria *et al.,* 2011), increasing tree canopy area (Design for London 2011), developing green walls (Alexandri and Jones 2008) and establishing cooling fountains (Nishimura *et al.,* 1998), these solutions can often be costly and/or only impact a small area.

Although there has been increased attention towards examining the role of urban water bodies in helping the cooling of cities, the lack of examination around canals meant that this prominent facet of urban infrastructure remained little understood. This research project identified that pre-existing research had yet to develop a coherent model that would allow the cooling potential of canals to be examined. The team set about creating the required model, making it adaptable and transferable, using available data, so that it can be used in other locations (McDonald *et al,* 2016). The research project initially tested the model for the Rochdale Canal in Manchester, before later adapting and verifying this through testing in canals in Birmingham and London. A further research project developed code for a model to make the original work more accessible and accurate, based on readily available data (Taylor, 2018). The following sections describe the creation of the model, the research findings and what these mean for further consideration around canals.

The Model

The model utilises a mixture of physically based equations, verified empirical formulae and carefully considered assumptions and values to allow the calculation of the thermal effect of the canal and its constituents upon the surrounding environment. It considers different mechanisms for the canal gaining and losing heat energy, particularly, radiative, evaporative and conductive/convective, as shown in Fig 1 below.

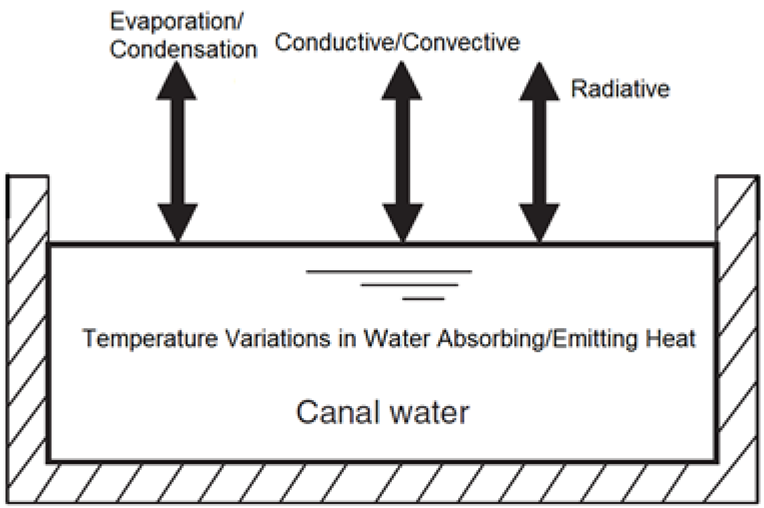

Figure 1: Heat Energy inputs and outputs from the canal (Adapted From Lu (2008))

The model utilises and combines the empirical formulae of others (PVEducation (2013; Webb (1997; Ennos 2011; Hathway & Sharples 2012; Umemiya 2007; Sugarwa 2009; Webb 1997; Lu 2008), whilst also bringing in additional relevant equations that had been overlooked by others. The inputs included various dimensions of the built environment and relevant spatial information such as hydrographic data, giving the canal dimensions, provided by the CRT, and surrounding building data, such as height and distance from canal. In addition, meteorological data was included from Weather Underground to establish what may constitute a 'typical day' in August (summer) and January (winter) and water temperature data was provided by the CRT. The data calculated from the model is initially in the form of heat energy given to or extracted from the air around the canal. This data is then converted to more tangible impacts, such as temperature changes in the surrounding urban area.

Results

1. Testing: Rochdale Canal

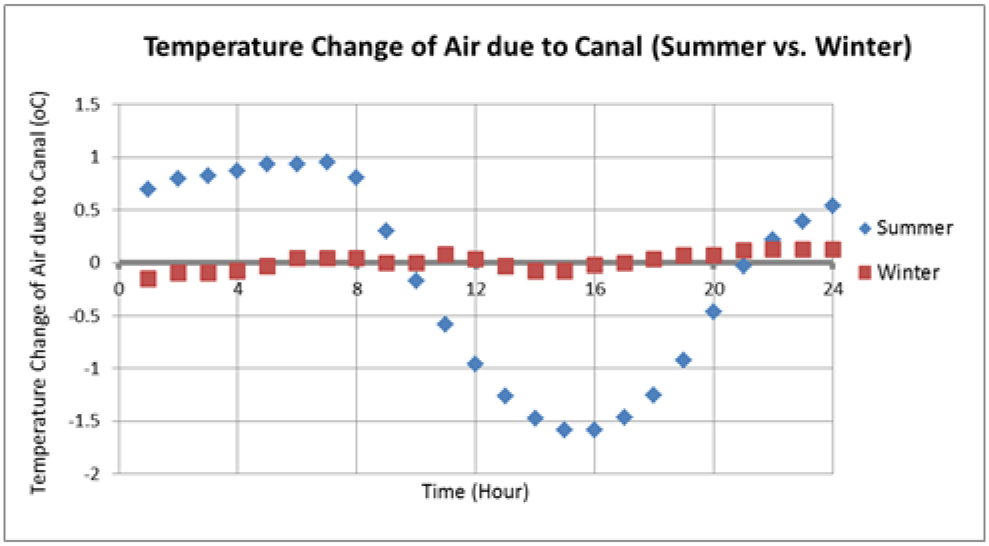

Figure 2: The Change of Air Temperature due to the canal in a 100m wide, 10m high area centred on the canal.

As Fig. 2 indicates, the temperature drop that the Rochdale Canal can offer for its immediate neighbourhood is around 1.6°C within a 100 m wide corridor during the hottest hours of the day, thus it can be strongly argued the canal is intrinsically a positive contributor to Manchester in terms of reducing peak temperature (note there may be an effect on a wider corridor, especially with breeze corridors, this width was chosen because it was more feasible to calculate cooling in this range). The model also shows that whilst the canal can contribute to urban cooling when needed during warmer summer temperatures, the cooling effects during the colder winter periods are far less significant.

2. Verification: London and Birmingham

The second component of the research required verification of the model by testing it at two additional sites in London and Birmingham. At each of these locations two sites were selected in order to allow examination regarding the impact of the surrounding built environment.

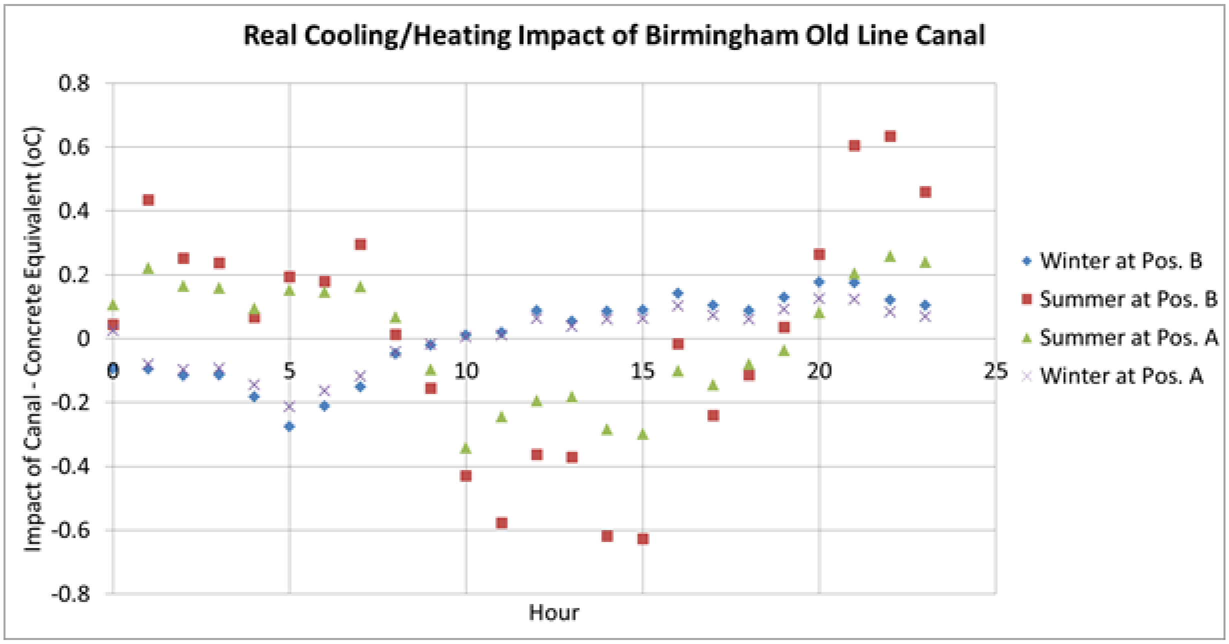

Figure 3. The Change of Air Temperature at two locations on Birmingham Old Line Canal

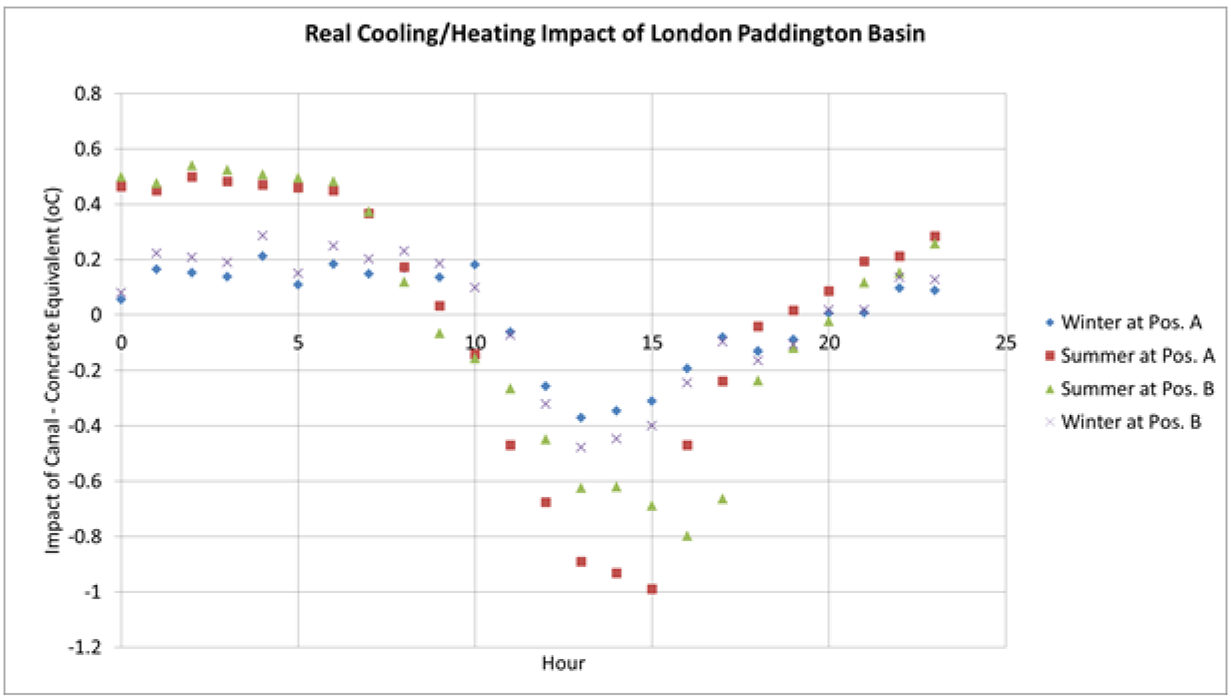

Figure 4. The Change of Air Temperature at two locations on London Paddington Basin

As Fig. 3 and Fig. 4 identify, for both London and Birmingham, the canals provide cooling to the local area. For Birmingham, whilst site A offered 0.3°C cooling impact during the hottest part of the day in summer, site B was around double at 0.6°C. Notably these occurred at different times of day (10am vs. 3pm); this is attributed to the differing orientations of the canals and the surrounding buildings, which alter the cooling potential. In both cases the buildings on the South side were large and close to the canal, which has a significant impact upon the cooling effect of the canals. Site B in particular has a significant contrast in building size and proximity to the canal on either bank; with larger, closer buildings on the South side and smaller, more distant buildings on the North side. It was found that by switching these cases (larger buildings on the North side and vice-versa) that an increase in cooling impact of 0.6°C was calculated.

For London, both locations presented similar maximum cooling of 1°C and 0.8°C, with slight differences in the time at which this occurred. This delay, as well as the maximum cooling potential, was largely as a result of the canal's orientation at each site, as this affects the time in direct sunlight which results in greater cooling potential for the surrounding vicinity. For all sites in London and Birmingham, the cooling effect was more significant in summer than winter and is only seen during the daytime, with a smaller heating effect observed during the night. In addition, at site B on the day considered during winter in Birmingham, from around 9am to midnight the canal was even able to provide a warming effect.

The code for the model has been made available online and open source, so that others can operationalise the model: https://github.com/jonnyhuck/canal-cooling. The next step for the team is to publish an academic paper describing the model in more detail. Our hope is that other researchers and practitioners in urban areas can use the model to assess the urban cooling of canals in their area, and can further verify the model. The model may also be useful for assessing the impact of different development decisions in relationship to the urban cooling.

Conclusion

The model identifies the positive contribution that canals make towards the cooling of cities, an issue that may have increasing significance in heat waves and with possible increased urban temperatures in coming years. In addition, the thermal model created by the research team and tested in three locations, identified similar patterns and noted the impact the building layout and canal orientation can have on canal's cooling potential. This suggests a fruitful area for further investigation into the implications for urban planning in terms of building relationship to the water bodies for urban thermal cooling.

The model created by the research team was verified and calibrated at three sites to test its suitability for examining a canal's cooling impact, with cooling of 1.6°C in Manchester, 0.3°C and 0.6°C in Birmingham and 0.8°C and 1.0°C in London. Although beyond the scope of this project to provide accurate models of energy savings, these cooling impacts will undoubtedly result in carbon dioxide (CO^2) savings, through reducing energy demand for neighbouring buildings. The urban cooling of canals thus has the potential to reduce further climate change. If up-to-date and suitable calculations were brought in, these cooling impacts could be equated to savings in both CO^2 per month / year and fuel savings per month / year. In addition, the research also identifies the impact of building layout on the cooling potential of canals, noting that for canals banked by buildings at close proximity; these can reduce their cooling potential.

A legacy of industrial infrastructure, canals now represent an attractive and highly prized component of cities across the world, especially in cities like Manchester, London and Birmingham. Whilst other forms of water bodies are beginning to be recognised for their cooling potential and in helping to tackle the UHI, canals had remained overlooked. This research provides an important first step in establishing an open and adaptable thermal model, that both demonstrates the value of canals in assisting with urban cooling and allows others to utilise and build on the model to improve its operation.

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