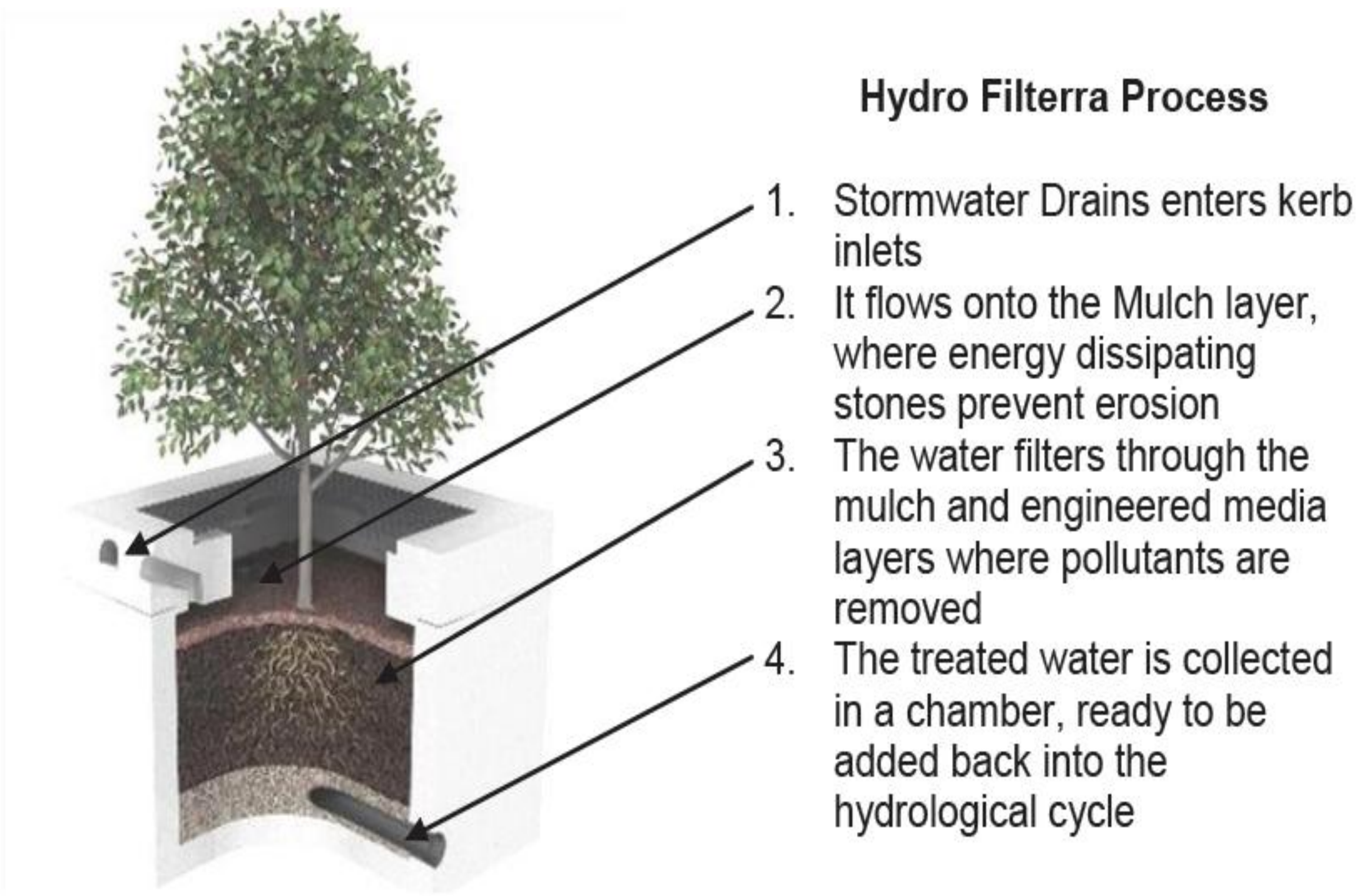
Investigating Stormwater Filters and Bioretention Systems

A Study on the *Hydro Filterra*™ System Manufactured by *Hydro International (UK)* - 4th Year MEng Project

1. Outline / Introduction

Stormwater management is an important aspect of controlling urban water systems. Increasingly restrictive legislation regarding water cleanliness and the growing focus on the environment in the wider culture, are driving factors for the design of such systems.

To purify wastewater, both large and small scale chemical and particulate pollutants need to be removed. It is possible to clean surface run-off using many small-scale biological and / or mechanical processes including bioretention units, at points of entry to the sewerage system. To this end, *Hydro International* has developed the *Hydro Filterra*™ bioretention system; an organic installation which treats stormwater runoff within urban environments. This type of system has been implemented at over 4000 sites in the USA and is currently being introduced to the UK market.



The following main deliverables required were identified through consultation with *Hydro International (UK)* and are listed below:

1. Develop current CFD approaches to characterise the filter media and verify these results experimentally

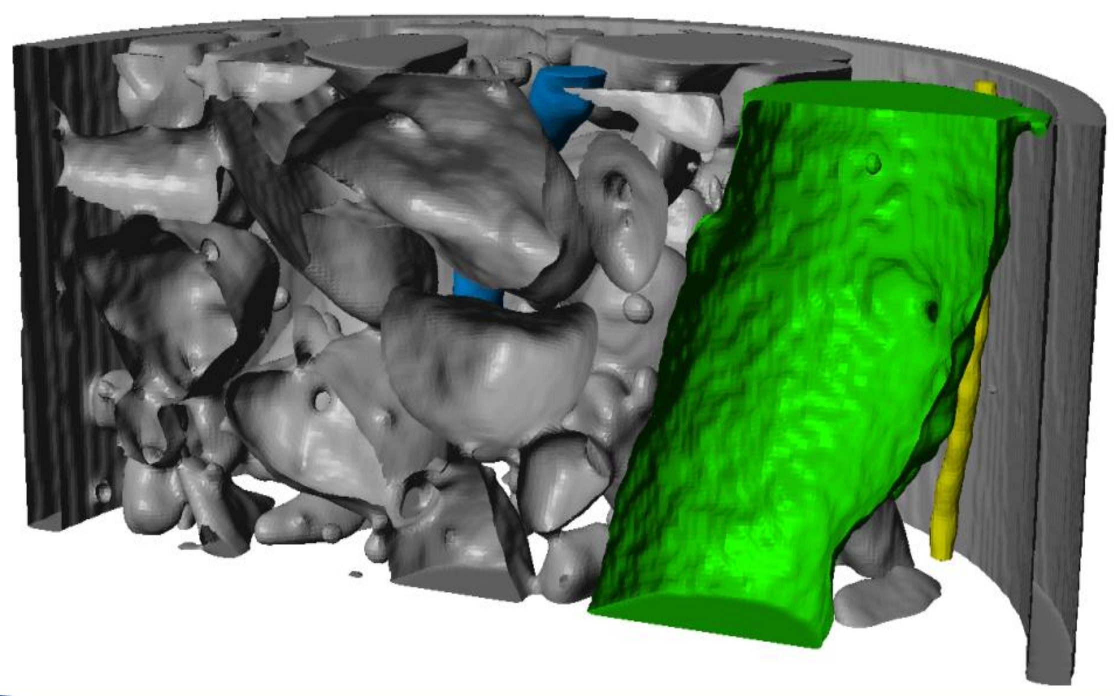
2. Develop a three dimensional model of the system; demonstrating interaction with the urban environment and outflow from the system including root effects

3. Analyse the current model in terms of the structural design of the chamber

4. Consider how the system interacts with the hydrological cycle on a larger scale

2. Experimental Analysis

A number of approaches were used in order to provide empirical data with which to verify the computational models. Micro-CT scanning was used to analyse samples of the filter media in order to determine their internal structure. These scans were used to create both Rapid Prototyping (RP) models for large-scale Reynolds-matched flow tests as well as computational meshes through the use of *ScanIP* software. An example of the result from the scan is given below. The image shows a soil sample included three root structures, identified in yellow, blue and green.

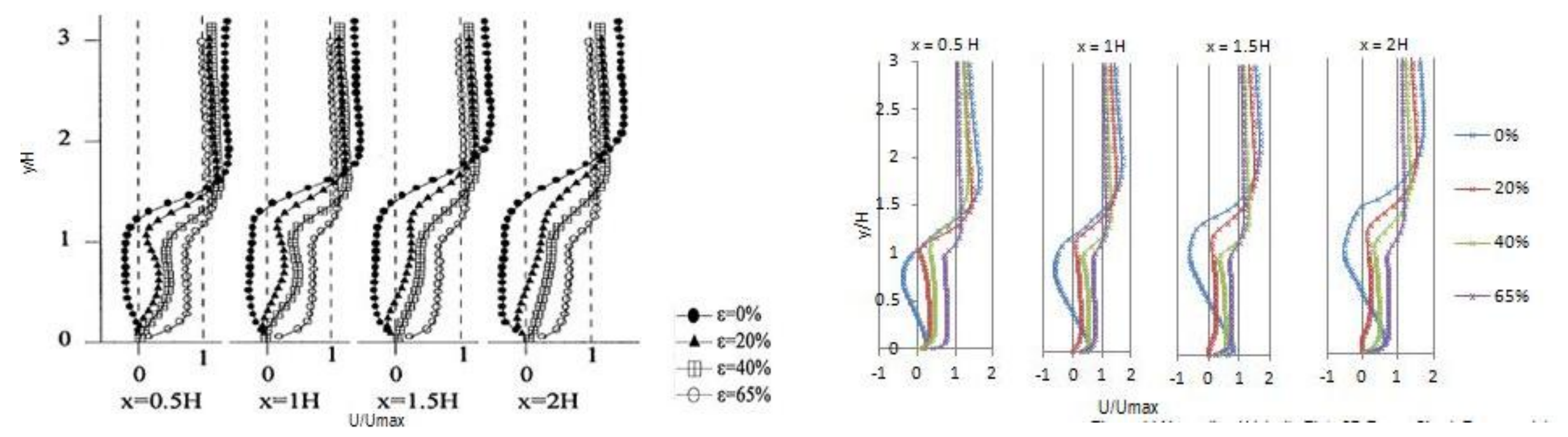


The hydraulic values of the media were determined experimentally through analysis of three different media samples and combinations. This was achieved through hydraulic conductivity flow tests using falling head measurements. The results were also to be compared with values from *Hydro International (UK)* and to those obtained through computational means by others.

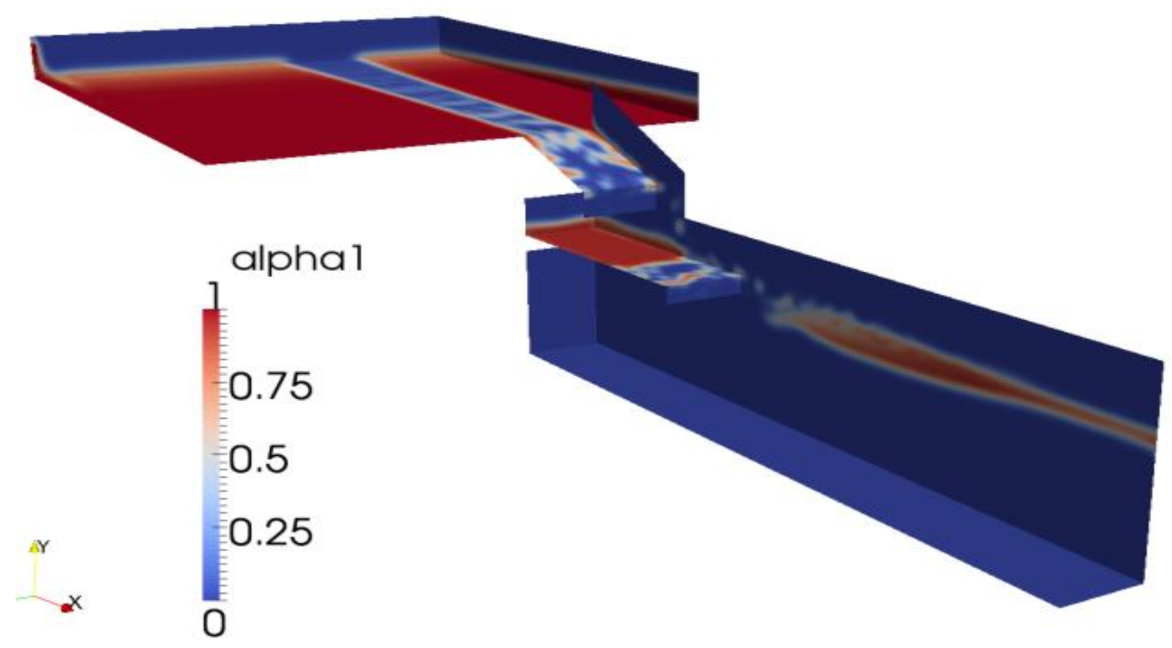
3. Computational Fluid Dynamics

The computational analysis was divided into four key areas: inlet conditions to the unit; the micro analysis of the fluid behaviour in the porous media; the influence of root structures on a porous media and the macro analysis and modelling of the porous media as a homogeneous porous zone. These factors were combined to create a full-scale 3D model of the case study *Hydro Filterra* system.

Use of the *OpenFOAM* code *porousInterFoam* was validated against the work of Lee and Kim with their experimentation of fluid flow around a porous fence. Values for fluid velocity were obtained using Particle Image Velocimetry. The validation can be seen in the figure below.



PorousInterFoam is a multiphase flow code which includes a *porousZones* dictionary,. Values for the porosity of a region can be assigned according to the Darcy-Forchheimer augmentation of the Navier-Stokes equation. These values are based on the average particle diameter and the volume fraction (the amount of empty space) in the sample. These values were achieved from the experimental analysis. In the *porousInterFoam* code, *Alpha1* field propagation can be used to determine spatially, the regions belonging to each phase of the fluid. In this case, 2 fluids were included (water and air). In the figure below Aapha1=0 (coloured blue) is the air phase and alpha1=1 (red) is water.



4. Summary & Conclusions

Through the use of the previously described computational and experimental analyses, it can be concluded that variation of the porous structure within the filter media greatly affects flow behaviour. Results also indicate that the porous filter media may not be modelled as a packed bed. In macro-scale analysis, homogeneous porous regions can be used to model the filter media since these are computationally cheaper, but its characteristics should be based on micro-structure analysis.

Optimisation of the chamber design has been achieved through FEA with a focus on the sustainability of the Hydro Filterra™, which itself has been shown to successfully regulate urban drainage in all but the highest storm surge conditions.

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