NATURE-BASED SOLUTIONS FOR WATER IN THE PERI-URBAN

CASE STUDY BRIEF: SWEDEN, STOCKHOLM ARCHIPELAGO, NORRTÄLJE

2018 JOINT CALL

ABSTRACT

This is a case study about using nature-based solutions (NBS) for greywater treatment in the summer cottages of Norrtälje, a coastal municipality located in the Stockholm Archi-pelago, Sweden. Greywater is the domestic waste-water emerging from the bath, kitchen and laundry, and can be treated using conventional (non-NBS) as well as NBS technologies. This case study focused on the common NBS options available in the market. The stage of NBS for greywater in this case can be described as both planning and implementation. The NBS is planned or implemented at a decentralised (household) scale with property owners driving their own projects in individual capacities or in collectives. The results are based on an empirical study in Norrtälje Municipality that includes a literature review, survey and in-depth interviews with key stakehold-ers. From the case study it emerges that the NBS options are environmentally sustainable, helping jointly address the two major water challenges – quality and quantity, without producing any harmful residues from the treatment process. These also offer social and cultural benefits at the local scale (e.g., fulfillment of safe water needs, enriching the leisure environment) as well as providing participatory opportunities for local residents in sustainable environmental stewardship. Economically, these can enable cost savings in short and long-term as well as have potential for enhancing property values.

PURPOSE OF THE CASE STUDY

An attempt was made in this study to understand the context of the decentralised NBS projects for domestic greywater treatment together with the pro-cesses of planning and implementation. The major opportunities and barriers in these processes were examined. Also, of interest was to explore the merits and drawbacks of the NBS options compared to the conventional (non-NBS) infrastructure available on the market. The comparison was important because the conventional (non-NBS) greywater treatment systems are unable to address both water quality and quantity challenges in an integrated manner. The study considered the three sustainability dimensions identified by the NATWiP Framework (environmental, social and economic). Thus, all three parts of the framework (context, process and results) were used to assess the NBS in question.

'Greywater dam' – a constructed wetland – where wastewater purification works through green phytotechnology. Seen in the background is the first step where the sludge in the greywater is composted in a reed bed; followed by the second step in the front where the separated greywater is recycled in a pond with plants via a water ladder for oxygenation.

AREA CHARACTERISATION

Country	Sweden
Province	Stockholm County
Municipality	Norrtälje
Town	Norrtälje
GPS coordinates	59.7596° N, 18.7014° E
Area	6 030,42 sq.km.

PHYSICAL CONTEXT

Local geography/ topography	Norrtälje is the largest and northernmost municipality of Stockholm County. It is a coastal municipality, situated in the northern part of the Stockholm Archipelago - the largest archipelago in Sweden and the second-largest in the Baltic Sea Region. On the whole, the Stockholm archipelago contains more than 24,000 islands, islets and sherries, and covers about 1,700 km², of which about 530 km² is land. The Stockholm archipelago is a joint valley landscape that has been shaped – and is still being shaped – by post-glacial rebound and the islands rise by about three millimeters each year. Norrtälje municipality has about 10,000 of the archipelago's islands, islets and sherries. The climate is cold and temperate and there is a great deal of rainfall, even in the driest month. This climate is considered to be Dfb according to the Köppen-Geiger climate classification. There is good weather with pleasant average temperatures between 15°-17°C during months of June, July and August, while coldest season / winter is in the months January and February, when temperatures dip to an average of -3.5°C . August is the wettest month.
Main water courses	The municipality has 62 rivers and streams flowing through its territories, of which the major ones are the Norrtälje and Skebo rivers.
Main soil types	The soil species in the municipality is dominated by moraine and different types of clays. In the lower parts of the landscape there are nutritious clays, containing moderately high levels of phosphorous and nitrogen.
Precipitation (monthly averages as well as climate change projections)	The rainfall here averages 515 mm. Monthly average precipitation (mm): Jan-40, Feb-27, Mar-25, Apr-29, May-28, Jun-38, Jul-59, Aug-62, Sep-56, Oct-51, Nov-54, Dec-46.
Temperature	Max 15°C (in summer) to min. -3.5°C (in winter)
Critical infrastructure	The municipality has all essential infrastructure in place, with energy (electricity), housing, education, water and wastewater, and solid waste being managed primarily by the municipality. However, a large proportion of the housing (55,5%) is in the form of individual private properties, many of which are not served by the municipal water & sewage lines.

SOCIO-ECONOMIC CONTEXT

Population	61,769
GPD/capita	Stockholm County has one of Europe's highest regional GDP per capita at 610 000 Sek. Of the 273 regions in Europe, Stockholm holds 7th place. However, specific figure for the study site is not available.
Economic status (i.e. low income, high income)	High income, the average annual income per inhabitant among those who are 20 years and older is 292 300 Sek (29 764 USD), compared to the national figure of 308 700 Sek (31 434 USD)
Other relevant socio-economic factors	Tourism is an important industry here which impacts the water cycle seriously since during the summer season, the municipality's population swells up to five times.

OBJECTIVE OF THE NBS

The NBS for greywater treatment in Norrtälje addresses water quality as well as water quantity (shortage) challenges. The Stockholm Archipelago is the second-largest archipelago in the Baltic Sea and a popular summer destination. Here, the Norrtälje Municipality has the largest number of summer cottages (13 900). Many of these cottages lie outside the reach of municipal water supply and sewerage. This poses challenges of access to safe water in adequate quantities for the inhabitants, while also contributing to eutrophication (excessive increase in nutrients and minerals) in of the Baltic Sea. The conversion of a large number of these houses into permanent residences and impact of climate change on the precipitation pattern further aggravate the problem.

POLICY AND GOVERNANCE CONTEXT

The governance context is mainly local (municipality) and regional (Stockholm county), though the parliament at national level has legislative powers to formulate legal frameworks for action at both these levels. An example of the latter is through the 1992 Swedish Local Government Act which regulates division into municipalities and the organization and powers of the municipalities and county councils. While there exists clear policy context supporting sustainable water management at all levels through goals set within the EU Water Framework Directive, the Baltic Sea Region Action Plan, the Environmental Code, 2000 enacted by the Swedish Parliament, and also under the United Nations 2030 Agenda for Sustainable Development Goals, an emphasis on promoting and adopting NBS for the same is weak.

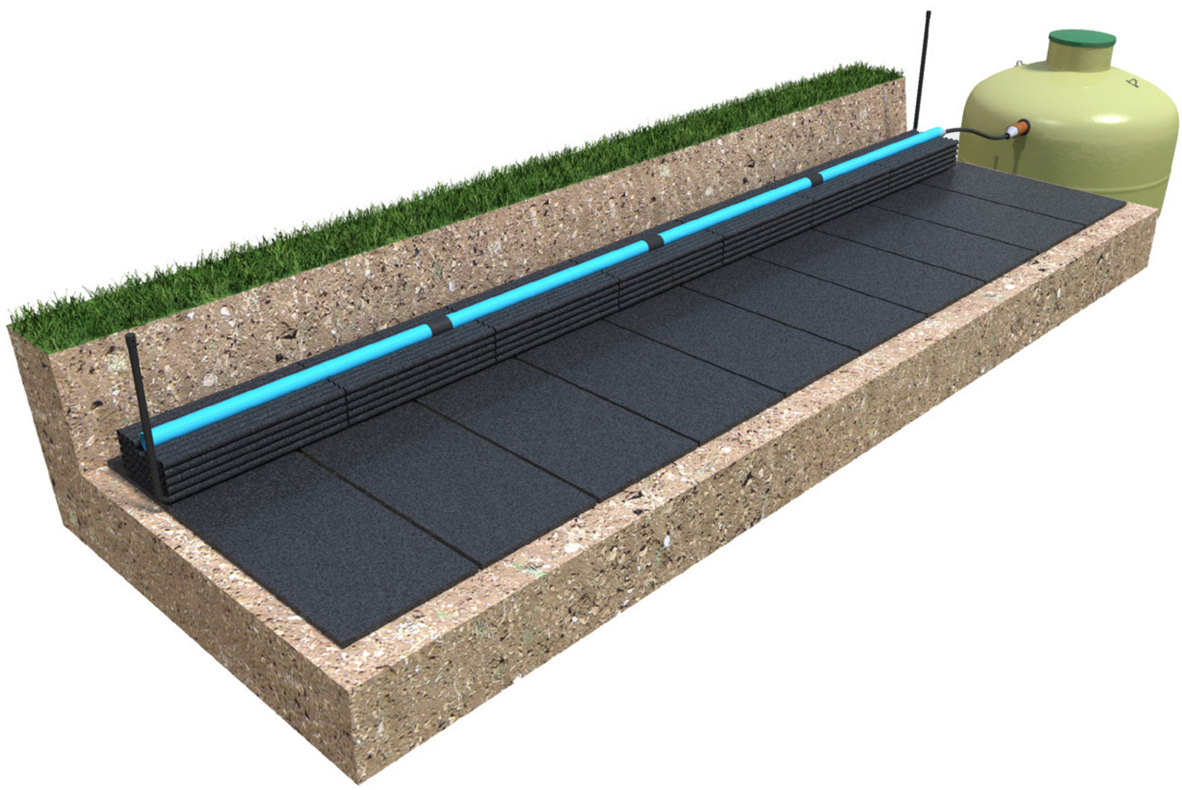
The Norrtälje municipality is directly responsible for environmental and water planning in the area, and hence planning and implementing NBS measures falls within their area of responsibility. However, the holiday home areas mostly lie outside of municipal planning areas (and hence can be classified as 'peri-urban'). Here, the individual property owners are responsible to organize wastewater treatment on their own. This may be done individually at a household scale or through neighborhood associations, but in either case, the property owners are responsible for ensuring that the solutions adopted meet the requirements of the Environmental Code. These small-scale systems may be conventional (non-NBS) or be 'nature-based' and are granted approval by the municipality that also helps with information dissemination through digital and other platforms. The property owners are responsible for financing their own greywater treatment projects, whether NBS or otherwise. The stakeholders involved are largely individual property owners, who either reside permanently in their properties or visit during holidays. They could also be renting out their houses to tourists during the year. Other stakeholders that should/could be involved in planned NBS interventions are tourist agencies and also nature conservation groups and NGOs that are involved in Baltic Sea protection.

ACTIONS

This case study considered a number of alternate NBS for greywater treatment:

Option 1: The 'infiltration facility' used for purifying and filtering greywater from an individual household. In the first stage, the domestic greywater reaches a so-called "sludge separator" where the larger solid pieces are trapped in a container in hard plastic, cement or the like. The greywater is then let into an 'infiltration bed' where it is evenly distributed through two or more pipes that are buried in the soil at a depth of about 30-50 cm. The length of the pipes is 1-2 m. The base of this infiltration bed consists of layers of crushed stone and/or coarse gravel. It is here that the cleaning of the water takes place, through biodegradation of the bacteria and other organic matter. This is facilitated by air which is let into the infiltration bed through air inlets. What happens chemically is that dangerous substances contained in the greywater, such as nitrogen or phosphorus, are effectively neutralized to a large extent. Although these substances are not completely eradicated, they are degraded enough to cause no damage to groundwater or any other part of the environment. The purified water from the system disappears into the soil, becoming groundwater.

Option 2: 'Soil bed' which can be used if the land is not suitable for infiltration described above. The soil bed acts as an infiltration plant where the purification takes place in a built-up sand layer rather than in the soil's natural soil layer. The soil



Schematic figure of 'bio-module' where after sludge separation in a tank, biological purification of the greywater takes place through a biofilm of bacteria and fungi formed on the walls of the tubular support material installed in soil.

bed is made up of several layers of gravel and sand where all layers have different functions. Additionally, its sides and bottom may be lined with a plastic or rubber cloth to prevent leakage to the natural soil layers. At the bottom of the sand layer, the water is collected and after that it is let out into the nature through a ditch. A plant of this type needs a space of about 20-50 m².

Option 3: 'Bio-module', where a biological purification of the greywater takes place according to the same principle as in a soil bed or infiltration. In the bio-module, a biofilm of bacteria and fungi is formed on the walls of a tubular support material that break down infectious agents and organic matter and oxidize ammonium to nitrate. Bio-modules can be used as a soil-bed with discharge to surface water or as a reinforced infiltration. One advantage is that it can be built on a smaller area than a conventional soil-bed, in about 10-15 m² and they enhance the efficiency of infiltration or soil-beds.

Option 4: 'Greywater dam' which is based on green phytotechnology and designed in accordance with constructed wetland principles. Here the purification function takes place in a cooperation with microorganisms and bacteria which breaks down the organic waste and plants that take up nutrients and other substances. The purification takes place in a number of steps, where the first is a sludge reed bed where the sludge from the drain is composted, followed by a pond with plants where the water is recycled via a water ladder for oxygenation. Later, the purified water is spread over a small gravel bed / stone coffin via a wide drain below the ground.

Option 5: 'Biotreatment plant' where the greywater is treated using microorganisms and green phytotechnology inside a compact tank. In the first step, microorganisms inside a pre-treatment tank form biofilm to degrade the sludge, which minimizes the need for sludge removal. From this tank, the greywater is pumped to the main chamber where it is exposed to other types of microorganisms and to natural aquatic plants whose root systems also make up a good environment for the microorganisms. The plants as well as the microorganisms feed on nutrients in the greywater. In some cases, an additional treatment step is required to achieve extra reduction of phosphorus to prevent eutrophication. Here phosphorus is bound to a lime material. When the filter material is saturated with phosphorus it can be spread on farmland as a fertilizer. This treatment system is very robust requiring little maintenance.

POTENTIAL (OR ACHIEVED) IMPACTS AND BENEFITS

Environmental impacts:

1. NBS for greywater treatment provide integrated solutions that help protect ground and surface water quality as well as augment groundwater recharge – these thus promote water sustainability at local as well as Baltic Sea Region (BSR) scales
2. In comparison to conventional non-NBS technologies, the NBS options do not produce any harmful chemical residues from the treatment process. Additionally, these filter out harmful chemicals, microbes, and some even pharmaceutical residues, thus being 'eco-friendly'
3. The treated greywater has the potential of reuse - for example, in toilet flushing or garden irrigation - which can further promote water sustainability in the coastal areas
4. Help maintain soil permeability (excluding the closed tank-based systems) (co-benefit)

Social impacts:

1. Enables fulfilment of safe water needs of the local residents by safeguarding quality as well as augmenting water quantity
2. This in turn promotes better physical and mental health, directly and indirectly

'Biotreatment plant' where the greywater is treated using microorganisms and green phytotechnology inside a compact tank. Seen in the picture is the main chamber in the treatment process where the greywater is biologically cleaned. In this chamber, natural aquatic plants as well as the microorganisms growing on their roots feed on nutrients in the pre-treated greywater.

3. Empowerment of local residents through participation in sustainable environmental stewardship (co-benefit)
4. Some systems are aesthetically designed (particularly options 4 and 5), thus adding to the leisure opportunities in holiday home areas (co-benefit)

Economic impacts:

1. The potential reuse of treated greywater (as noted above) can promote cost savings
2. Protection of the groundwater quality – the basic drinking water resource in the area – can promote cost saving by minimizing need of installing drinking water filters
3. Eco-friendly NBS options for greywater treatment installed in the property has the potential to attract higher sale value (co-benefit)

SUSTAINABLE DEVELOPMENT GOALS AND/OR ANY OTHER WATER-RELATED DEVELOPMENT GOALS ADDRESSED

The use of NBS for greywater treatment most importantly addresses SDG 6 (clean water and sanitation). Particularly addressed targets, in order of priority, are: Target 6.3 (by improving water quality through reduced pollution, decreasing the proportion of untreated wastewater, and potentially increasing safe reuse of treated water); Target 6.1 (by facilitating equitable access to safe drinking water); and Target 6.4 (by contributing to increasing water-use efficiency across sectors and sustainable withdrawals of freshwater to address water scarcity). It also addresses SDG 14 (life below water), particularly Target 14.1 by preventing and contributing to reduction of pollution in the Baltic Sea from land-based activities, and Target 14.2 by sustainably managing and protecting marine and coastal ecosystems to avoid significant adverse impacts, including by strengthening their resilience, and take action for their restoration in order to achieve healthy and productive oceans. Also addressed are SDG 3 (good health and well-being) by promoting healthier lives and well-being for local residents; and SDG 16 (peace, justice and strong institutions) by promoting inclusive societies for sustainable development through local participation in environmental stewardship.

LESSONS LEARNT

Certain key factors help in making the NBS for greywater treatment sustainable along environmental, social and economic axes. These are summarized below:

1. The NBS options help jointly address the two major water challenges in the area – quality and quantity, without producing any harmful chemical residues from the treatment process. This contributes to their environmental sustainability.
2. Social sustainability of the NBS for greywater treatment comes from the social and cultural benefits these offer at local scale (e.g., fulfillment of safe water needs, enriching the leisure environment) as well as the participatory opportunities offered to the local residents in sustainable environmental stewardship
3. Economic sustainability of the NBS comes from the cost savings in short and long-term that these solutions offer as well as the potential for enhancing property values.

The main lessons from this case study can be summarized below. These include opportunities as well as constraints, and would be useful for policy makers, practitioners, community, scientists, and other actors.

1. There exists an overall supportive policy environment promoting sustainable water management in the peri-urban areas, including coastal zones. This is supported at international, regional (EU and BSR scales) and national levels. However, a policy emphasis on NBS needs to be developed so that specific actions can be initiated with active participation of state and local administration.
2. The industry is actively engaged in producing/installing NBS for greywater treatment, and a number of different options are available in the market. However, their uptake appears to be low, some of the constraints being their high cost (when seen in a short term perspective), lack of awareness about the need and long-term benefits of NBS options, and absence of knowledge about the scope of public participation in environmental stewardship through NBS adoption. There is need to design measures to address these constraints.
3. In comparison to the conventional non-NBS technologies for greywater treatment, the NBS options are easy to install and their operation and maintenance at household level is simple and low-cost. This enables a good marketing opportunity for NBS and hence, a pro-NBS marketing strategy can help the consumers make sustainable choices.

4. Finally, the municipality needs to adopt an active role in promoting NBS for greywater treatment. This can be through municipal policy support, public education, simplified procedures, or even financial support especially for senior citizens to improve the affordability of NBS.

TRANSFERABILITY OF RESULTS

The results of this case study can be used by local practitioners in Norrtälje municipality by following the recommendations included in the lessons drawn above. These are also usable in other municipalities in Sweden and outside where greywater treatment needs to be organized by individual property owners. It is suggested that a context analysis be undertaken in the beginning using the NATWiP framework and the constraints and opportunities are analyzed in advance before supporting and promoting NBS for greywater treatment. This will enable sustainable uptake of NBS and achievement of water sustainability trough NBS in the long term.

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WHAT IS NATWIP?

NATWiP is an acronym for a project entitled: Nature-Based Solutions for Water Management in the Peri-Urban: Linking Ecological, Social and Economic Dimensions.

This is an EU-Cooperation project funded under the Water Joint Programming Initiative (JPI) Call 2018 and is led by an international consortium of scientists. The NATWiP team works towards promot-ing sustainable implementation of nature-based solutions to address water challenges in peri-urban areas.

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