2.5 A way forward … a tool for selecting sustainable sanitation arrangements

How to obtain all the information we need?

Learning objective: selecting a sustainable arrangement is more than just choosing between technical solutions.

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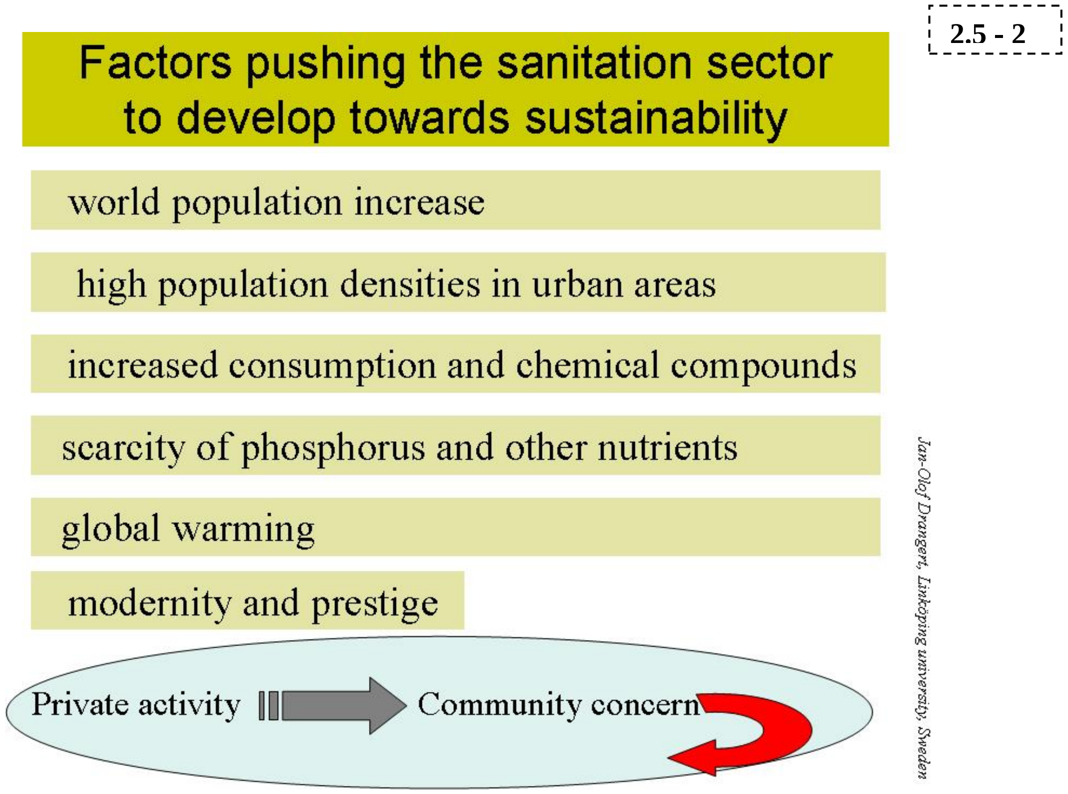
In this sourcebook we focus on systems and arrangements for water, wastewater, storm water excreta and (organic) solid waste. A good system requires that the parts fit together into a well-functioning whole. We need criteria and methods of thinking and acting in order to select a desirable system that will provide services and not add pressure on natural resources. Only after defining service levels, acceptable environmental impacts and pollution levels is it time to select the technical bits and pieces of the entire arrangement.

We discuss systems for new housing areas with a focus on selecting the system as a whole, not just choosing parts to be added to an existing system. Keep in mind that as many NEW urban houses as there are houses today will be built within the next generation! This is a golden opportunity to erect more sustainable cities.

Most of the new houses will be built in the developing and urbanising world. In 2008, a rapidly urbanising China built 2 billion square metres of floor area – almost half of the world´s total built floor area for that year (*The Straits Times*, 2009). Chinese construction companies must apply for a Green Building Certificate which gives an assessment of their environmental footprints with respect to a range of indicators, including energy savings, reduction of air and noise pollution, smart water usage, carbon dioxide emissions and impact on surroundings.

A joint assault on the silent sanitation crisis facing many countries around the world is not only a municipal council responsibility. Researchers, sanitary engineers, architects, plumbers, manufacturers of sanitary ware, farmers etc. are all involved – and so are the residents themselves. In this chapter we are not restricted to poor communities, because the need to choose sustainable sanitation applies to all residents all over the globe. The emissions from our sanitation systems, be they centralised or not, are substantial and have to be reduced. This was part of the agenda at the climate change summit in Copenhagen in 2009.



The resource flows are gradually changing in volume due to increases in population and wealth, and in composition due to new consumption patterns and products. With the looming scarcity of (virgin) resources and rising discharges/emissions of undesirable waste products (slide 1.1-?) new requirements are forthcoming. Our point of departure is such recent global experiences which push for more sustainable sanitation arrangements. The private activities of defecating and disposing of used products become a community concern which – in turn – may restrict these private activities.

Urban living requires inputs of food, water and energy. Resources are transported from other parts of the globe to urban areas which implies imbalances, unless these resources are returned to agricultural fields and water bodies. One such imbalance that was recently 'discovered' is the looming scarcity of phosphorus, an essential ingredient in food production and products – and thus in food waste (see Module 5.1). In a world with some millions of people this problem would not mean much, but when we are 7 billion people and soon 9 billion, the imbalance really matters. If planners and decision-makers do not act quickly, the consequence will – again – be widespread food shortages and famines. Such man-made shortages should not be allowed where the solutions are easy to access.

Changes in resource usage are closely linked to the influence of the perceived modernity and prestige of products on residents' self-esteem. Unfortunately, the life-span of conventional water supply and sewerage is a hundred years, and therefore it is not possible to anticipate what kind of consumption we will have at the end of the period – and appropriate treatment system.

To grasp what the future holds one can make rough estimates of the increase of each factor in the picture above. For example world population will increase 50% in the next 50 years. Even without improved diet and energy intake, the world will need to produce 50% more food. If China and India, with close to half of the world's population, continue to increase their gross national product (GNP) by 10% per year today's GNP will double in seven years. Their demand for oil and other natural resources will continue to grow and prices will go up. This will spur innovation of new resource usage and reuse. This also applies to their demand for water and fertilisers which will make recycling common – and necessary for survival. There will be little room for wasteful practices. These countries may well spearhead sustainable development out of necessity.

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The role of sanitation in solving the looming water and nutrient crises and global warming

- save H_2O (demand management) and prevent pollution of H_2O
- use treated greywater to save on ground- and surface water
- sanitise nutrients (P, K and S) from households and restaurants
- recycle nutrients and organics for food production and soil restoration
- reduce emissions of CO_2 and other greenhouse gases

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The potential contribution of the sanitation sector in reducing pressure on virgin fresh water and chemical fertiliser is substantial and the sector can also reduce atmospheric emissions. So far authorities have not set up very strict environmental regulations for the sanitation sector. Emission limits are confined to what is measurable and what the existing technology can achieve. More proactive laws and regulations would determine what the sector shall do in a planned future, and ethical values tell what should be done. There is a difference between doing that which you have a right to do and doing what is right to do (Friedman, 2009). Therefore, individuals as well as the private sector and municipalities could go ahead and do what they think is right to avoid the looming crises of water scarcity, nutrient scarcity leading to food insecurity, and global warming.

The most important priority in urban areas is to prevent pollution of water while using it. This will facilitate treatment and directly reduce the use of chemicals and energy for the processes. Depending on the quality of the treated water and the sludge, these resources may be used for useful purposes. Collection of organic matter at the source will reduce water pollution and facilitate recovery of nutrients and recycling. Lastly, all these measures will also reduce emissions of greenhouse gases.

Many framework issues to consider

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- Challenges for the present sanitation arrangements
- Policies, building codes and other regulations
- New housing area, densification or retrofit
- Landscape, soil and groundwater characteristics
- Wind, temperature variation and rainfall pattern
- Open areas (gardens etc.) and urban agriculture
- Availability (intermittent supply?) and cost of water
- Availability (intermittent supply) and cost of energy
- Collection and recirculation of solid waste, organic waste in particular, etc.

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The selection of a sanitation arrangement involves many considerations and some of these are shown in the picture. One can acquire a fair understanding of the general capacity of a society by looking at what challenges the existing sanitation arrangements are facing. If wastewater is not being treated, and solid waste not collected, it may be due to a heavy influx of people or poor fee collection, or a lack of skills and resources available to remedy the situation etc. Such limitations and hurdles are likely to show up when introducing new sanitation arrangements, and need to be addressed in the selection process. If such circumstances are not taken seriously, the next system is likely to suffer from a negative path dependence with similar shortcomings.

Future-oriented policies on aims of building codes can assist builders to know what the council is promoting. The policies may differ between retrofits, densification of existing housing areas, and opening up new areas to be developed. The codes hopefully provide many sustainable options to be applied in new areas.

The shape of the landscape can be utilised for gravity flows and siting of collection tanks, vaults and bins (Module. 2.6). The groundwater level and soil properties are crucial for the choices of storage tanks, infiltration of treated wastewater and siting of water and rainwater infiltration wells. Soil and water also indicate prospects of urban food production. Wind and temperature gradients decide what natural and forced ventilation solutions are feasible.

Rainfall patterns determine the extent to which residents can rely on rainwater harvesting, and the need for irrigation of plants and lawns. If there are open areas and gardens in the neighbourhood, much of the greywater and urine can be used productively. The composted faecal matter and organics can also be used. If the space is very small, these products have to be transported out of the community, or collected and first fed to a biogas reactor.

If tap water is available but not supplied 24 hours per day, there is reason to go for dry sanitation. The same is also true if the water tariff is high. If energy is intermittent it becomes risky to have forced ventilation, and one should try to use the wind and temperature difference between outdoors and indoors to drive ventilation. If there is an efficient collection system for organic waste, the collection of faecal matter could become part of it. So, where do we go from here?

Up to now the WC has set the standard, but from now on the resilience of nature will do so

2.5 - 5

El Grand Canal, Mexico City with ”treated” effluent

Courtesy of Ian Adler, IRRI-Mexico

Wastewater and stormwater drainage in Bangalore, India

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The impression from information gathered in urban and rural areas is that ‘*almost everyone would like to have a flush toilet* ’. The reasons are probably multi-facetted, but have not been studied. A first step in addressing the popularity of the WC is taken in Module 2.4 where the flush toilet is compared with other options, using a number of criteria that are often referred to. The preliminary findings are that the flush toilet displays a number of convenient features for the user, but it often receives a poor rating on environmental indicators (pictures).

A new era is now emerging where nature’s resilience to human activities will guide sanitation standards, not the flush toilet (slide 1.1-16). This is a radical change, and the sooner it is implemented the better. New qualitative regulations such as reducing fresh water use by, say 80%, and recovering 90% of the nutrients in household organic waste, etc. will improve the performance of stakeholders – planners, architects, and builders in facing up to the challenge to increase the environmental efficiency of buildings. Such achievement-oriented rules make it possible for developers to find technical and management mixes suitable for the area where they are going to build. Such a function-based approach may lead away from approaches with a single technical solution. A successful example from the transport sector is that thanks to binding legal requirements on fuel efficiency, technical development succeeded to make a small car today run some 15 km on a litre of petrol, while thirty years ago the car would only reach 5 km (Friedman, 2009).

Similar progress may be possible in the sanitation sector. For instance, a requirement that 90% of nutrients be recycled would result in more efficient technical design. Architects would have to design kitchens with proper storage places for food remains (including ventilation), and collection and composting facilities in the neighbourhood. Another contribution may be to collect urine separately and use it as a fertiliser. However, greater recycling of nutrients could be achieved in other ways as well. For instance, by not using phosphorus-based detergents, shampoos, etc. and by providing disposal places for household chemicals instead of the sink or toilet so that sludge could be recycled with less treatment. The flush toilet could still have a place among toilet options if it fulfils such recycling and other legal requirements.

Such requirement-driven rulings would have a profound impact on professionals as well as daily routines of common people.

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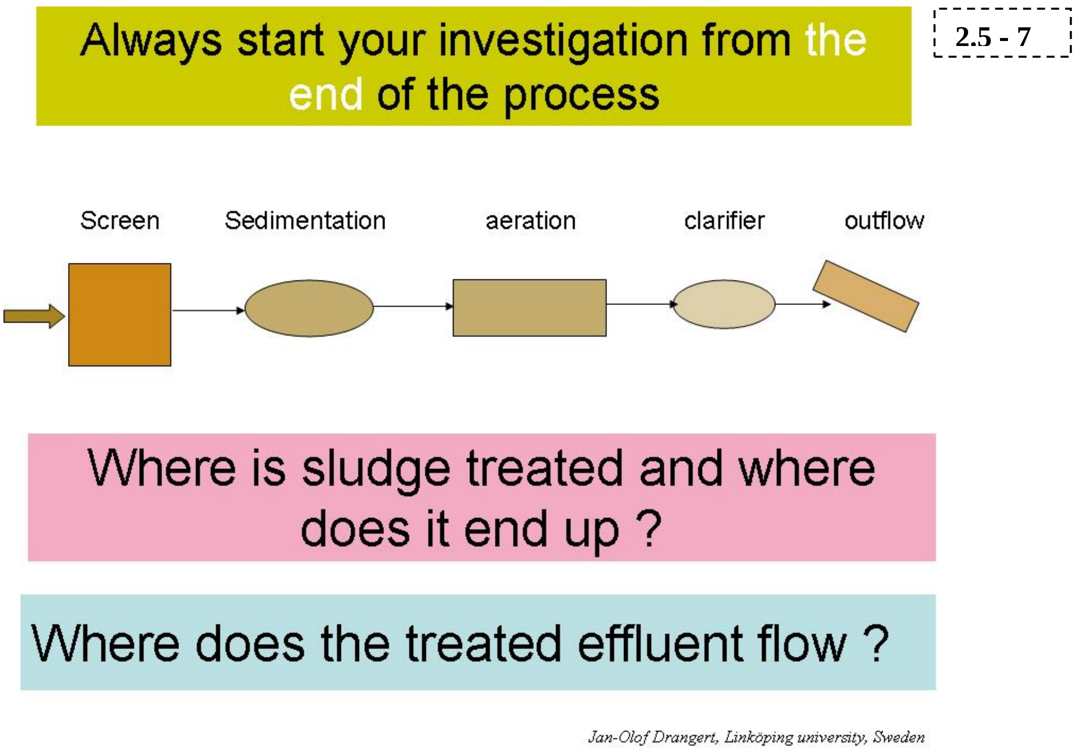
Oceans, forest and deserts look endless, but there is a growing awareness that even so, they are not big enough to make waste disappear. Today, plastic residues are floating in every sea and forests are affected by acid rain. The new realisation is that already human demands exceed what the globe can provide (Brown, 2011). The present generation's impact on the globe as a result of linear resource flows through communities will restrict the livelihood of future generations (Weizsäcker et al., 1998). The current crises also provide guidance for sustainable improvements. New approaches tend to be contested and create a lively political process leading up to new rules to meet environmental challenges. The present Millennium Development Goal to halve the number of people without proper sanitation and water has to be achieved within a sustainable framework.

The good news is that the sanitation goals can be achieved with limited environmental impact if we manage our resources wisely. A resource that has been used once must go back as an input in new production and use. Nature can show us the way, as in the case of renewable water. Dirty and contaminated water is evaporated to the atmosphere and in the process salts and most impurities are left behind and the raindrops provide a decent quality of water for human use.

We can help nature by not adding unnecessary chemicals to the water we use and by keeping excreta separate from other organic waste. If we do so, we can treat and reuse all used resources again and again, and there will be no scarcity. The corollary is that we face food and water scarcity only if we manage the already available resources in a wasteful way. Already, recycling is becoming more common. People's attitudes towards and responses to recycling therefore become more familiar with time. In the final analysis, residents are the most important actor group in managing the new helpful devices and systems.

There is an inherent difference between water and wastewater; individuals can always manage to discharge fair-quality wastewater, but not everyone can secure enough fresh water. Individuals can select household products that are environmentally friendly and also treat the disposed water to a good-enough quality for reuse. If and when almost everyone applies such good management practices there will be no scarcity of water or fertiliser.

So, let us start our thinking from the final output from a system or arrangement.



A simple and productive idea is to start your thinking and planning process from the output or end point of the contemplated sanitation system. For instance, if we want to understand and assess a conventional sewerage we can line up the processes in the WWTP (see slide). We decide what quality of end products we would be prepared to accept in this case.

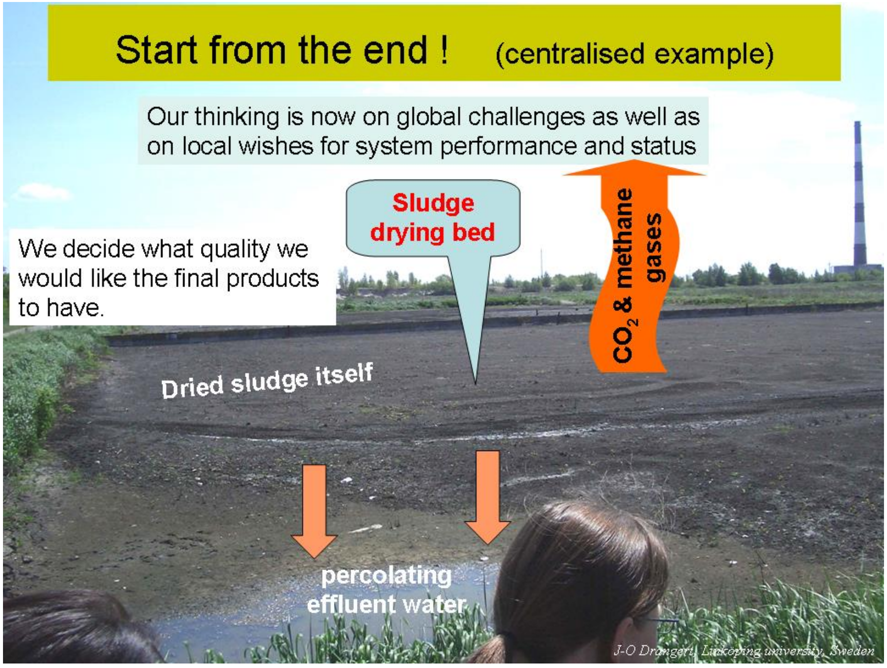
The sludge consists of matter that has been taken out of the wastewater, but still the wastewater contains a variety of compounds that have not been removed. For instance, some nutrients and most pharmaceuticals, hormones and heavy metals remain in the effluent. This means that the effluent was only partly treated and is perhaps not safe for reuse. One has to know more about what has been added to the water while using it. This is difficult and costly to find out for mixed wastewater from various places in town, but easy for individual households.

A decentralised system tends to be easier to manage simply because householders usually know what products they have discharged into the wastewater. It is also easier for people to adopt eco-friendly practices if they themselves are affected by nuisances due to polluting practices. It may be possible for small housing units to negotiate with fellow residents to use only non-harmful detergents and to restrict the use of other chemicals in their households.

Partly treated effluent causes less damage if applied on soil than if discharged in water bodies. The reason is that there are lots of microorganisms in the soil that can decompose compounds such as hormones (Module 4.6). Also, nutrients belong to the soil, not to water.

Any sanitation arrangement can be overloaded and therefore malfunction. During heavy rains wastewater treatment plants often receive too much wastewater and they have to let some pass by without treatment, or worse, it flushes the treatment units, causing sludge to leave the WWTP. Household treatment units may also be overloaded, but in this case the household will soon notice it and take measures to reduce the flow. Next time they have many guests, they will plan ahead to cater for the expected volume of wastewater. Next time they buy a washing machine they will select one that saves water and energy.

Treatment of wastewater always produces sludge which contains products which are harmful for the environment. The better the treatment, the greater the amount of sludge produced. The treatment and potential reuse of sludge is dealt with next.



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We start from the end point of the flow through a community. The end point could be where the effluent and sludge leave the wastewater treatment plant, or before the greywater, urine or composted organic material is applied on plants and soil in the garden. This picture of only a sludge drying bed is suitable as a short exercise to find out what the participants think of when they look at it.

The picture shows an ordinary sludge drying bed, and one may ponder about what comes out of the bed. The bed releases a number of gases into the atmosphere, including harmful greenhouse gases. We may decide that not more than *x* tons of carbon dioxide should be released per year, and less than y tons of nitrous gases. Also, the bed is likely to leak and the leachate is commonly highly polluted. Often the utility has a set of monitoring holes in the ground to be able to test the leachate quality. The leachate should be treated as wastewater before it is allowed to infiltrate the soil. The volume of percolating treated leachate which goes into the groundwater may be acceptable up to *z* litres per square meter and year provided it contains no more than w mg of heavy metals, etc.

In addition to emissions and leakages, the dried sludge itself contains high concentrations of chemicals and nutrients, often too high to be accepted by farmers as a fertiliser (Module 4.8).

The interesting question is how all requirements on sludge and emissions can be met. The leakage can be contained by an impermeable layer underneath the drying bed which withstands the hydraulic pressure from the sludge. The leachate is collected in a sedimentation and aeration tank and then goes to a vegetative wetland which is not harvested for fodder.

The emission of CO_2 originates from aerobic (composting at the surface) as well as anaerobic (digestion in the interior) conversion of starch in the sludge. Also, methane is produced during digestion. We want as much of the organic matter as possible in the wastewater to be trapped as sludge and not to remain in the effluent. So either we need to have less organic material in the water coming to the treatment plant (residents would be responsible for this) or to try to collect the emitted gases in a kind of tent covering the drying bed.

The quality of the sludge itself can only be economically improved by changing what residents put into the water while using it. Sludge can also be incinerated at a high cost. This issue is dealt with in Module 4.5.

This example shows the strength of the back-casting approach. Other questions come to the fore and you decide which compounds to follow backwards all the way to the household. This is more comprehensive than trying to calibrate a given system to get acceptable end products.

2.5 - 9

The effluent is usually clear and transparent (see bottle) which indicates that much of the organic material has been reduced. However, a more sophisticated process would be needed to take away microorganisms (viruses, helminth eggs etc.), heavy metals and other contaminants (see greywater module). The "stairs" or small waterfalls (left picture) add oxygen to the effluent that helps aerobic microorganisms to degrade the remaining organic material.

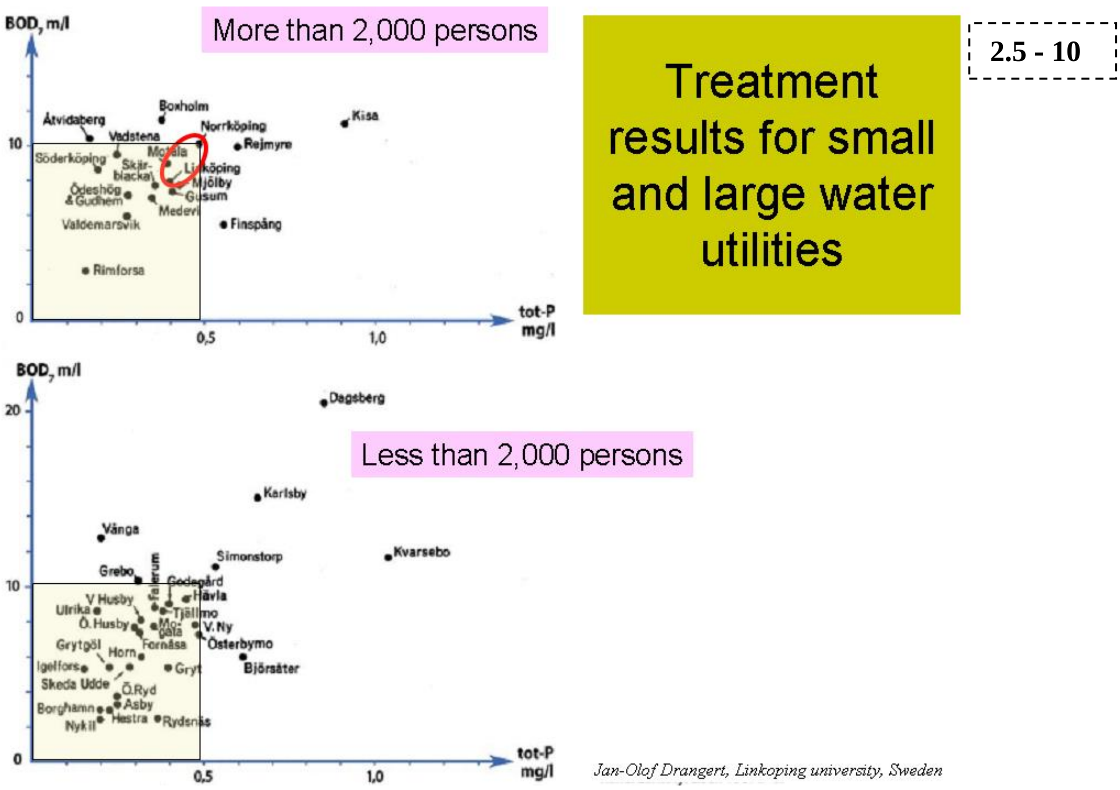
An alternative to the conventional sewerage comprises a sustainable system for a single household or group of houses which can be wholly self-contained as described in Module 2.1. A house may have an indoor urine-diverting dry toilet and a garden compost system for organic material, and greywater treatment.

The urine from a single family can, according to the WHO Guidelines, be used immediately as a fertiliser in the garden with very few precautions (see Chapter 3). Plants will take up the nutrients and if a person's daily urine volume is applied on a new square meter every day, the plants can utilise these nutrients productively (see Module 4.8).

Faecal matter mixed with toilet paper stored for a year is hygienised and ready to be applied in the garden (WHO, 2006). It may also be co-composted with kitchen waste. When the mature material is worked into the topsoil it will provide much-needed soil improvement (see Module 4.3). There is nothing left to take care of since we have only returned the organic material we ate earlier. However, both urine and faecal matter may contain medicinal remains such as endocrine disruptors and pharmaceuticals. Such chemicals will most likely be degraded by micro-organisms in the soil in a rather short while, and they are not taken up by plants (WHO, 2006).

The kitchen water is screened in a grease-trap before being treated in a soil filter (see greywater chapter). Solid organic particles and fat/oil/grease will be trapped and can be added to the compost of organics and faecal matter, and later applied to the garden. What remains in the greywater is further sieved by soil grains and degraded by microorganisms in the soil. If only a few chemical products have been added to the water while using it, the greywater does not contain a lot of chemical compounds and can be used for underground irrigation of a hedge or trees. The capacity of the soil to treat wastewater depends on the permeability of the soil and the water uptake of plants (evapotranspiration). Assuming that the household does not pollute the water too much and tries to conserve water, the emissions and rest products from the sanitation system can all be gainfully reused for soil improvement, and as feed to microorganisms and plants.

There are no fees or other expenses incurred, only some work to be done by householders. Whether it is well paid or not depends on income levels, but more important is perhaps the satisfaction of leaving no sludge and minimising emissions to the air.

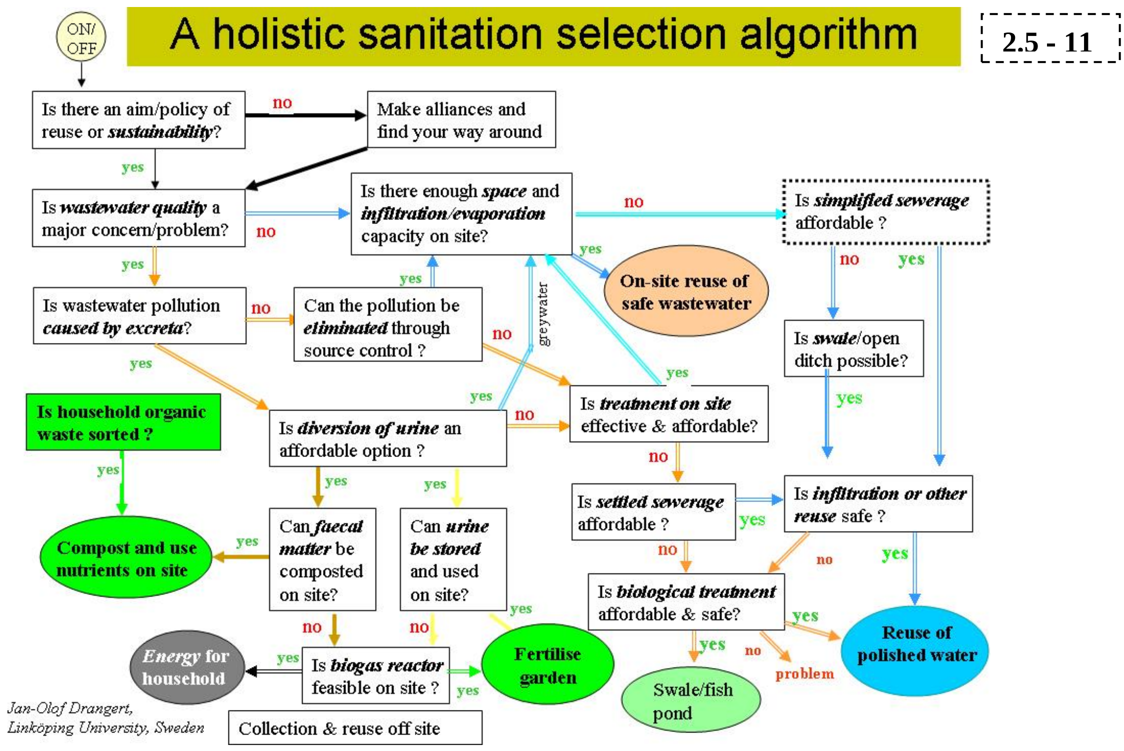


A powerful standard argument in favour of centralised networks is that a large-scale utility will use the latest technology, have better trained staff to operate and maintain the system, and can provide cheaper services for its customers. Research and development of wastewater treatment has focussed on large units, and household options such as septic tanks attract almost no R&D. Yet, there is evidence that the large units in practice do not necessarily improve the effluent quality above what the small systems can achieve.

The picture above shows a comparison of treatment results for small and large wastewater treatment units in a Swedish county (slide 2.3-11). Two important indicators of effluent quality, BOD and total phosphorus levels, were selected and the findings are presented for 18 communities with more than 2,000 persons and for 26 with less than 2,000 person equivalents (picture). Linköping and Norrköping cities have by far the largest WWTP serving about 100 000 inhabitants. The BOD-levels in their effluent is 10 mg/l, and the total P level is 0.4 and 0.5 mg/l respectively. Only three communities with some thousands inhabitants served by small WWTPs had higher values, while ten had clearly better results than the cities (inside the coloured rectangle).

The communities with less than 2,000 inhabitants also exhibit better treatment results than the two cities with three exceptions (far outside the rectangle). The finding that small and middle-sized communities fare so well is not because the industries are located in the two cities. That could have been the case for other compounds but not for BOD (organic matter) and P. The conclusion is that bigger treatment plants do not guarantee better treatment results. Since then, more research has gone into small treatment units down to household level and today, treatment quality is not an argument in favour of centralised solutions.

In the future, when households are acknowledged partners in managing the waste flows, it will still be easier for residents to make meaningful contributions in a small system than a large one. This contribution is likely to have a huge bearing on reuse management.



The number of requirements placed on a sanitation system is overwhelming, and we need some kind of guidance on how to sequence our thinking. The above flow diagram shows such a guide. The question or issue raised in each box has a yes or no response. The answer guides you to the following box etc. Blue arrows indicate fairly good wastewater quality, while the yellow colour indicates a concern of its quality.

The first issue is about policy. A good environmental policy is likely to permit alternative sanitation arrangements. However, if the community does not have a progressive legal framework, you need to find ways to align with other stakeholders to implement your sustainability ideas.

You start your '*thinking journey*' from the end product wastewater and its quality. The concerns about the quality of the wastewater – determined by tests or just by residents' perceptions – is fundamental. It is mainly a matter of perceptions since we rarely have solid knowledge about the health and environmental impacts of various wastewaters. Therefore, the precautionary principle (and compound substitution) should be followed (slide 2.3-3). Available methods to treat wastewater are detailed in the greywater chapter and in Mara et al., 2007.

If there is no concern about the quality of wastewater, it can be used on site – given there is space enough for irrigation (pink oval) and/or infiltration and evaporation. The risk of ground-water contamination is minimal, since the wastewater is considered safe. However, if space is limited, the wastewater has to be moved outside the plot through a simplified sewer – if affordable – otherwise in a swale or open ditch to a site where it can be reused (blue oval). If the quality has deteriorated during the transport e.g. mixed with solid waste, it has to be treated before use in a swale or fish pond (white oval). If this is not affordable, there is a real risk of degradation of the environment (named problem in the picture)

In conclusion, if the wastewater is relatively clean it can almost always be used productively on site or nearby.

Now, we go back to the box in the top left which asks ‘Is wastewater quality a major concern/ problem?’ If the quality is considered a problem, we need to know the perceived reason. If it is thought to be caused by chemicals or solids other than excreta, such as grease, paint residues or smell, the first question is whether residents can eliminate the problem by simple source control. If they agree to be more careful with what they put into the water, the wastewater quality improves and again is considered ‘safe’ regarding chemicals. The line of investigation follows the one above and the wastewater can be used on site or nearby.

However, if the quality cannot be improved through source control, the wastewater has to be treated somehow. If treatment is affordable and effective on site (simple treatment unit) the effluent can be used on site – if space is available (pink oval). Otherwise, the wastewater has to be transferred to a settled sewage pond followed by reuse – if this option is affordable.

If the quality problem arises from excreta, a simple source control measure is to divert urine and faeces. If a urine-diverting toilet is not affordable, treatment on site will not be affordable (since it is more expensive) and nor will settled sewerage or biological treatment. So, there would be a genuine problem. However, there are urine-diverting toilets costing from zero to several hundred US dollars. Where faecal matter can be composted on site, it is done together with organic waste, while the urine is collected, stored and used in the garden. If there is no space for this storage or no garden, the products can be transported off site for treatment, or to a biogas reactor that takes care of faecal matter, greywater and organic waste on-site or off-site (see Module on biogas). The gas is for cooking and lighting, and the effluent goes to farmland if treated enough.

This algorithm gives first priority to source control (slide 1.3-8), and to on-site no-mix arrangements (slide 1.3-24) and recovery/reuse/recycling of the treated wastewater. The reason is simply that small systems leave a less polluted product and can often cater for reuse on site. This is in line with the household-centred approach that Eawag/Sandec promotes (Schertenleib et al., 2003).

The questions in the algorithm deal with the functional appropriateness of each step in the selection process due to landscape characteristics, density, affordability, and other important factors. The answers will decide what solutions are possible at each step. Even after finding a possible option there is often more than one technology device that can bring the desired services. At this stage the search starts for sustainable technical options that are manageable.

Among all the possible solutions you eventually make your choice. At this stage you are supposed to reflect on why you perhaps denounce some feasible options and favour others. The algorithm makes the process more transparent and any resident or house buyer can ask proper questions about what options there are under the local circumstances, and decide what could be an appropriate arrangement for him or her.

Time to search for technical solutions!

2.5 - 12

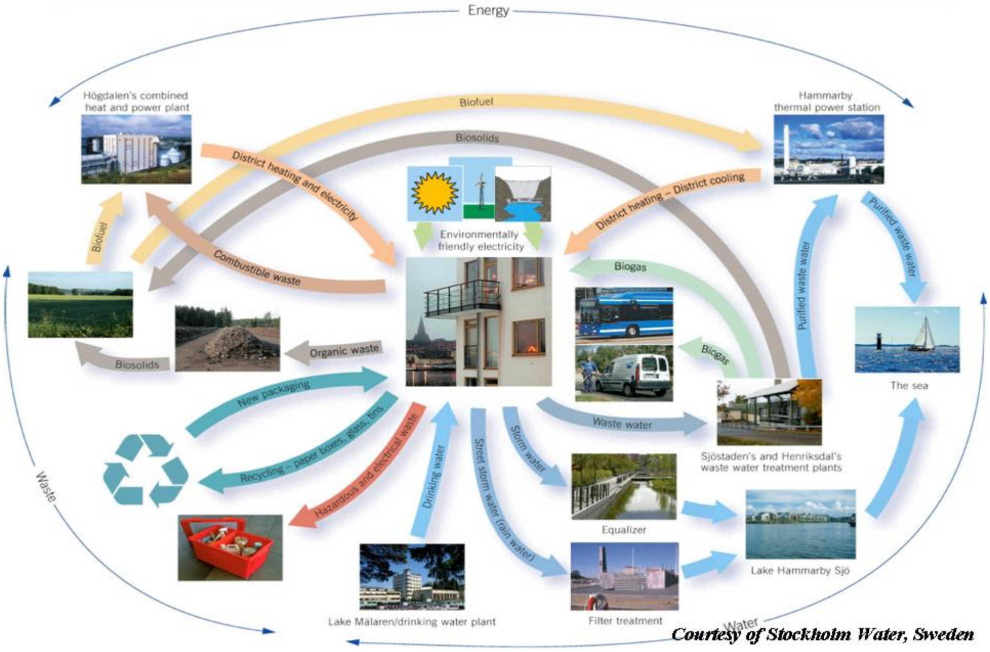
Module 2.1 provides examples of eco-friendly arrangements in urban areas: for a single house, to small communities and all the way to a town district. If there is water scarcity or irregular supply of water or electricity, there is a strong case for collecting rainwater, and treating and using greywater in order to secure a constant supply of water. The pressing demand on groundwater and surface water will lessen through such measures, and the sustainability will improve.

Many of the decisions on planning and zoning are based on an early choice of technology and not on a proper analysis of how this stands in comparison with other solutions. The new strategy is to solve the sanitation arrangements as close to the household as possible. This approach makes the households partners in reaching the development goals and also reduces the use of scarce resources ranging from funds to administrative capacity in the municipality, both for primary construction as well as for operation and maintenance. We have also mentioned several times that environmentally sound behaviour is strengthened when negative consequences affect wrong-doers directly.

One additional point should be made here. Since the future is not known, there is good reason for constructing new sanitation systems in such a way that they can (easily) be adjusted to new technologies or management solutions. For instance, preparing for solar heated water on the rooftop, pre-preparing for urinals in the toilet rooms, and making appropriate space available for water meters to be installed later are all valid and cost-effective installations. Another example of such pre-preparation is to install dual water pipes in all new houses in areas with water scarcity. This would make future investments in high-degree treatment of wastewater and recycling of secondary-water quality affordable, since no retrofitting will be needed. In the same vein, the builder could install a pipe for future connection of a separate urine collection system. Such measures would be VERY cheap and worthwhile to do even if they are never used. The added value of making the arrangement more flexible is worth the small investment.

A new housing area in central Stockholm

2.5 - 13



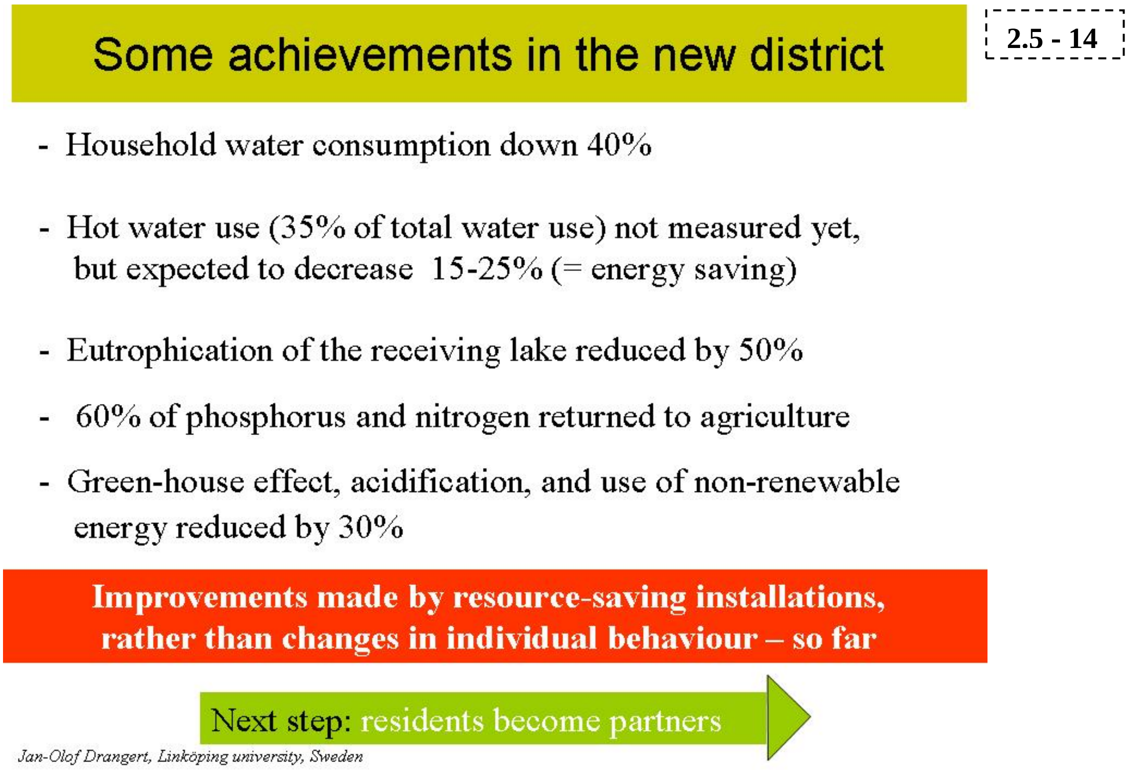
Courtesy of Stockholm Water, Sweden

The Stockholm city council decided to build a new housing district, Hammarby Sjöstad, in what was a cottage industry area near to the city centre. They seized the opportunity to build a sustainable housing and office area where resource flows were geared towards reuse. The municipal agencies in charge of water, wastewater, energy and solid waste handling coordinated their planning activities so that each single flow was viewed in a holistic fashion irrespective of which utility had the formal responsibility. The goal was to become *'twice as good as conventional buildings*'. That meant using only half of the usual amount of water and half the energy, reducing eutrophication, heavy metals etc. by half, but an 80 % reduction in person transport with individual cars. This model shows how sewage processing and energy provision interact, how refuse can be handled and the added-values society may gain from modern sewage and waste processing (http://www.hammarbysjostad.se/).

The incentive to envisage such a radical shift for a new district with 9,000 flats and offices and public services came in 1996 during the initial planning to apply for the 2004 Olympic Games. Stockholm wanted to show a green face and use some of the housing for the games. The detailed planning went ahead and, although Stockholm was not selected to host the games, the housing project continued with slightly lower sustainable ambitions.

The project was an invigorating experience for many professionals in that they could pool their competences and achieve better results. The cooperation between the utilities was partly driven by a politically appointed steering group. When the energy company owned by the municipality was sold in 2001 the new multinational company that purchased the unit was not as interested in investing more. Towards the end of the 10-year construction phase issues about operation and maintenance took precedence. Yet, the municipality set additional environmental goals for Hammarby Sjöstad in 2005 for improved designs and formulated new roles to households in order to engage them to a greater extent (Lind, 2006).

Almost a decade later, when another new housing district was planned to be built in 2010–20 many of the sustainable ideas survived but the cooperation between the utilities was not as close. Still, the Olympic project has had a long-term impact on building practices in the city by introducing a programme of environmental adjustment of water and sanitation which integrates lifestyles, technology and conscious planning. A new interest-arousing idea is needed in order to take the next leap in sustainable urban housing. Maybe the need to lower emissions of greenhouse gases will create this momentum?



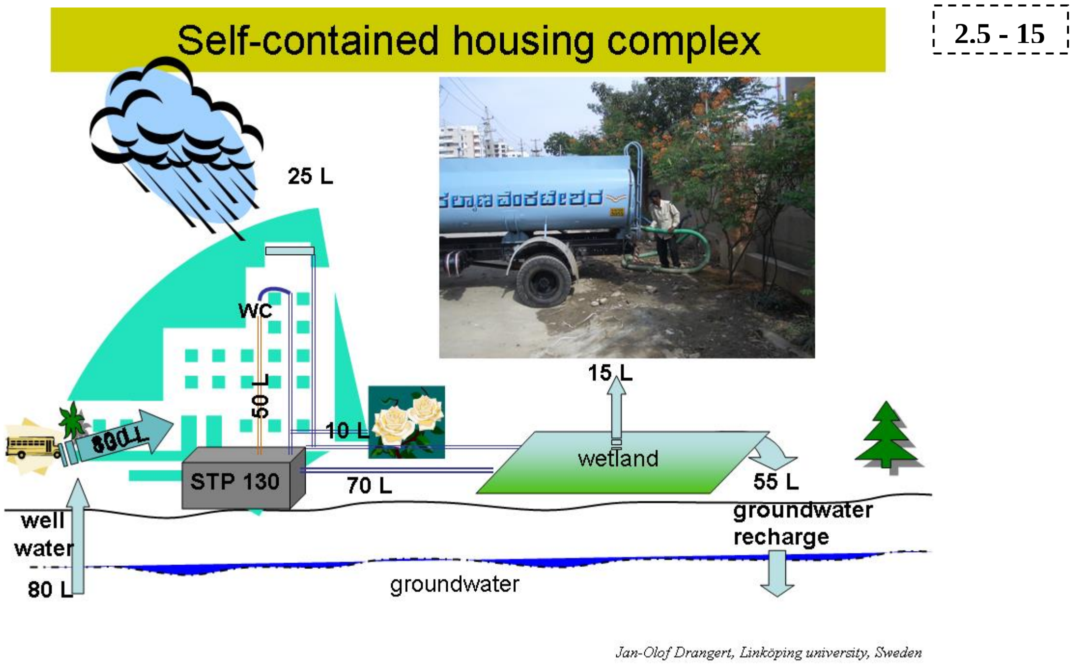
The selection of sanitation arrangements has profound impact on resource flows and resource use in urban areas. In the case of the sustainable housing district in the capital Stockholm the arrangements led to a reduction of resource use and negative environmental impacts:

- Water use fell by 40% compared to a comparable housing area without eco-installations. If dry toilets had also been installed (these were too new and not sufficiently tested when this project was begun in the 1990s) another 30% reduction would have been achieved.
- The use of hot water decreased by about 20%, which is an important energy saving and a reduction of the energy cost for the household – all achieved without affecting comfort levels.
- The housing area is situated on a lake, and the reduction (compared to ordinary houses) of eutrophication by 50% will gradually improve lake water quality and make bathing possible in the future.
- In this case 60% of the nutrients are returned to agriculture, and it could have been more if some of the organic waste was not incinerated for heating purposes.
- Emissions of greenhouse gases and acidification of the air was reduced by one-third. This is not seen by residents, but is very favourable for the environment.

All these improvements were achieved with careful selection of flows and technical outfit.

The next step to improve sustainability will be to involve residents as partners. Once they start being more cautious about water usage and use more environmentally friendly products, the achievements will be even better. It is not wishful thinking to strive for zero emissions and ultra-low use of natural resources. The energy sector can inspire new thinking, since it is closing in on zero-energy houses in cold climates.

A globally important decision was taken in China in 2006. Beijing authorities issued new building design regulations that mandate new building to adopt energy-saving technologies for cooling, heating, ventilation and lighting. The stated target is to cut building energy use in all cities by 50 per cent by 2010 and 65 per cent by 2020, compared with buildings constructed in the 1980s (*The Straits Times*, Dec 7, 2009). A similar visionary regulation is required for the sanitation sector, but this has not yet gotten the attention of the authorities or the industry.



A water balance calculation is helpful in exploring and assessing different strategies to achieve sustainability. Wasteful behaviour is common, since humans have had little experience in measuring water volumes, and even less in estimating the volume of flowing water. A person could leave taps gushing while doing other things. Practical demonstrations of how much water is flowing from an open tap per hour shows that 100 litres is easy to waste (slide 1.1-18). This is equal to the water used by a normal user for all his activities in a full day. Our poor grasp of how much water can be saved or lost, may explain a large part of present wasteful use of water.

Let us assume a design volume of 130 lpcd (litres per capita per day) which is deemed to be enough for all water-related activities, including flushing the toilet. Any demand in excess of this amount can be eliminated by demand management measures such as higher tariffs. Initially we can imagine that this amount was planned to be brought to a housing complex by a truck (top right and slide 2.1-18). This was deemed to be too costly and the resident decided to treat their wastewater in a mini-sewage treatment plant (STP) in the basement. The treated effluent is used for toilet flushing and watering the garden. An average resident uses 50 litres for toilet flushing, so they needed to truck only 80 litres of 'fresh' water from the well 2 km away.

All 130 litres used by the person in this example are treated in the mini-STP and 50 L goes back to the flush toilet, some 10 L is used in the garden and 70 L remains. In order not to waste this treated water, they decided to treat it further so that it could be used for washing, bathing and cooking. The main alternatives were to treat it in a more advanced WWTP, or biologically in a wetland – if space is available. Some water in the wetland would evaporate; say 15 lpcd, while the remaining 55 litres would recharge the groundwater together with 25 lpcd of rain falling on the housing area.

In this scenario, 80 lpcd can be withdrawn from wells in the garden without compromising the groundwater level. And no need to truck water. The quality of the well water can be further secured by adding a simple treatment (Module 4.7) before it is distributed to the flats in separate water pipes. The quality of this water is better than the truck water that would otherwise be delivered to the housing complex. No wastewater or stormwater leaves the compound, but the sludge has to be treated in situ or sent to a WWTP. The saved fees for water supply and wastewater treatment are used to pay for investments and operation of the system. No changes are required in resident behaviour.

The volume of used water can be reduced further and the quality of the water going to the mini-STP can be enhanced further by installing dry toilets with separate handling of urine and faecal matter. Such a system would also retain the valuable nutrients from the water flow and make them available as a fertiliser for the gardens.

2.5 - 16

A vision for sanitation arrangements

National and local governments provide guidelines for installation and operation of eco-friendly arrangements.

A single household or a housing company can find eco-friendly products in ordinary hardware shops and outlets for contractors.

Small and large contractors, plumbers and engineering firms, architects are familiar with the requirements of eco-friendly installations.

Jan-Olof Drangert, Linköping university, Sweden

Sanitation for the world’s growing urban population requires new eco-friendly devices and management solutions that involve residents. Not only do residents need to be aware of resource-saving arrangements, they need to have easy access to them. Therefore, the professional groups engaged in the sanitation and water sector should provide these services, and not just provide or copy earlier environmentally unfriendly arrangements.

The vision is that national and local governments will provide guidelines to reshape the sector so that it plays its part for a more sustainable society and city. This will translate into local decision-makers on building boards being knowledgeable about new technologies and management options, and being able to assist and advise builders and residents.

A family looking for a house or flat should be provided with green data on what is on the market, so that they can make an informed choice.

Planners, architects, and builders should face the challenge of increasing the efficiency of buildings through qualitative regulations such as reducing fresh water use by, say 80 %, and recovery of nutrients in organic waste by 90 % etc. Such achievement-oriented rules make it possible for the developers and manufacturing industry to find technical and management mixes suitable for the area where they are going to build the houses – without distorting the housing or sanitation market.

Once such regulations are in place, the whole sector will adjust and adapt by coming up with craftsmen and O&M staff who can handle the new technical and management arrangements.

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