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Integration of grey water recycling with PGWS in residential building

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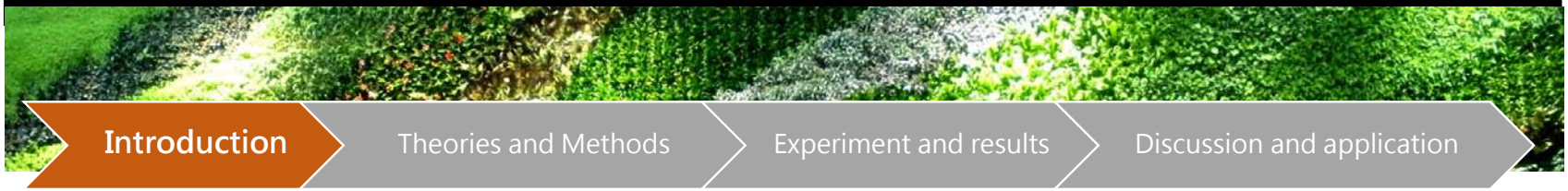


Under the severe environment of climate change and increasingly amount of global population, water as one of the necessary conditions for human living, will definitely become an important competitive resource between countries.

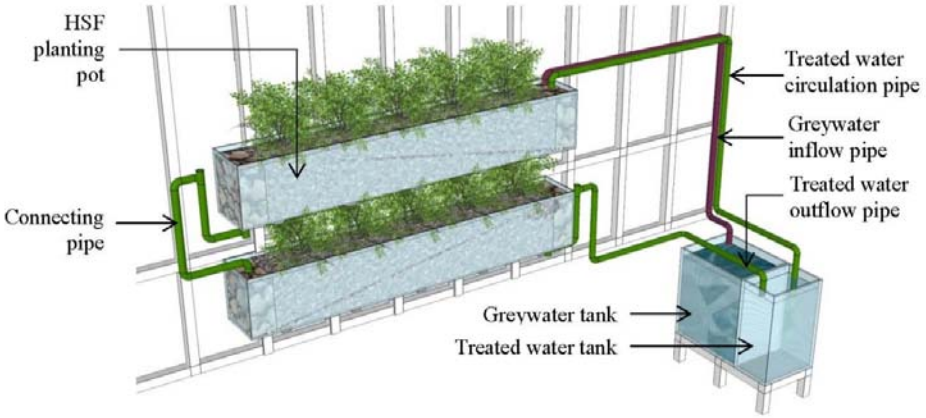
In high-density urban area, using the mode of reuse and on-site circulation is one of the effective strategies which can efficiently improve resource utilization.

The PGWS is a new pattern of ecological engineering used for both greening and water saving. This system can not only achieve the goal for on-site circulation of water reusing inside the building, but also result many aspects of benefit for high-density urban area such as air quality improvement, heat island reduction, landscape aesthetic enhancement, reduction of water resource consumption and cost-down of sewage treatment.

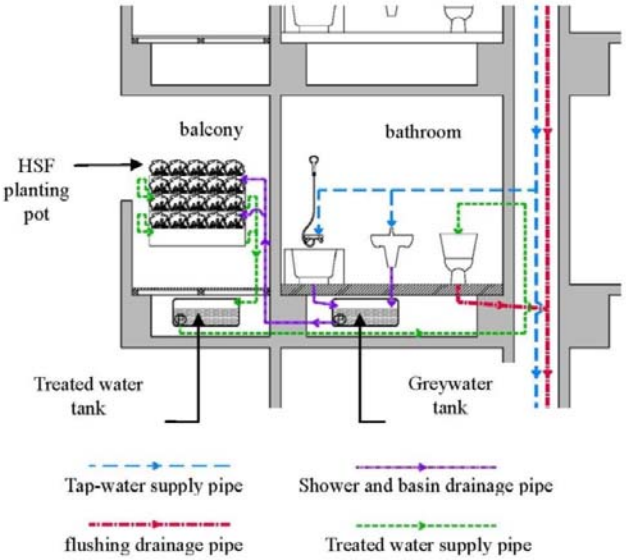
Purification green-wall system (PGWS) established by C.H. Yeh (2016)

On the other hand, in accordance with E.Friedler(2004),various kinds of domestic grey water result in different pollutants. Thus if we separate different grey water drainage according to its pollutants' composition as well as import relative treatment mechanism of PGWS, more multiple and flexible reuse program of domestic grey water shall be supplied.

A PGWS of two planting pots connected full of 18 liters each, under a model of 9 liters per hour inflow frequency, 4 hours HRT, could be a feasible system. It can treat 216 liters of less polluted grey water continuously each day.

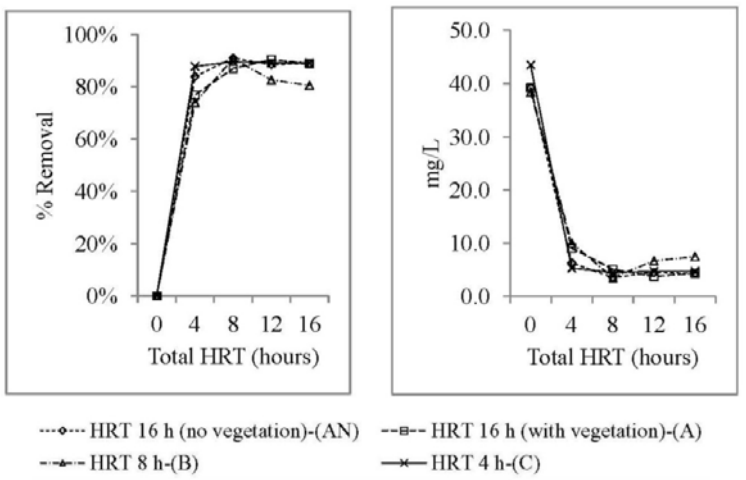


Purification green-wall system (PGWS)

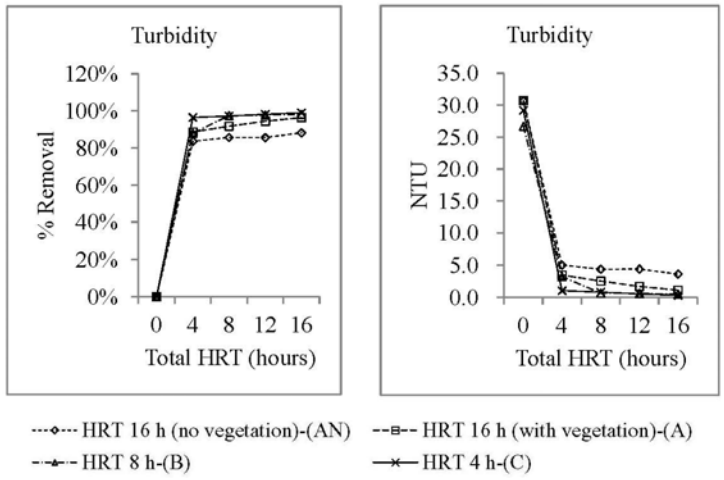


The water supply and drainage system of PGWS in apartment

According to the experimenting results, the removal efficiency of BOD_5 and turbidity both reached excellent degree at the fourth hour. Using the same equipment and testing methods, this study will observe the pollutant removal effect within 1-4 hours.



Variation of BOD_5,20℃

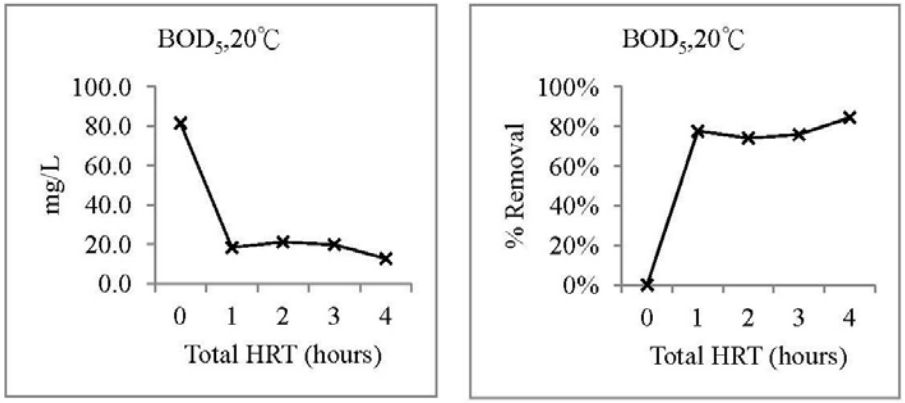


Variation of turbidity

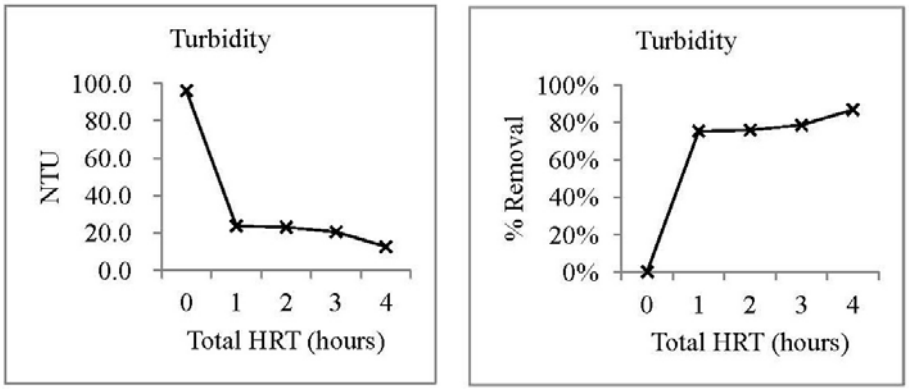
Experiments, sampling and water quality analysis are taken in May 2017. This experiments verified that a good effect of pollutant removal can also be held under a shortened HRT(1 hour) of PGWS. According to the result, PWGS with a 1/4 planting pots of the origin can also treat grey water recycled from daily shower and basin in a 4 people family efficiently. Meanwhile, a better effect of pollutant removal is shown with a longer HRT. Thus, if the purpose of reuse require higher standard of water quality, the HRT should be prolonged appropriately.

Results of lab analysis

HRT	Total Coliform (TC)		BOD_5,20℃		Turbidity		pH
	CFU/100mL	Removal%	mg/L	Removal%	NTU	Removal%	--
0 hr	2200000	0%	81.480	0%	96.10	0%	6.78
1 hr	250	99.99%	18.226	77.63%	23.70	75.34%	7.25
2 hr	13000	99.41%	21.042	74.18%	23.10	75.96%	7.57
3 hr	35000	98.41%	19.662	75.87%	20.50	78.67%	7.93
4 hr	40000	98.18%	12.591	84.55%	12.60	86.89%	7.80



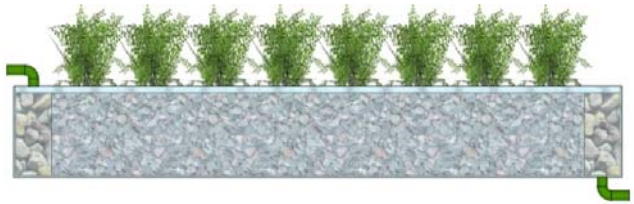
Variation of BOD_5,20℃



Variation of turbidity

Modularized PGWS

According to C.H. Yeh (2016), A PGWS with single planting pot of 150 cm in length, 20cm in width, 25cm in height, and 20cm height of full water level can accommodate 18 liters of water after placing substrate.

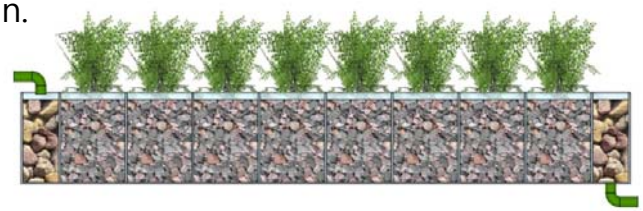


Prototype of PGWS

Considering the inconvenient replacement of substrate or planting as well as the total weight, the installation and placing of the pot cannot be done by a single person. Thus, in aspect of operation and maintenance, the purpose of a PGWS designed for a single family usage cannot be achieved. On the other hand, being a devise of treating individual grey water streams classified from domestic drainage, the PGWS need to have a satisfying flexibility of treatment mechanism, which is not provided in its original prototype. This study tries to add a flexible modularized system, easy for operating, into the prototype of PGWS. The installation steps are shown as below.

Modularized PGWS

1. The single planting pot is divided into 10 small units which 2 of them at both ends are in-flow and out-flow units and others are planting pot units. Each small unit are separated by permeable partition.



Dividing method of the single planting pot

2. Each small unit is a container made of non-woven fabric. By putting substrate mixed with ϕ5~10mm gravel and ceramsite into the in-flow and out-flow units, grey water is evenly distributed in the section of pot. Mixture of ϕ3~5mm perlite、ϕ5~10mm ceramsite and ϕ5~10mm vermiculite are placed in the planting pot units as growing base material for aquatic plants. Each unit can be planted 1-2 aquatic plants.

Small unit of the single planting pot

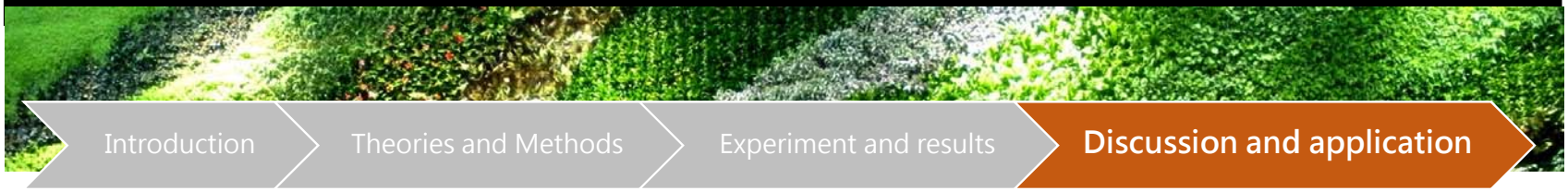
Modularized PGWS

3. Each planting pot unit can change the sort of substrate flexibly according to the grey water source and pollutant characteristics. Plant species can be determined by user likes.

Modularized planting pot

4. The number of planting pot unit is adjustable according to the space and the concentration of pollutant in grey water.

Flexible combination of the planting pot



Modularized PGWS

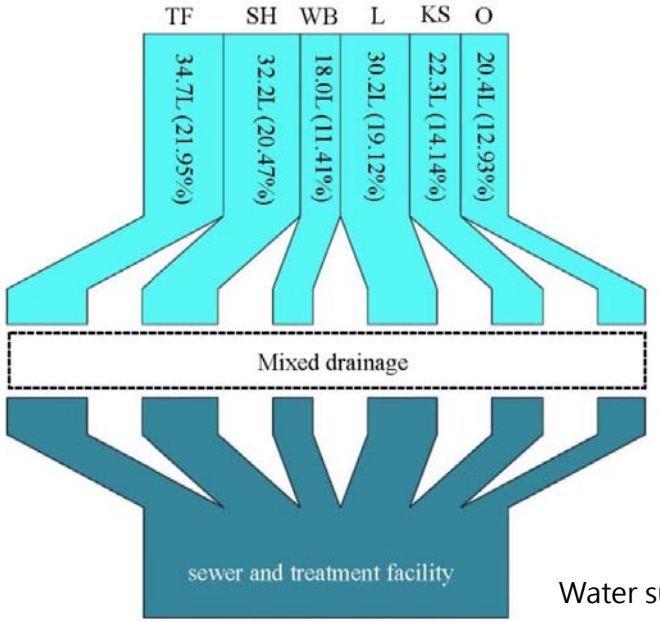
Besides the advantages on installation, operation, maintenance and individualization, the water treatment ability, which is the core characteristic of modularized PGWS, is provided with more flexible property for both source and amount of individual grey water streams.

According to the result of experiments, modularized PGWS with only 4 planting pot units added between the in-flow and out-flow units could be a feasible devise which can supply an adequate amount of reused water for flushing in a 4 person family.

Despite of space restriction on newly-built or existing buildings and different individual domestic grey water streams, the modularized PGWS is applied to all kinds of urban building as well as supplies a more convenient water reuse system of on-site circulation.

individual grey water streams in residential building

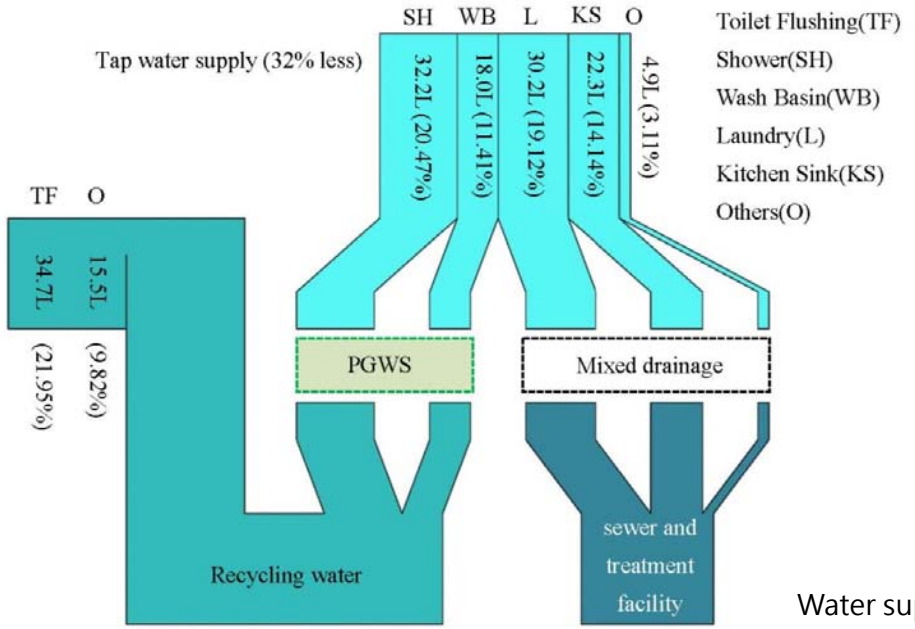
According to the reports from Water Resource Agency, Minister of Economic Affairs of Taiwan, the average tap-water consumption of housing is 157.8 liters per person per day, 19.12% of which is laundry, 20.47% of which is shower, 11.41% of which is basin, 21.95% of which is flushing, 14.14% of which is kitchen, and the remaining 12.93% is for other use.



Toilet Flushing(TF)
Shower(SH)
Wash Basin(WB)
Laundry(L)
Kitchen Sink(KS)
Others(O)

Water supply and drainage of traditional system

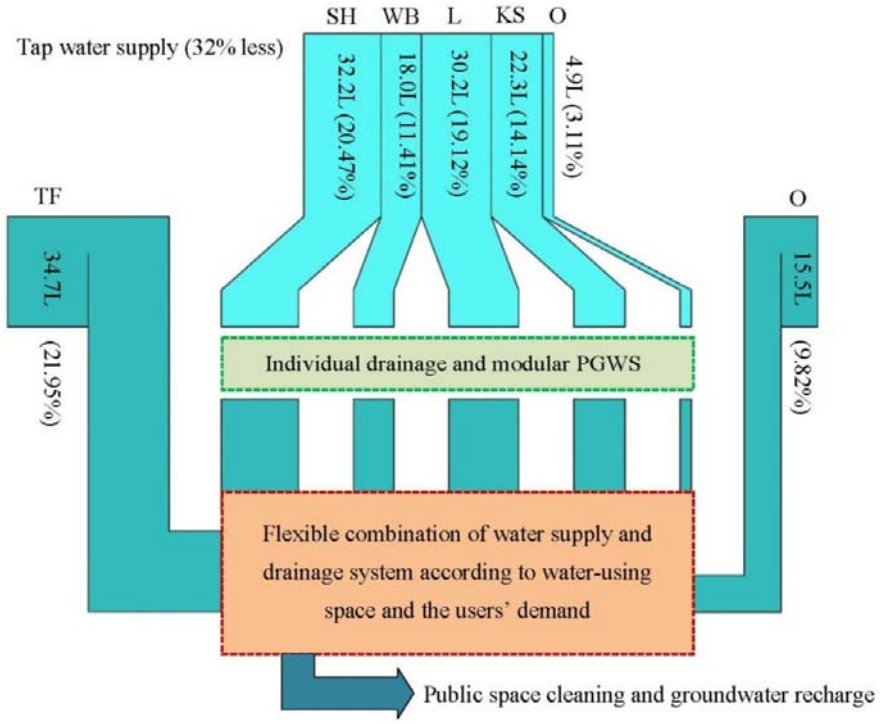
individual grey water streams in residential building



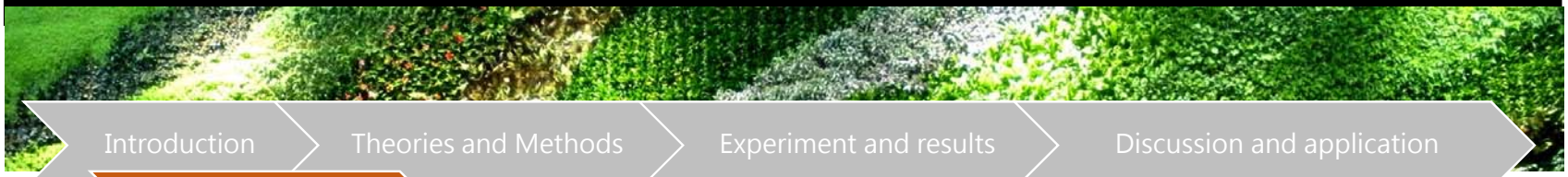
Water supply and drainage of PGWS

individual grey water streams in residential building

Treating individual domestic grey water can supply not only for the flushing and landscape irrigation which is a 32% saving of tap water supply, but also a daily production of about 57 liter per family which can replace the water consumption of street cleaning and sidewalk plant irrigation if we separate and treat all kinds of domestic grey water.



Water supply and drainage of modular PGWS

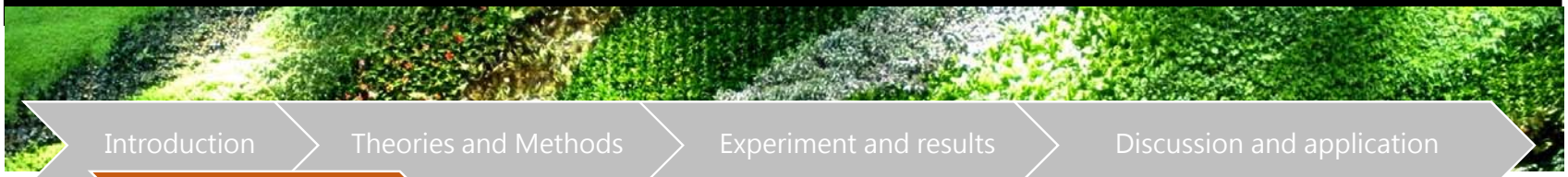


Conclusion

- This experiments verified that a good effect of pollutant removal can be held under a shortened HRT(1 hour) of PGWS. According to the result, PWGS with a 1/4 planting pots of the origin can also treat grey water recycled from daily shower and basin in a 4 people family efficiently.

- A better effect of pollutant removal is shown with a longer HRT. Thus, if the purpose of reuse require higher standard of water quality, the HRT should be prolonged appropriately.

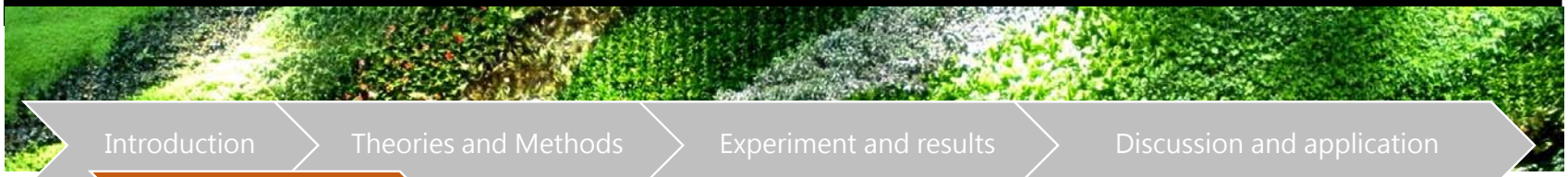
- Adding the concept of modularization to the prototype of PGWS, a system with more flexible property for source and amount of individual grey water streams can thus be developed. The convenience and individualization on its operation and maintenance are helpful for the application and promotion of the system.



Conclusion

- The concept of separating treatment of domestic grey water can exert the advantage of modularized PGWS. This system can supply not only for the demand of individual domestic reused water but also a large amount of recycled water for the public water use in urban area.

- This study will continue observing the efficiency of modularized PGWS in a following long term as well as the grey water treatment capacity affected by all kinds of system variables. Moreover, the combination of system and individual treatment of domestic grey water is also a main exploring area afterwards.



References

1. E.Friedler · 2004 · Quality of Individual Domestic Greywater Streams and its Implication for On-Site Treatment and Reuse Possibilities · Environmental technology · Vol. 25 · pp997~1008.
2. C.H. Yeh · 2016 · Application of Green Wall in Domestic Greywater Recycling · Master Thesis · National Taiwan University of Science and Technology。
3. C.L.Cheng., C.H. Yeh., J.J Peng., H.P. Lin. · 2016 · Green wall applying to the grey water recycling in residential building · 42th International Symposium of CIB W062 on Water Supply and Drainage for Buildings.

Thank You !