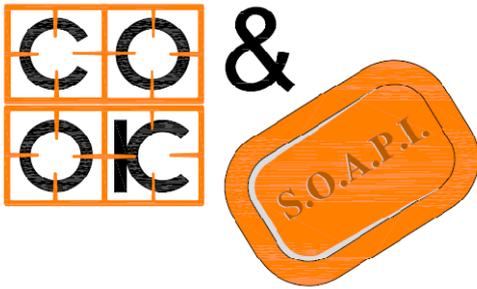


## 1.) Elevator pitch

*Cook & SOAPI*® provides the rural areas of India with a custom made sanitation system. We have designed a modular and expandable system which fits both individual and communal needs. The system is based around the principles of *Cradle to Cradle*. We do this by using cardboard building material; rainwater harvesting; a separated sanitation system; producing biogas from faeces for cooking; and use of nutrients of urine for growing crops. *Cook & SOAPI*® provides an integrated concept that meets the need for sanitation of all people (SOAP) in rural India.



## 2.) Key expectations

- **Adaptable to local conditions in rural area**

The *Cook & SOAPI*® approach is designed as a flexible system. Due to the modular concept the system can be build as a single household solution or expanded as a community facility. Considering variable population density the system can be easily up or down scaled to the amount of people living in a certain area. Depending on the local weather conditions the system can be adjusted to the amount of rain, sunlight and wind available in the region. As waste products can be reused within the direct environment *Cook & SOAPI*® is providing a closed system.

- **Cheap and easy to implement**

As the *Cook & SOAPI*® design is making use of local materials and can be produced in India itself costs are considerably low. Thanks to the modular design the system can be produced in mass production which will decrease the production costs per single unit. Due to the possibility of flat packing transport costs can be reduced. *Cook & SOAPI*® is designed in a way that the basic model is easy to install and operate.

- **The design should be appealing to end users and should have aesthetic appeal**

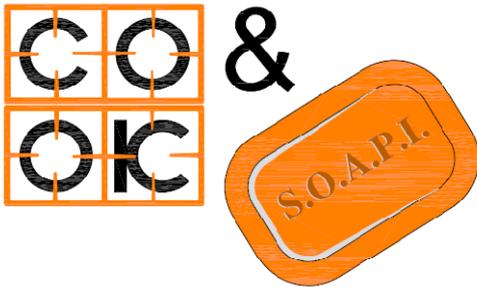
*Cook & SOAPI*® is delivering an innovative and integrated concept. The system is easy in use and maintenance. Waste produced by the system will be directly transformed into benefits like cooking gas and nutrients for agriculture. Everybody will be able to decorate the walls of the structure to their individual or communal taste. The *Cook & SOAPI*® has been designed with a squat toilet in order to fit the local culture.

- **Materials used should be locally available unless there are good reasons**

The cardboard panels constructing the walls of the *Cook & SOAPI*® system can be produced by local factories. The panels will be water proof due to an innovative technology using a phosphor ceramic coating. The toilet of the system can be made of locally produced ceramic. The buckets to collect the faeces and urine are made of large PTFE bags. Although being cost friendly, lightweight, and simple the materials provide a reliable and sustainable construction.

- **Design should be scalable to produce in big numbers**

The modular design is especially suited for standardization and therefore for mass production.



### 3) Our solution

The *Cook & SOAPI*<sup>®</sup> concept is an integrated sanitary solution. By using a modular based design the facility can be altered or expanded easily to the needs of the users. The basic model is a sustainable solution that provides in the basic needs for sanitation in the rural areas of India. This basic sanitation design can be improved or expanded with addition modules. These additional modules add capacity (e.g. number of toilets) or functions to the sanitary system. Hence, the basic model can be turned into a luxury model if there is a need and possibility to do so.

Within this chapter we explain our integrated design from both a development and a technical perspective. From the development perspective we show the advantages of our design based on the livelihood principles. In the technical perspective we explain our design based on the modular parts. First the building, second the sanitary system and third the additional functions.

#### 3.1 *Cook & SOAPI*<sup>®</sup> in development

##### Social capital

The *Cook & SOAPI*<sup>®</sup> sanitary system is designed to meet the needs of individual households, groups and even entire communities. Our basic model is designed for one household, but this basic model can easily be adapted to serve more than one household. The best fitting alternative can be installed depending on local conditions, investment options and social standards.

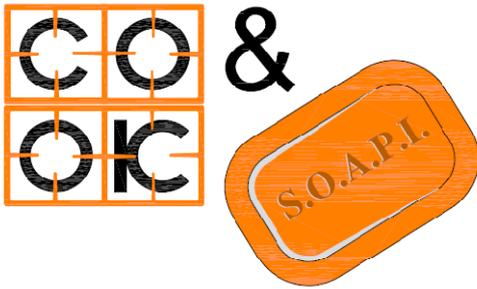
*In the case of a community service attention should be paid to the community responsibility for the facility. We recognize the risk of neglect of maintenance of the facility if nobody feels responsible. A possible solution is creating a small business model for the community *Cook & SOAPI*<sup>®</sup> sanitary facility. One or more genitors could be made responsible for cleaning and maintaining. A measure like this should be supported by the community. The families could pay a small (weekly) fee for the service from which the genitors are paid and the system is cleaned and maintained.*

*The community sized *Cook & SOAPI*<sup>®</sup> sanitary system does give the advantages of economy of scale for the production of biogas and fertilizers.*

##### Human capital

Sanitation systems improve the general health conditions of families. Better health because of increased hygiene, increases people's ability to work, learns and generate income. The *Cook & SOAPI*<sup>®</sup> design is accessible for many people as it is easy to build and operate.

When buying the *Cook & SOAPI*<sup>®</sup> sanitary system people will receive an instruction on how to ensemble and operate it in text and pictures. It is our vision that everybody should be able to attain and maintain this system whether a person is literate or not.



### Financial capital

Positive influence on health has direct consequences for the ability of people to generate income. Hence, the investment in a sanitary system is one with benefits. Households possibly see a reduction of investments in fertilisers by using the output of the sanitary system (or increase crop yields where fertilisers were not used before).

The building materials used in the concept are relatively cheap to buy and easy to transport. An estimation of the costs of the construction is given in the following table.

Cardboard (€ 10/m <sup>2</sup> )	Rs 600 / m <sup>2</sup>	50 m <sup>2</sup>	Rs 30,000
Coating			Rs 4,000
Concrete			Rs 6,000
Sanitation unit (UDDT)			Rs 8,000
Biogas + urine unit			Rs 10,000
<b>Total</b>			<b>Rs 58,000</b>

(Rate: € 1 = 60 Rs)

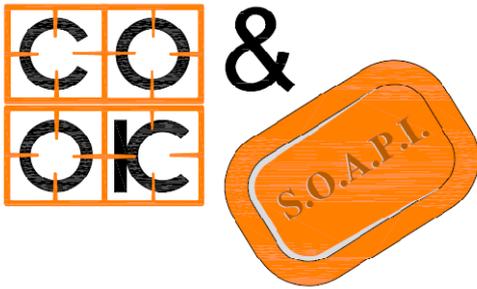
### Natural capital

Our integrated sanitation system offers possibilities to improve the accessibility of natural resources like rainwater and fertilizers. The *Cook & SOAPI*<sup>®</sup> concept is designed to collect rainwater. The rainwater is collected in a water tank that is positioned above ground level. The rain water can be used for multiple purposes, like flushing, cleaning and cooking. Depending on the climate the water tank can differ in size.

Urine will be collected separately and can easily be turned into fertilizers for agriculture. The urine can be either used untreated or by adding magnesium in order to create struvite. Using this natural fertilizer leads to less degradation of the soil.

We have chosen to use materials that are durable and recyclable. There is no use of wood in the construction to prevent unauthorised chopping of wood (if it is available) which leads to degradation of the soil and increases erosion. On top of that, the production of biogas from faeces can reduce the use of wood as a primary fuel to cook on.

Our design is adaptable to different natural conditions. The *Cook & SOAPI*<sup>®</sup> sanitary system stimulates better use of natural resources such as water, sun and wind.



### Physical capital

The physical capital is the basic infrastructure that is locally available. Our design is easily adaptable to the local infrastructure, e.g. availability and accessibility of water and/or power.

The accessibility of local areas by road influences the access to building materials for the *Cook & SOAPi*<sup>®</sup> sanitary system. In our design we have chosen to use materials that are either locally available or easy to transport. Important design choices have been made from a sustainable and transport view. The latter is incorporated in our flat packing solution, hence the choice for cardboard building materials.

### Conclusion

The entire *Cook & SOAPi*<sup>®</sup> sanitary system can be adapted if the local conditions change. Development in households and/or regions can lead to additional needs and increased access to assets. The basic model has been designed with options for extra functions or more capacity.

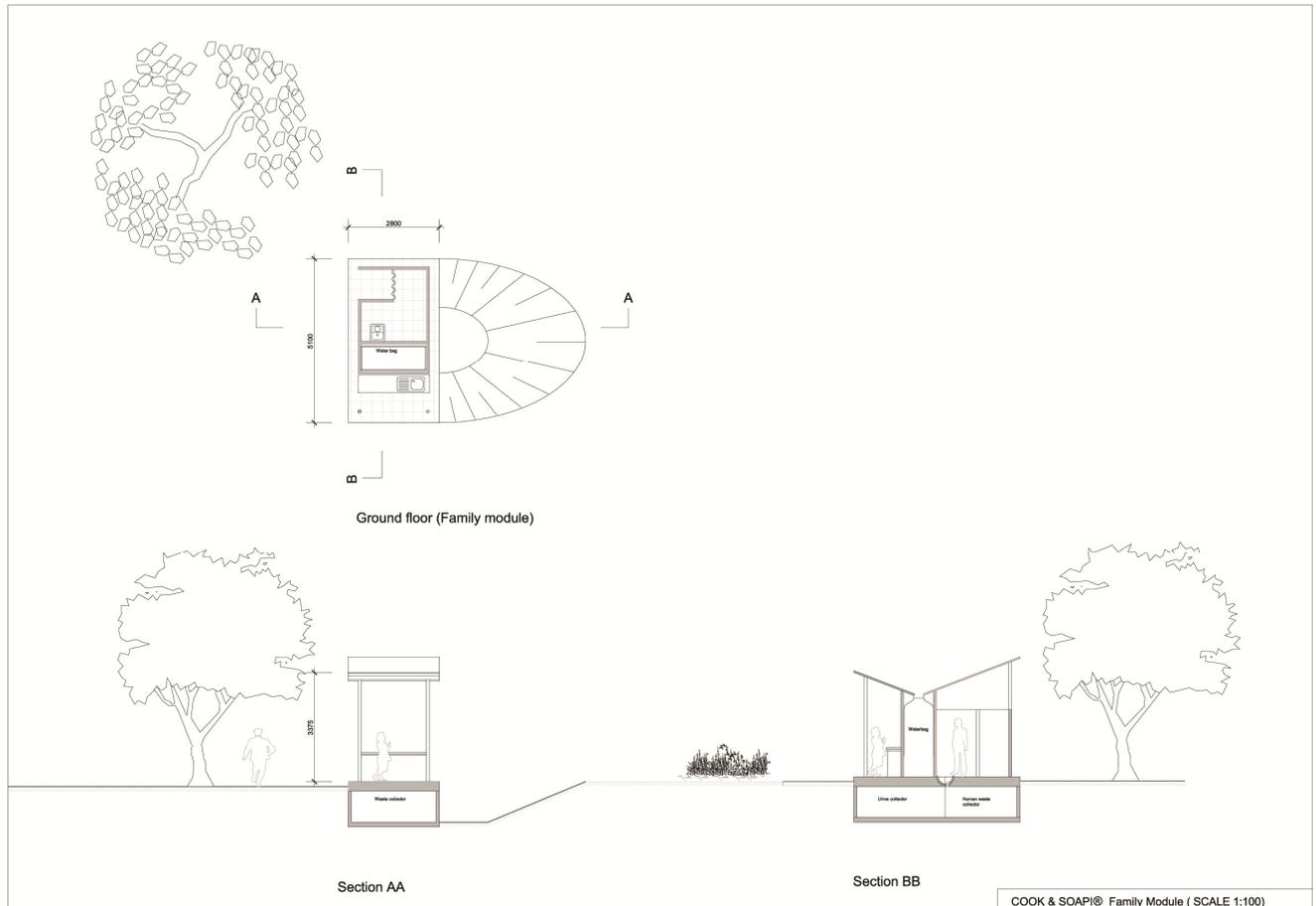
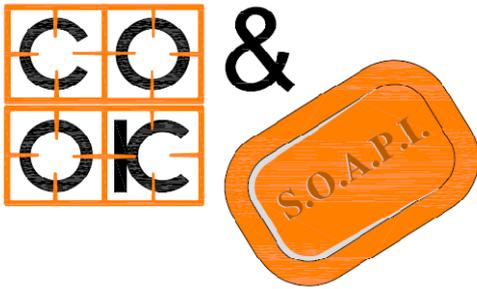
## 3.2 Technical solution

### 3.2.1 Building

#### Household module

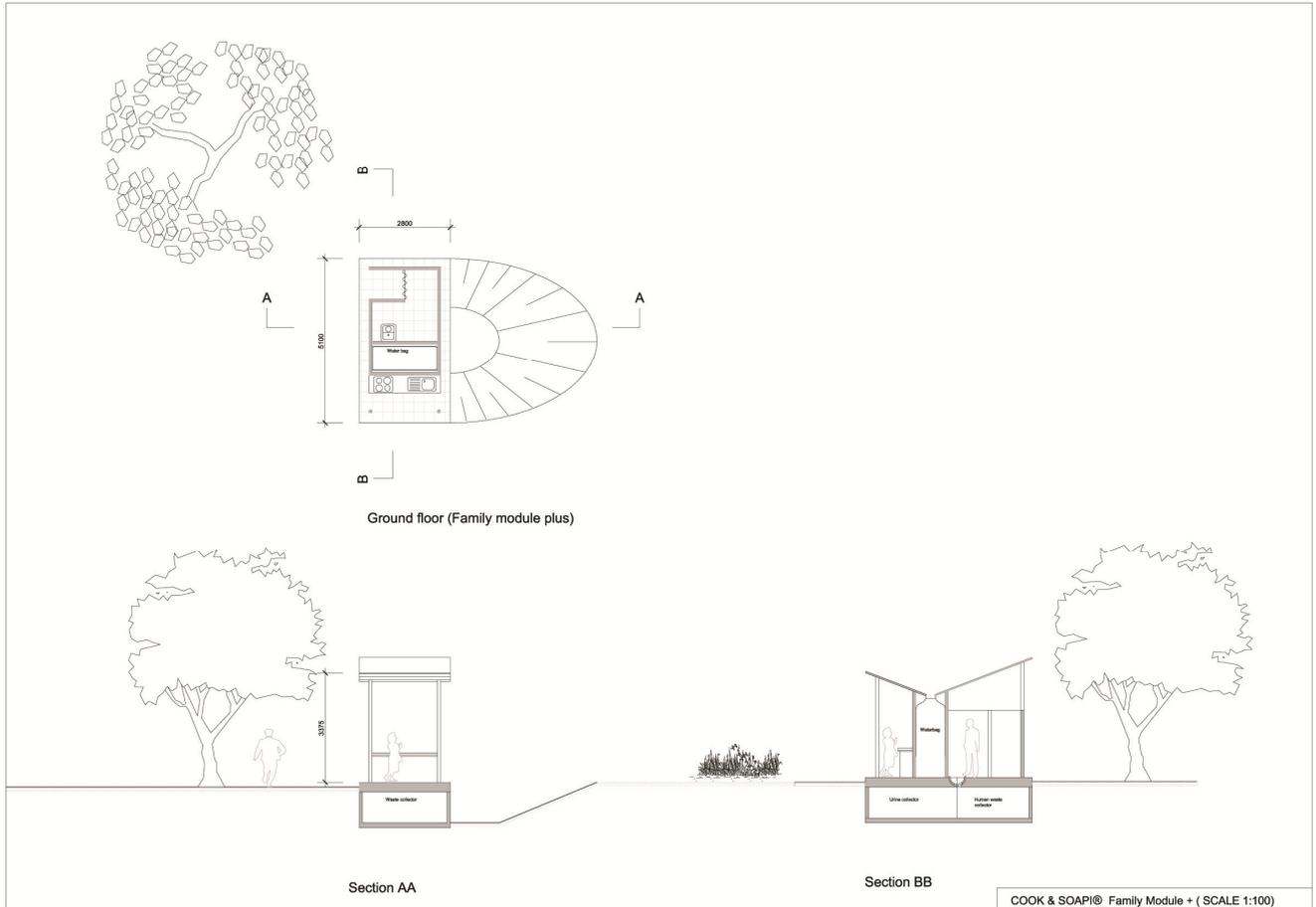
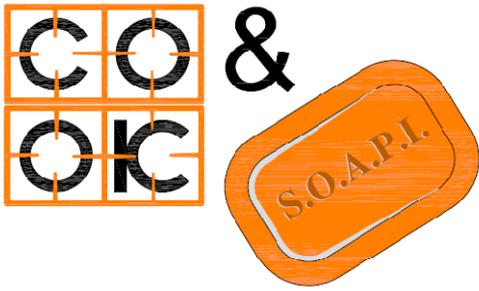
The household module (or family module) of *Cook & SOAPi*<sup>®</sup> has been designed for use by a single household and has several key properties and advantages. The layout of the building is designed to give maximum shelter from the elements to the user. An entrance with a curtain gives privacy to the user, as a door with hinges would give problems with durability.

The household module consists of a single toilet. The toilet can be flushed with the water from the water tank, which is placed at the centre of the module. The water tank will fill up with water during rainfall. The roof is designed to act as a large water collector, with a slope directing the water into the water tank. The collected water can also be used for washing hands after a toilet visit or for doing laundry. For this last option, a water tap point can be installed at one of the outer walls of the unit.



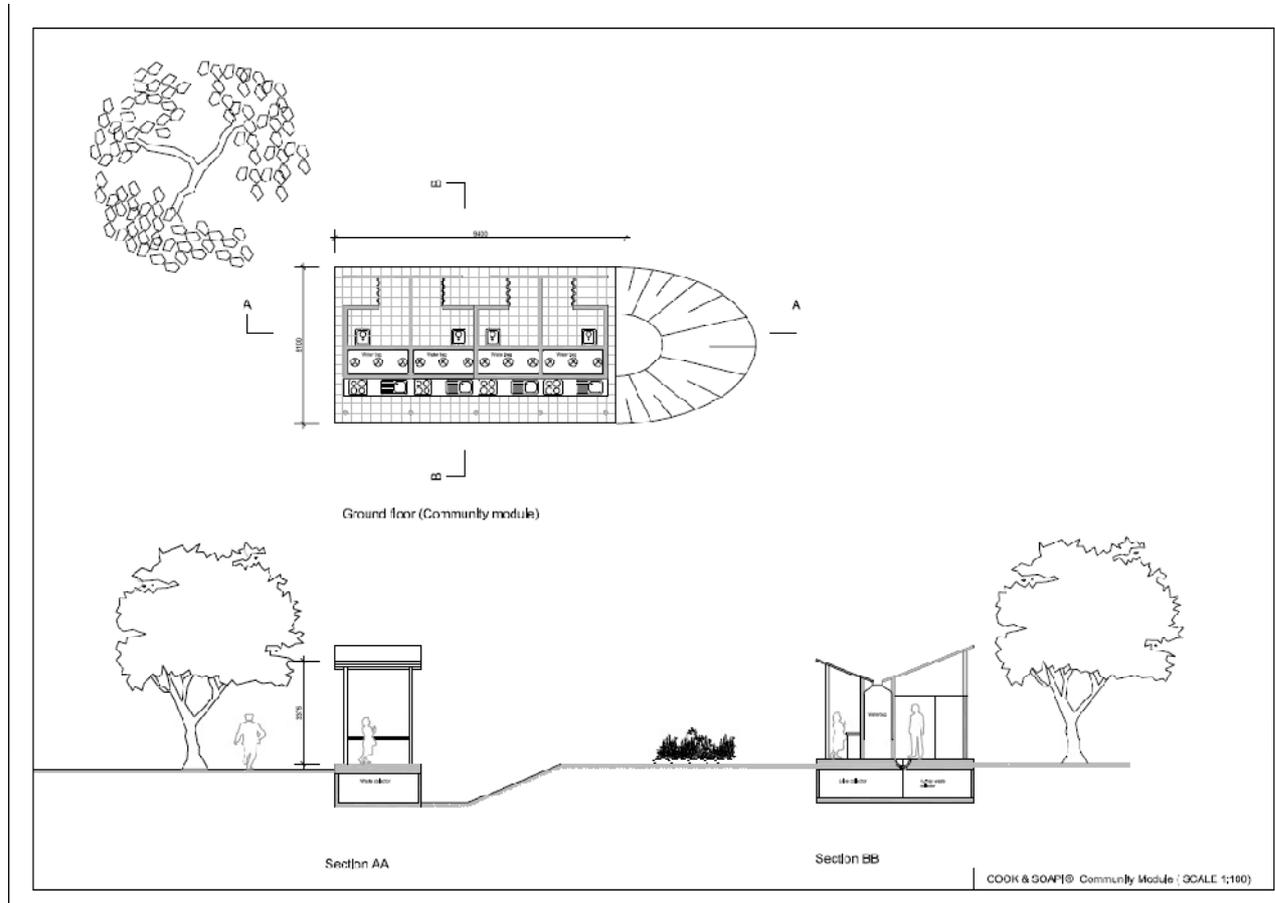
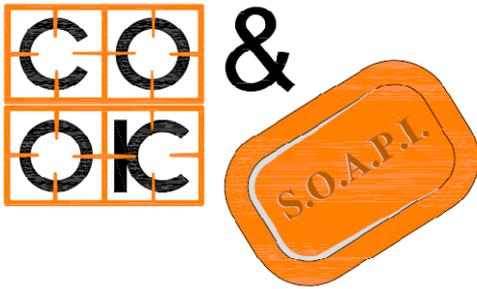
### Household module plus

The *Cook & SOAPI*® household module plus (or family module plus) has also been designed for a single household, but has several key properties and advantages. The building layout of the household module plus is the same as the household module. It has also an entrance with a curtain, a single toilet and a water tank. The key difference is the presence of a stove for cooking. More information about the use of biogas for cooking is explained in the next paragraph.



### Community module

For small communities, several (mirrored) household module plus units can be combined in such a way that a large building is created. More units can be added easily, enabling in future growth. Just like the household module plus, water is available for washing hands, cooking or doing the laundry and stoves are available for cooking. The layout of the units and the location of the entrances give maximum shelter and privacy.



### Luxury module

All Cook & SOAP.I.® modules can optionally be upgraded with solar panels for generating electricity and a vacuum toilet. A vacuum toilet enables for automatic flushing with only one liter of water per flush, but it does require the presence of electricity.

### Building material (equal for all scenarios)

*Walls and columns:* Cardboard with coating, seams protected with sealant tape

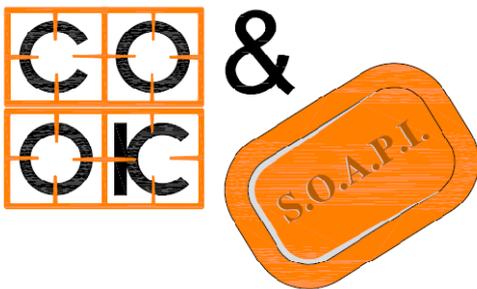
*Roof:* Cardboard with a water resistant coating.

*Floors and foundation:* Concrete with aggregate depending on local availability.

*Toilet:* Ceramic.

*Water tank:* Commonly used PTFE plastic, equipped with zipper for maintenance (Source: 1).

*Coating:* Lower 30 cm of walls, roof and flooring coated with Grancrete (Source: 2 and 3). Remaining cardboard walls coated with thin and transparent phosphor ceramic coating (Source: 4).



For all the materials used counts that the focus lies on low cost and sustainable, local available products. The walls are made as a sandwich material of corrugated fibreboard skins, using recycled cardboard for the thickening core structure. Lightweight but stiff honeycomb cardboard is used for the roofing structure. The outer columns are made of standard sizes cardboard tubing.

Both the Grancrete and phosphor ceramic coating are essential to preserve the cardboard from weather influences and minor damages. Additionally the coatings make the structure easy to clean and maintain contributing to the hygiene of the system. Both the coatings are non-toxic and feasible to apply in open air conditions without any complex equipment or expertise.

### 3.2.2 Sanitary system

The system of *Cook & SOAP.I.*® will be equipped with separated collection of urine and faeces. The system will not use a sewerage system, but the black water will be collected in a digester (UASB) in order to produce biogas. This biogas can either be used for cooking facilities or to produce electricity. Magnesium will be added to the urine in order to bound nitrogen and phosphate in order to produce struvite (Source: 5). This can be used as fertilizer for agriculture purposes.



To improve the *Cook & SOAP.I.*® system it can be equipped with vacuum toilets. The use of a vacuum toilet has two advantages above a conventional toilet. One vacuum toilet can reduce the amount of water used per flush to one litre. Additionally there will be less water in the digester which will improve the fermentation process in order to produce biogas.

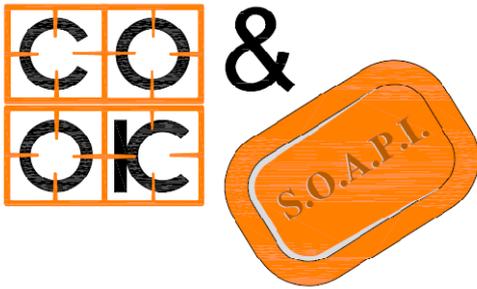
### Biogas production

The produced biogas for cooking purpose or electricity will be of direct benefit for the participating households. Gas cylinders can be distributed among the various households.

### Gas supply

The amount of produced biogas is calculated based on tests of the project EET at Sneek, the Netherlands (Source: 6).

32 households in Sneek produce around 1 m<sup>3</sup> biogas per day. One household provides on average per day 0.03m<sup>3</sup> biogas (1m<sup>3</sup>/ 32 households). This would mean that the gas production in India for 1 million households would result in 1.000.000 x 0.03m<sup>3</sup>= 30.000m<sup>3</sup> biogas/per day. However the differences in gas production between Dutch and Indian households can be significant. This is due to different households composition (number of people) and to different eating patterns resulting in more or less liquid faeces.



### Demand of biogas

The demand of gas in the Netherlands for one household is around 1600 m<sup>3</sup> per year, which means around 4,4 m<sup>3</sup> gas per day. There are no reliable numbers that present the average gas demand of rural India, caused by the diversity of the country.

Considering the weather conditions in India the use of gas will be considerably lower than in the Netherlands. In the Netherlands gas is used mainly for heating the house (78%), warm water (19%) and cooking (3%) (*Source: 7*). This lead to the conclusion that a Dutch household needs 0.132 m<sup>3</sup> a day for cooking and 0.836 m<sup>3</sup> for warming water. We take the assumption that the gas demand in India for cooking is the same as in the Netherlands.

Considering the calculations made, the gas demand for cooking cannot be 100% supplied with biogas. The supply of biogas on the total gas demand is  $0.03\text{m}^3 / 0.132\text{m}^3 = 0.23$ . In percentage this is 23% of total gas demand. This will need to be supplemented with conventional gas.

It is also possible to extend the biogas digester by using cow dung and other organic waste in addition to the human excreta in order to increase the biogas production. However, it is a recommended to use extra 'conventional' gas cylinders as a back-up system to meet the gas demand (*Source: 8*).

### Fertilizer production

The liquid fraction of the digester consists mainly out of nitrogen, phosphate, pathogens, viruses and organic material. The organic material can be transformed into mud and CO<sup>2</sup> by adding oxygen. The mud can be separated from the water by using a membrane. The membrane also filters the pathogens and viruses. The water provided by the system will contain nitrogen and phosphate. By adding magnesium to this water struvite will be produced which can be used as granular fertilizer (*Source: 9*).

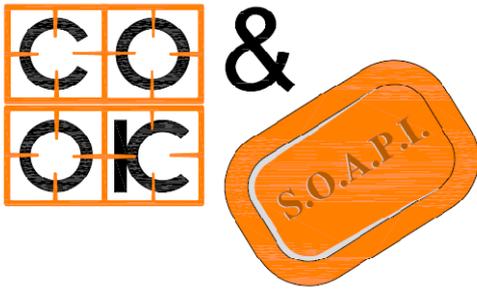
### Building materials:

*Floors and foundation:* Concrete with aggregate depending on local availability.

*Urine tank:* PTFE plastic bag inside concrete structure.

*Biogas/faeces tank:* PTFE plastic bag inside concrete structure.

The concrete floor and foundation provide a strong but low-tech base for the *Cook & SOAPI*®. To improve the reliability, both the tanks are made as large plastic bags, making them replaceable when needed, and deduct the necessity of toxic waterproofing coatings for the concrete structure.



### 3.2.3 Water collection and use

All Cook & SOAPI<sup>®</sup> modules are equipped with a water tank with a capacity of 4 m<sup>3</sup> (2.0 m x 0.9 m x 2.25 m). This gives a buffer to store water for toilet use and hand washing during the dry season.

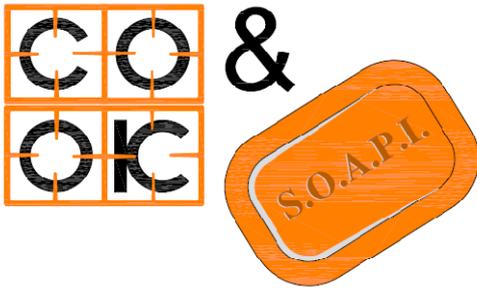
The area available to harvest rain (the roof) is 14.3 m<sup>2</sup> (5.1 m x 2.8 m).

During the rainy season (May/June – August), more than 200 mm of rain falls monthly in many areas in India (see attached file 'Rainfall\_data.xlsx'). Therefore, monthly more than 2850 litres of water can be collected (14.3 m<sup>2</sup> x 200 mm).

The following table gives an estimate of the monthly water use per unit.

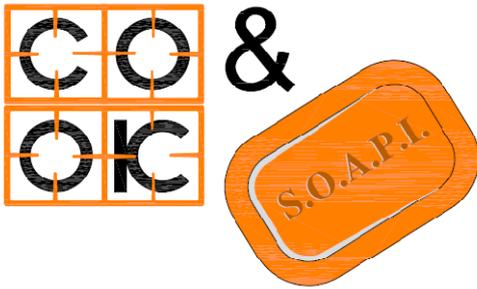
Activity	Water use (litres)	Times/day	Daily use (litres)
Toilet flushing	1	20	20
Washing hands	0.5	20	10
Cooking	5	1	5
<i>Daily Total</i>			35
	Water use (litres)	Times/month	Total
Daily activities	35	30	1050
Laundry	25	4	100
<i>Monthly total</i>			1150

The capacity of the water tank and the monthly rain water harvesting in the rainy season, gives a water buffer of several months in the dry season. To guarantee the availability of water for toilet flushing and washing hands, the water tap point for cooking and laundry is placed at a height of 1.3 m. If the water level drops below this point, water is automatically only available for toilet use and washing hands.



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## 5) Conclusion and closing remarks

*Cook & SOAPI*<sup>®</sup> is a custom made sanitation system which is especially suitable for the rural areas of India. Individual, household and communal needs are met as *Cook & SOAPI*<sup>®</sup> provides a modular and expandable system. The principles of *Cradle to Cradle* are implemented by using cardboard building material; rainwater harvesting; a separated sanitation system; producing biogas from faeces for cooking; and use of nutrients of urine for growing crops. An integrated concept that meets the need for sanitation of all people (SOAP) in rural India is provided by *Cook & SOAPI*<sup>®</sup>.