

# **Application of closed-loop sanitation approaches in the township of Yang Song**

## **Baseline-Study**

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<b>0</b>	<b>Introduction .....</b>	<b>0-3</b>
0.1	Study aims.....	0-3
0.2	ecosan – ecological sanitation .....	0-3
0.3	Methodology .....	0-5
0.4	Summary .....	0-6
<b>1</b>	<b>Yang Song township.....</b>	<b>1-12</b>
1.1	Location and Geography.....	1-12
1.2	Population.....	1-12
1.3	Infrastructure .....	1-13
1.4	Economy, Industry and Trade.....	1-14
1.5	Agriculture .....	1-15
1.6	Housing Area.....	1-16
1.7	Villages .....	1-16
1.8	New settlements .....	1-17
1.9	Township and village environments .....	1-18
1.9.1	Water .....	1-18
1.9.2	Recreation areas.....	1-19
1.9.3	Climate .....	1-19
<b>2</b>	<b>Township construction planning .....</b>	<b>2-20</b>
2.1	Historical review.....	2-20
2.2	Today's situation.....	2-20
2.3	Future developments .....	2-20
2.4	Model and Eco-Model Cities .....	2-22
<b>3</b>	<b>Urban and Rural Water Supply.....</b>	<b>3-24</b>
3.1	Sources, Quantities and Qualities .....	3-24
3.1.1	Groundwater.....	3-24
3.1.2	Surface water.....	3-24
3.1.3	Rainwater .....	3-25
3.2	Water protection .....	3-25
3.3	Today's and future use .....	3-26
3.3.1	Waterworks.....	3-26
3.3.2	Today's water supply .....	3-27
3.3.3	Future water supply .....	3-27
3.3.4	Water consumption/demand .....	3-27
3.4	Implemented water saving measures.....	3-30
3.5	Water Pricing.....	3-30
3.6	Strategic proposals.....	3-31
<b>4</b>	<b>Sanitary situation .....</b>	<b>4-32</b>
4.1	Historical development.....	4-32
4.2	Today's situation.....	4-32
4.2.1	Wastewater.....	4-32
4.2.2	Solid Wastes:.....	4-34
4.3	Future planning.....	4-37
4.3.1	Wastewater treatment.....	4-37
4.3.2	Wastewater reuse.....	4-38
4.3.3	Solid Waste.....	4-38
4.3.4	Sanitation.....	4-39
4.3.5	Faeces collection .....	4-40
<b>5</b>	<b>Strategic ecosan-oriented proposals.....</b>	<b>5-42</b>
5.1	How does wastewater harm the environment? .....	5-42
5.2	What is domestic wastewater?.....	5-43
5.3	Proposed Water/wastewater Concept:.....	5-45
5.4	Nutrient concept:.....	5-46

5.5	Practical Proposals .....	5-47
5.5.1	Recommendations for existing residential areas .....	5-47
5.5.2	Recommendations for new residential areas.....	5-47
5.5.3	Decentralized wastewater treatment system (DEWATS).....	5-48
5.5.4	Direct Greywater Distribution system .....	5-49
5.5.5	Reed Bed - the Greywater Treatment and Distribution system.....	5-49
5.5.6	Vacuum Sewerage Systems (Outdoor Sewage Collection).....	5-50
5.5.7	Urine Separating Toilet .....	5-51
5.5.8	Summarized recommendations for the wastewater treatment.....	5-52
5.5.9	Summarized recommendations for sanitary equipment.....	5-52
<b>6</b>	<b>Appendices .....</b>	<b>6-53</b>

1 Y = 0.13 Euro

1 mu = 1/15 ha = 2.5 A

# 0 Introduction

## 0.1 Study aims

To demonstrate the application of ecosan-principles in township planning in China this study aims to come out with a definition of an ecosan-strategy for the township of Yang Song and could be the base for joint project proposals in the field of integrated ecological sanitation, preferably suitable for innovative technologies. The intention of this proposal is to show the practical implementation of water conservation and nutrient reuse in urban areas by using greywater and organic wastes from individual households for irrigation, toilet flushing and urban greenery and agriculture. It is essential to harness the scarce water resources to ensure an adequate supply of safe drinking water for all citizens.

## 0.2 ecosan – ecological sanitation

Dominant forms of central wastewater management, i.e. a combined system with post-connected multistage wastewater treatment facilities, are still standard in developed industrialized nations today. Increasing criticism has, however, been leveled at these methods for ecological and economic reasons. Increasing investment costs, high operating and maintenance costs and high water consumption as a result of misusing valuable drinking water just for transport give grounds to question such methods in rich nations, as well as in developing countries.

Particularly for arid and semiarid zones, the search for appropriate solutions has become a pressing problem. With increasing population density and the resultant groundwater pollution, conventional decentralized disposal systems such as latrines and seepage pits are not a viable alternative either. In the past, the development of water resources has been more demand driven, and conservation measures have not been adequately addressed.

In addition to this, conventional wastewater disposal systems directly impair soil fertility as the valuable nutrients and trace elements contained in human excrement are not usually re-channeled into agriculture. Even where sewage sludge is put to agricultural use only a small fraction of the nutrients are reintroduced into the living soil layer. Most are either lost (e.g. ammonia) or enter the water balance, where they pollute the environment and create hygienic problems. Frequently, the use of sewage sludge from central wastewater systems is also restricted as it contains a too high concentration of heavy metals and other hazardous substances, often as a result of intermixing household with commercial/industrial wastewater and with rainwater from contaminated streets.

In fact, conventional wastewater systems are largely linear end-of-pipe systems where drinking water is misused to mix and transport waste into the water cycle, causing environmental damage and hygienic hazards.

An alternative approach to avoid the disadvantages of conventional wastewater systems is ecological sanitation, 'ecosan' for short. This is based on an overall view of material and energy flows as part of ecologically and economically sustainable wastewater management systems tailored to local needs. It does not favor a specific technology, but constitutes a new philosophy in handling substances that have so far been seen merely as wastewater and water-carried waste for disposal.

In traditional agriculture since about 1000 years, that is still found in many parts of China and even in Yang Song area, suburb of Beijing, the farmers utilize a nutrient-rich mixture of urine and faeces (“night soil”) from simple latrine and pits, even from nearby towns, and manure from their livestock operations as organic fertilizer for their gardens and fields. The implementation of a new sanitation technology and sewer system (flushing toilet, combined sewer system) dilutes the night soil to black water. Consequence: the nutrient content becomes too low for fertilizing fields. The farmers are deprived of their cheap fertilizer sources and are forced to use more expensive artificial fertilizer and irrigation water. On the other hand there are severe concerns about the health and hygienic risks caused by the traditional untreated night soil distribution. Pathogens and bacteria are transferred onto the plants or into the soils, where they can persist and enter the food chain via certain crops.

Based on the experience and limitations of the so called traditional system, there is a great opportunity for implementation and establishment of improved “ecosan” strategies in China, where they can guarantee an appropriate treatment standard to minimize health risks, to prevent water and soil pollution and support the efficient utilization of wastewater and available nutrients.

Systems based on this approach are used for the systematic closure of local material flow cycles and thus ultimately allow recycling systems as are already in common use for solid waste. They also restore a remarkable natural balance between the quantity of nutrients excreted by one person a year and nutrients needed to produce his food (7.5 kg nitrate, phosphorous and potassium for 250 kg grain<sup>1</sup>). Ideally, ecosan systems enable almost complete recovery of nutrients and trace elements in household wastewater and their reuse in agriculture - after appropriate treatment. In this way they help to preserve soil fertility and safeguard long-term food security.

As an integral alternative, a hallmark of ecosan is its interdisciplinary approach that goes beyond the narrow domestic water supply and their technological aspects: the approach subsumes agricultural use, other wastes, specific plant production for treatment purposes, energy aspects, sociology, employment, hygiene, health, town planning, economy/small-enterprise promotion, administration, etc. in its system development.

In addition, water conservation measures are strongly encouraged by the Chinese Government to protect the nation’s limited and valuable water resources. In view of the scarcity of these resources, conservation measures will assume even greater importance in the future. Water conservation measures that can reduce wastewater quantities are:

- Appropriate pricing structure of water supply
- The fitting of water efficient plumbing devices
- The use of water saving domestic appliances
- The use of sullage for garden watering (Greywater)
- Good “housekeeping” by industries
- The recycling of industrial process water
- Collection of rainwater for gardening and agricultural use

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<sup>1</sup> (Wolgast, 1993, *Recycling System, WM Ek ologen AB, Stockholm*)

- Changes in water use behavior (showers instead baths)
- Reduction of water and wastewater losses in the piping system

In practice, the ecosan strategies of separation and separate treatment of faeces, urine and greywater for example, minimize consumption of valuable drinking water and treat separated and specific wastewaters at often lower costs and preferably for subsequent soil amelioration, fertilizer, for domestic and irrigation purposes.

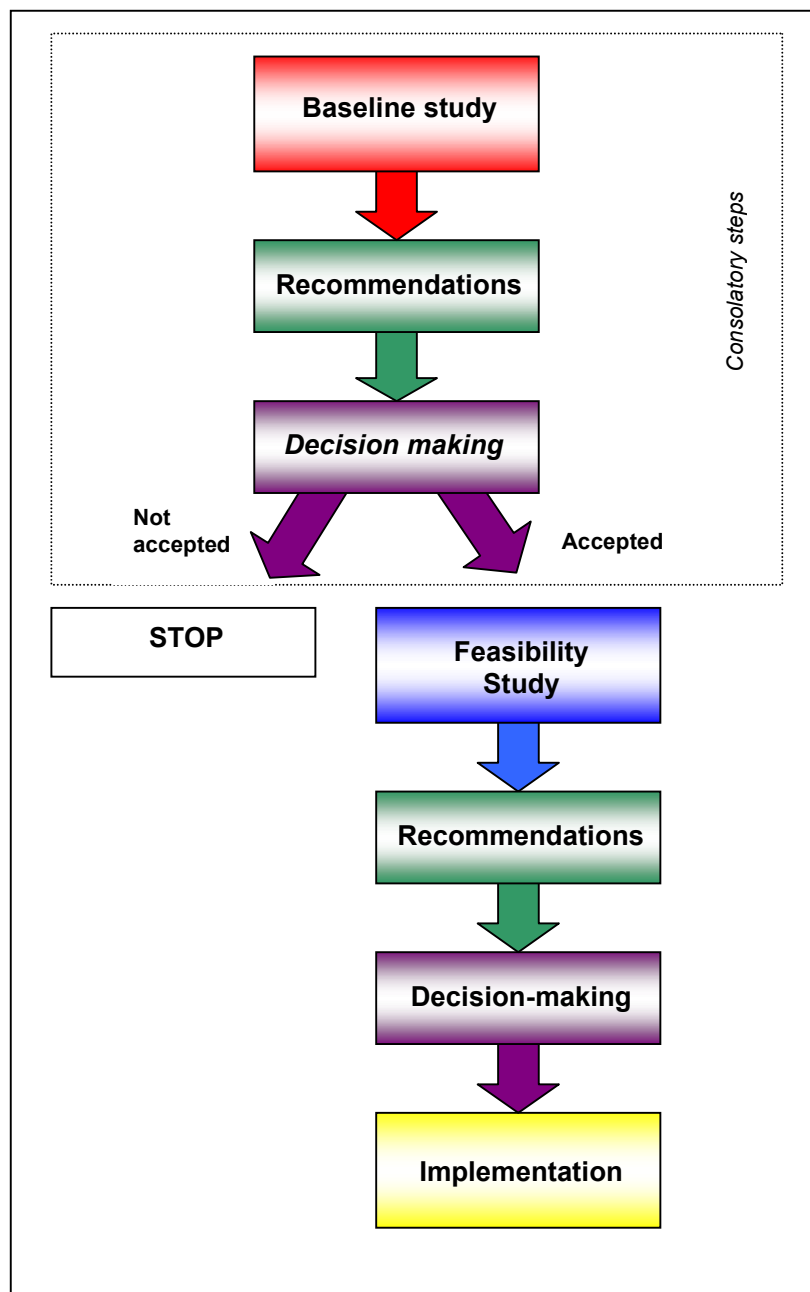
### **0.3 Methodology**

Main activities of the study team in cooperation with Yang Song Municipality, which have been executed between June and October 2002:

- √ A database about existing and further planned infrastructure, housing areas, industrial areas, entertainment facilities and agricultural areas was prepared.
- √ Existing and potential waste and wastewater related problems, impacts, quality and quantity, if possible separated by streams and sources have been listed.
- √ Environmental standards permitted for the specific area have been analyzed.
- √ Technical, environmental and economical frame parameter and criteria for nutrient recycling oriented waste and wastewater treatment, disposal and reuse, were listed.
- √ Technical solutions to fulfill ecosan-criteria under the given infrastructure and economical situation are being proposed.

To collect the data for the study in Yang Song, four methodologies have been used:

- A) Interview with authorities on local, provincial, and national level
- B) Interview with village and town population
- C) Field and site visits
- D) Statistical analysis and report studies



#### 0.4 Summary

With rapid urbanization and modernization, Yang Song, like other developing towns in China, is facing a huge environmental challenge, particularly with regard to waste and wastewater treatment. The implementation of flushing toilet systems and the planned construction of a conventional wastewater treatment plant deprives the local farmers, who are still dependent on the traditional use of night-soil, of valuable nutrients. As Yang Song local council is currently considering various treatment technologies for municipal wastewater, this study aims to produce a definition of a jointly developed ecological sanitation strategy for the urban and rural district. With regard to the model-status of the township and the upcoming Beijing Olympic games in 2008, the GTZ-ecosan project expects an announcement effect for other townships and cities in China, and worldwide.

Yang Song township is located in Beijing province, 45 km from the Chinese capital. It consists of a city surrounded by 15 villages. Actually, it has a total population of 21.00 inhabitants. Yang Song was named as a “model township” for small-town construction in 1997. This status obliges the government to develop the industrial and urban sector, and to protect and improve environmental conditions. In the township development plan the government plans to combine the 15 villages into 9, and to resettle the village population in the city by 2010, increasing the total population to 50.000 inhabitants. For this purpose the construction of new apartment houses, in the form of panel buildings, has already started since 2001. Additionally, the government wants to attract middle and upper class Beijing residents to move to this suburb, and to invest inside a new countryside villa-district by providing an environmental friendly atmosphere for them.

The economy of Yang Song is still dominated by the agricultural sector. The main agricultural activities are animal breeding, with a projected increasing in the number of cattle over the next years. In addition, there is a turning from classical crop production (corn, hops) towards more viable plants (medical plants, ging-seng, aloe vera, flower farms, fruits, etc.).

Yang Song is located in the main water catchments area for Beijing. Extraction for high and increasing water demand and consumption in Beijing province leads to a serious reduction of the groundwater resources, lowering the water table up to 1.5 meters annually. Yang Song relies heavily on the groundwater resources, as all freshwater for household, industry, greenery and agricultural purpose is coming from that source. In addition, in the last years the flow of 3 rivers in Yang Song area have decreased, even in the rainy summer months.

The construction of a central sewage pipe for the city and industrial district finished in November 2002, leading to a potential future treatment site 2 km south of the city. Presently, there is no treatment of municipal wastewater established, and the wastewater is just discharged onto the fields nearby. Yang Song council is seeking a solution, for an estimated total capacity of 2000 m<sup>3</sup>/day with the possibility of a future increase to 5000 m<sup>3</sup>/day. All already build new houses, however, are equipped with modern flushing toilets.

For the villages a sewerage system has not been planned and their population still relies on on-site sanitation. Designs and hygienic conditions differ with the economic status of the population and the village committee: the poor villagers have simple pit latrines, while the wealthier villagers have squatting toilets connected to septic tanks or storage tanks, and already use their own collected greywater for flushing. In 3 villages a greywater flushing device and a 3-compartment septic tank latrine have been introduced with financial support by the village committees. Vacuum tankers collect the content of the septic tanks, and the night-soil mixture is spread on the local fields. The household pays 10 Yuan/m<sup>3</sup> (~1,2 \$) to the private collector for this service.

Yang Song township represents a closed area, with both urban and rural components, that can secure the utilization in its local agriculture. Good reasons for an ecosan concept in Yang Song are:

**Environment:** Pressure of water saving and groundwater protection in an area with considerable water scarcity; there is a high potential to substitute fresh water (groundwater) for irrigation in gardens, agriculture, the city greenbelts and or for the

existing water park. There is a big loss of organic material through its disposal in “landfills” (the organic content of the solid wastes disposed of is 60% and more) from household and market waste. Existing landfills are open pits without drainage, groundwater protection, protective cover, gas and leachate capture or pre-treatment.

**Sanitation:** An improvement on sanitation in the poor villages is urgently needed. Hygienic disposal and sanitary latrines with greywater flushing are already promoted. The households of the villa area can decide themselves about their choice of sanitary equipment.

**Agriculture sector:** Farmers still depend on night soil from village households and manure from farms with livestock. There is no social prejudice about excrement utilization, but over-fertilization with nutrients through artificial fertilizer, manure and night soil is assumed. Livestock operations have to comply with a new law on pollution prevention from animal production adopted in October 2001. However, there is an increasing demand of organic fertilizer for viable plantations, but under stricter environmental regulations.

**Local Government:** Existing willingness and public pressure to improve the environment (“model character”). Township and County governments are interested to implement advanced technologies and strategies is seeking a solution for the treatment of municipal wastewater from existing flush systems and non-polluting industries and offering financial support and free land.

**Other considerations:** As the farmers in Yang Song rely on night soil, manure and artificial fertilizer, the need for urine or compost from faecal sludge and organic wastes has to be carefully investigated. Therefore it is important to contact and co-operate with the local Bureau of Agriculture, which can give advice and support.

**Urine separation:** Urine separation is a traditional device in Southern China, and even proved their function in modern eco-toilets in Guanxi province. But in Yang Song a separate collection was not found in any part of the township. For implementing urine-separating toilets in the new buildings the panel construction would support a standardized design. On the other hand, the small bathroom limits the installation possibilities.

**Night soil or Compost:** Night soil and manure is still used in Yang Song to fertilize the fields. But nevertheless, no controls of the hygienic quality and the utilization of the product are carried out. Already existing reliable and private collection operations should be considered and integrated in the concept. Processing and the utilization of compost were not observed in Yang Song. Compost would represent a new kind of fertilizer for the farmers, and it would demand a change from traditional habits. The implementation of a new technology, like composting, for Yang Song can be considered as rather extensive.

**Drawbacks for ecosan:** The construction of first main sewers for the town was finished in November 2002. The location for the sewage treatment plant is fixed and a modification for the first step is almost not possible. Limited experience with ecological sanitation strategies in urban areas/large settlements, industrial wastewater has to be

treated anyway, and a separation of components seems not to be achievable. The actual low water price, which includes fees for wastewater, will not cover the cost for operation and maintenance, even not for fresh water supply. Financial support is necessary. The future development of the township (construction, agricultural and industrial sector, population, etc.) is strictly connected to the economic development, which makes forecasting and detailed planning difficult.

### **Proposed New Water concept**

The water concept focuses specifically on water saving, rainwater infiltration, reuse and a discharge control to protect the water resources.

**Water saving:** Water saving is possible for the households, industry and farming areas. In the villages, with low water consumption and utilization of greywater for toilet flushing, further water saving is hardly achievable.

**Rainwater infiltration:** As rainwater is collected in separate pipes, and precipitation takes place mainly in the summer months, its separation from the municipal wastewater is very promising. This will minimize the capacity of the treatment plant and is beneficial to the recharge of the groundwater.

**Discharge control:** For water resource protection, especially of the groundwater, a discharge control is very important. Particular focus should be put on the control of non-point source pollution from agricultural activities, such as fertilizer, overspill and the infiltration of manure from animal husbandry, faeces from pit latrines and overflows from septic tanks, that are responsible for nitrogen eutrophication in the water sources. In the future treatment plant the effluent has to be controlled. This should be done regularly by the Environmental Protection Department of Huai Rou County, and supported by measures of the Yang Song Government.

**Reuse:** There is a huge potential in the township for water reuse instead of groundwater extraction. Especially for irrigation, groundwater can be replaced to a greater or lesser extent by greywater, process water from industry, rainwater and, in the future by with treated wastewater from the (decentralized) treatment plant(s). In the summer months, when demand for irrigation water is very high, the greenbelts and the water park can benefit from recycled water. A crop, plant and especially flower irrigation with pre-treated wastewater is possible.<sup>2</sup>

**Nutrient concept:** The nutrient concept emphasizes the recovery of nutrients from the urine, faecal sludge and wastewater. These nutrients can benefit local agriculture and support - to a certain degree substitute - artificial fertilizers. In the villages the utilization of faecal sludge from latrine pits and septic tanks is still common, and the intention is to guarantee its safe utilization by establishing approved and improved designs, which allow for sufficient storage and thus treatment time<sup>3</sup>. For the town, a construction of a conventional wastewater plant will primarily eliminate and not recover the nutrients. In addition, the sludge produced has to be disposed of. But in an ecological sanitation

<sup>2</sup> In China irrigation with wastewater has to fulfill the 'national Standards for irrigation water quality [GB5084-92]' that are considering the type of irrigation area, and type of crops.

<sup>3</sup> National 'standards for Safe disposal of Excreta' were promulgated in 1987 [GB 7959-87]. 5 types of sanitary latrines are currently promoted in China: three-compartment septic tank latrine, double Urin latrine, Triplex biogas latrine, VIP latrines, urine diversion eco-latrine

concept the production and use of valuable fertilizer from the treatment process is an important factor. Sludge produced by sewage treatment plants should be used as a soil conditioner-fertilizer after treatment. Composting the sludge will control most pathogens and, if properly marketed, can contribute to the economic feasibility of the treatment plant. However, the agricultural application rate of composted sludge should be carefully calculated. The build-up of toxic metals in the soil can be neglected, because for Yang Song only household water and no hazardous components have to be considered. According to the agriculture legislation, the treatment of animal manure before use in agriculture is now imminent. Additionally, the treatment of a separately collected organic waste fraction from the municipal waste should be either added in biogas plants or to composting piles that also compost faecal sludge.

### **Technical and practical proposals**

Proposals are made in the fields of sanitary equipment (see tab. 1) and for the treatment of wastewater streams (see tab. 2). For a better understanding and to give appropriate proposals a matrix is set up. With respect to the different conditions the township area is divided into village and town (subdivision residential area and industry), and with respect to the development planning into existing, new and planned structures.

**Villages:** The design of on-site sanitation must be improved to assure a hygienic utilization of night soil. The squatting toilets built with greywater flushing and a connection to a septic tank, are a suitable technology. Concerning the collection of greywater, there are alternatives to the conventional sewerage system: simplified sewerage and settled sewerage. If a household keeps animals, established and well-known Chinese biogas systems with toilet connection seem to be the best solution.

**Recommendations for existing residential areas:** For the existing panel building area and the new panel building area only rainwater and household wastewater can be separated, this due to economic reasons: the investors are real estate companies and not yet willing to invest without extra subsidies into two internal wastewater piping systems. All changes will be hardly possible at once, but for further restoration and rehabilitation work ecological solutions should then always be respected. To permit a decentralized reuse of the wastewater, combined „Decentralized Wastewater Treatment Systems“ as developed by CEEIC (Chengdu) and HRIIEE (Hangzhou) are recommended. For on-site wastewater effluent improvement, additional anaerobic filter chambers could be constructed for the **villa area**, which is already under construction, treating wastewater instead of or after existing septic tanks. Future inhabitants can decide on their sanitary equipment; for example UDS (urine-diversion-System) can be one appropriate solution.

**Recommendations for new residential areas:** Separated blackwater/greywater collection systems and decentralized wastewater systems with a secondary treatment should be implemented. On-site treatment of blackwater by using baffled septic tanks with up-flow anaerobic filters is one of the feasible alternatives with promising high cost-benefit efficiency. After pre-treatment, treated blackwater should be discharged through vacuum sewers into sludge post-treatment biogas stations, where the organic solids fraction from the municipal solid waste are added. Then the effluent should be earthed in sludge decomposition lagoons and/or can be used directly as liquid soil conditioner.

Greywater is collected into a decentralized community treatment plant, that consists of Imhoff tank / waste stabilization ponds or constructed wetland, integrated into the greenbelts.

	Village	Town			
		Residential Buildings	Communal Buildings	Villa area	Industry
Existing	Improved latrine design: greywater flushing or separation toilettes	(Changes hardly achievable)		Owner can decide about sanitary equipment: Implementation of Urine diversion toilets difficult, vacuum toilets and -sewer system preferable, Separate blackwater and greywater disposal	(Changes hardly achievable)
New		Upgrade toilets with water saving device			Upgrade toilets with water saving device
Planned		Separate blackwater and greywater disposal. Toilets with water saving device, greywater flushing			Separate blackwater, greywater and process water disposal. Toilets with water saving device, greywater flushing, process water reuse

**Table:** Recommendations for sanitary equipment

	Village	Town			
		Residential Buildings	Communal Buildings	Villa area	Industry
Existing		DEWATS Modular expandable		-	Treatment with residential wastewater (Wastewater quality meet household quality)
New	Improved pit design with retention time Or: Simplified sewage with biogas or dry separation toilettes	Separate treatment of blackwater and greywater Black water: baffled septic tank with up-flow anaerobic filter, sludge post-treatment biogas stations Greywater: decentralized community's treatment plant. Consisting of Imhoff tank or constructed wetlands		Owner can decide: On-site treatment: Septic tanks with anaerobic filter chambers, dry separation etc.	Pre-treatment up to household wastewater quality
Planned					

**Table:** Recommendations for treatment of wastewater streams

# 1 Yang Song township

## 1.1 Location and Geography

Yang Song is a small township in Huai Rou County, 45 km northeast from Beijing city, and 25 km from the international airport. The township covers a total area of 30.5 sq km and lies on a flat terrain. The municipal government administrates the town and 15 villages. The urban district with a total area of about 3 square kilometers can be found in the northwest, the villages are located in the south and east of the Township.

Today Yang Song is gaining particular importance as a suburb of Beijing:

- The industry can profit from the neighborhood to the capital and good investment conditions (*see economy, industry and trade*).
- A good environment will support the development as a recreation and leisure area for Beijing citizens.
- According to official information<sup>4</sup> Yang Song has developed economically as well above average; in 1992 Beijing provincial Government chose Yang Song as a model-township.
- This status includes financial support from the Chinese government for further urbanization, economic development and not at last for environmental protection.



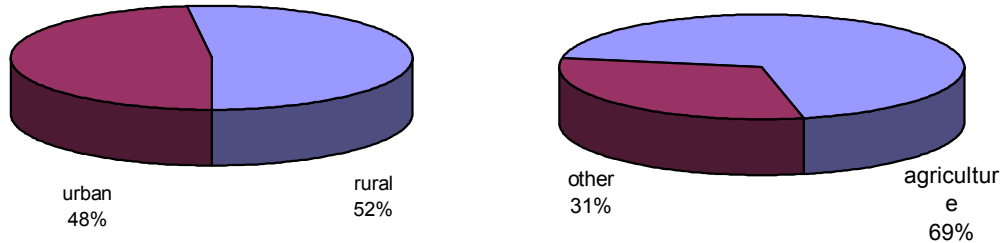
*Model of YS development plan in the governmental building*

## 1.2 Population

The population by the end of 2001:

21.000	people
5.500	households
14.500	agricultural population

<sup>4</sup> Interview with the township leader



The urbanization rate in 1996 was 46%, increasing to 48% in the year 2000 [5] and is now steadily growing<sup>5</sup>. The main reason is orders from the government to have villagers increasingly settle in townships, to increase the urbanization rate and thus assumingly reduce resource consumption (see *housing areas*). By finalizing the construction of the villa area by the end of 2002, an additional number of 3000 people are meant to move to the urban township area in 2003.

The average income in Yang Song is 5.300 Y/year/person

### 1.3 Infrastructure

One important priority in township planning is to build up the urban infrastructure. To that effect, in the last years the township government improved its technical infrastructure for the industrial park (telecommunication, water and energy-supply) in order to set up new industries and services. Since 1992 the Yang Song Government invested from its own funds more than 200 Billion RMB for road construction, communication, water and sanitation infrastructure, power and even into a gas network to develop the industrial zone.

The following infrastructure exists in the town (Sep 2002)

- The road construction has been completed in the last years, with a net of two vertical main roads and 7 horizontal main roads, all equipped with street lights, and sewerd to both sides
- Transportation: bus lines, collective taxis to Huai Rou county
- For approximately 1000 school kids there are 3 schools: 1 middle school and 2 primary schools,
- Kindergarden, asylums of the aged, small hospital
- Every household has telephone, guaranteed heat, electricity and water supply
- The power switching station has a capacity of 12.000 kilovolt ampere
- Two heating stations, including Long Xiang Heating Power service center and Feng Xiang gas station
- Organized Waste collection and a landfill for municipal refuse

The following infrastructure exists in the villages:

<sup>5</sup> In 2000 the population was 17943, plus 870 short-time inhabitants = 18813, representing a growth rate of 2.93% (from 1996 to 1998). <sup>[5]</sup> In the township and 6 neighbor villages: 8311, representing a growth rate of 4.11% (from 1996- 2000) <sup>[5]</sup>

- Main roads with street lights
- Transportation: public busses
- Water supply via pipes
- Landfill



#### 1.4 Economy, Industry and Trade

One of the first priorities for the Township Government is to improve its economy through a forced development of the industrial sector. To this end, Beijing Municipal Government approved the Feng Xiang Scien-tech Development Zone in 1992. It is located in the northwest of Yang Song Township; with an occupied area of 1 sq km. Yang Song provides specific investment-friendly tax regulations for attracting national and also foreign investors<sup>6</sup>. If the recent economical rates of growth are considered, the technical infrastructure is sufficient for the next 5 years.

*Excuse: In some places, the local governments may have special policies of taxation for industry and services in mountain areas. Yang Song belongs to Huai Rou County, which is located in a mountain area.*

In the year 2001 the Township Government sold more than 600 mu of its commercial lands to new investors. In the industrial zone, more than 40 companies are operating now, with more than 2000 employers.<sup>7</sup> These companies mainly operate in the field of services and consulting, in the beverage-industry, clothes and also in electro-technical engineering and electronics. Another big share is working in the IT sector. The majority are joint ventures and non-governmental companies. The only international company is a Danish furniture-manufacturer.

The township is not responsible for the control of the legal requirement and technical and environmental protection regulation, this is done on Huai Rou county and provincial level. To be able to keep the status as a model- township, the government only allows non-

<sup>6</sup> The leader of the IDZ: "Because of the special geographical position and specific cost advantages the Yang Song Development Zone is at present one of the much asked for investment areas in suburban Beijing."

<sup>7</sup> Leader of IDZ

polluting companies here.<sup>8</sup> Environmental impacts on air pollution, water consumption, sanitation and waste have to be low, or else the company is obliged to treat the wastes, wastewater and air by themselves.

## 1.5 Agriculture

Yang Song is still dominated by the agricultural sector, with 69% of the population working in agriculture.<sup>9</sup> Concerning the plans of Yang Song Township, there will be new regulations to strengthen development of the agricultural sector. To increase yield and financial benefit, the next important step will be to attract more companies that work in new technologies.

Today Yang Songs total area for agricultural use is 28.000 mu. The landscape is flat and the soil conditions are suited for agriculture. The water demand for irrigation is met by the groundwater derived from several wells (*see water supply*).

Presently Yang Song's main agricultural activities are the following:

- Milk-production: all animal husbandry farms in Yang Song have a total number of 4200 milking cows, with a total milk production of about 40 tons per day. In the last year the number has duplicated. Today there are four main farms, each with more than 200 cows and furthermore 6 farms for breeding.
- Grass and hay production: the cultivated area occupies 4000 mu, this is a share of about 25 % of the total area.
- Medical plants: More than 40 different types of medical plants are produced on 3500 mu. The farmers prefer these crops, because they can earn up to five times more. In the last year the demand increased, and especially international exports become a new source of revenue. One example is that farmers are investing into Ging-Seng plantations. The cultivated area up to now is 1000 mu.
- Other products are: wheat, fruits and vegetables. Some families have flower farms. Because of the increasing rate of new construction of parks and greenbelts in the urban areas, the trade with flowers and trees and other horticultural products (and so the need of organic fertilizer) is high.

The choice of products to be cultivated annually is fixed by Chinese governmental regulations, in line with the Chinese food demand and market situation.

Cultivated land (Z) is in public ownership, or belongs to the villages. Each farmer has the option to lease 1.4 mu of the land for subsistence cultivation. Crops produced beyond the subsistence level are sold on the local market.

*One typical farm is located in the Suo Cao Village. In 1998 18 farmers aligned to a joint stock- company. Today they own 600 milk cows. The cows are producing 8.000 Liters of milk per day, sold to one of the largest milk processing companies in Beijing. The 22 workers have plans to increase the capacity up to 1000 milk cows.*

*The animals are mainly fed with groundnut husks, hay, hop and grass. The company can get this feed easily from small farmers around the village. The manure is sold back to the farmers.*

<sup>8</sup> During an interview with a government officer he reported that in the future there would be a chemical industry.

<sup>9</sup> Although the township planning wants to strengthen the industrial sector.



*Livestock Farm*



*Flower Farm*

## **1.6 Housing Area**

Since being declared a model township for small-town-construction the urban district developed very fast. In the 2010-plan, one overall measure for the township development is to combine, respectively reduce the existing 15 villages to 9 village units. Some will be combined into 6 bigger administrative units; the rest of the population will be resettled in the town. For this purpose, the construction of new apartment houses is a must and has been firmly decided. In addition, financial support from Government is given to the “surviving” villages.

## **1.7 Villages**

The style of the houses in the villages and their sanitary equipment vary. In general, the houses of the settlements have the shape of a horseshoe, with 3 separated buildings and a courtyard, all surrounded by a wall. The main residential building consists of a living room and 3 to 5 sleeping rooms, partly with power supply, TV, telephone and central heating. The adjoining buildings are the kitchen together with a food storage room and the sanitary room in form of a wet booth (*see sanitation*). The other buildings are small and simple lofts. The courtyard has a little garden for subsistence purposes.

The fresh water is supplied via the village network. Some of the villages have no water supply for each house. The inhabitants have mostly built up their own water supply and drainage system for sanitation.



### 1.8 New settlements

In general, three different types of apartment houses can be distinguished in Yang Song, similar to the whole of China.

First category: The apartments have a simple architecture with 6 floors and four entries. Each block provides apartments for 12 families. ( $4 \times 12 = 48$  units) Every apartment unit consists of a living room and 4 sleeping rooms. The whole living area is about 80 sqm. The houses are connected to the central heating station, water supply and gas network. The buildings are characterized by a bad building-substance. The walls often are wet and the sanitary equipment in the bathrooms have low standard. In Yang Song that type of apartments is now occupied by previous village inhabitants since four years.

- Second category: The apartments have an improved construction with a higher standard of equipment. In Yang Song, those kinds of apartments are used in the trading and business area. The shops are in the ground floor; the upper floors are used as living areas.

- Villas: Today more and more villa areas in suburbs are built up. The total area of those houses in average is up to 400 sqm.



*New housing area first category, Yang Song*



*Apartment, second category*

## **1.9 Township and village environments**

The whole area is still dominated by rural or agricultural areas. The township gives the impression of an organized and clean environment. Groundwater-levels used to be, and soils still are excellent, in particular for agricultural use and cultivation. Yang Song Township is known to have an environment, where the air is fresh and free from pollution, and it enjoys as well plenty of surface water.

### **1.9.1 Water**

Yang Song is located in the major watershed area of Beijing. Surface water is coming from 3 small rivers in the Yang Song area. These are only serving as recreation areas, not as a fresh water source. There are 3 waterworks extracting groundwater for the town and village water supply. The water is now distributed via pipes in Yang Song. In recent years the population in the villages had to use conventional pumps. The majority of the

households are not using the water for drinking; they buy potable water in bottles or canisters.

### 1.9.2 Recreation areas

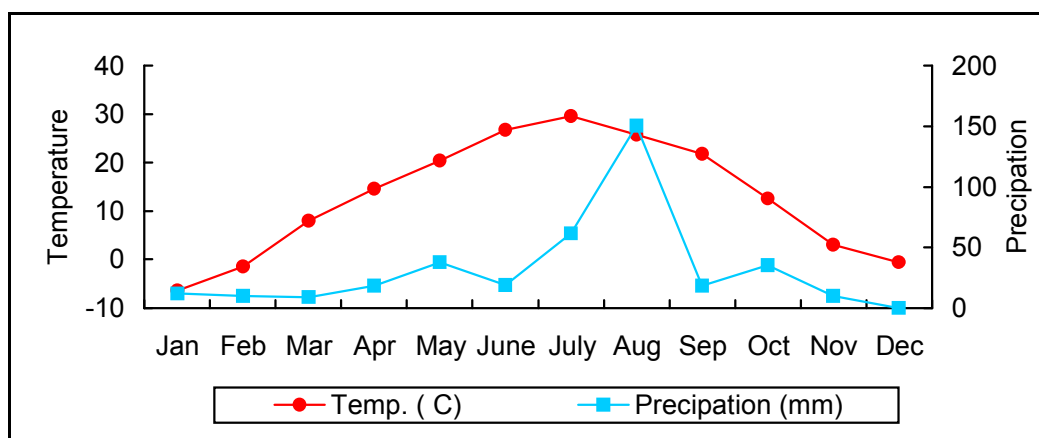
For recreation there are several places in the town and as well in the villages. In the middle of the town is the “plaza” with sporting facilities and the township statue. Located next to the public space, an attractive water park can be found, covering an area of about 100 mu. In the villages as well, there are some small meeting places and comfortable green areas.

### 1.9.3 Climate

Beijing province has a continental temperate (semi-humid) climate, with a cold dry winter, and wet, warm summers. In January, the temperature is as low as -4 °C; July is the warmest month with about 26° C, and a maximum of over 38° C. The average temperature in Beijing area is 7°C. The average annual precipitation is 600 mm, about 80 percent of rainfalls during the wet summer between June and September. The last 3 years have been draught years with rainfall below the average. During 1999, for example, the city received only 40% of its normal level of rainfall.

Tab: monthly average temperature

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Temp. (C)	-6.4	-1.5	8.0	14.6	20.4	26.7	29.6	25.7	21.8	12.6	3.0	-0.6
Humidity	55	40	36	40	57	53	61	76	64	62	59	48



Temperature and precipitation in Beijing area for the year 2000

## 2 Township construction planning

### 2.1 Historical review

The Department of Urban Planning and Design of Huai Rou County made the actual land use-plan. Involved in the designing and decision process were different departments and bureaus of all three administrative levels <sup>10</sup> (see *institutional background*). The last and final decision to accept this plan was up to the Beijing municipal government.

### 2.2 Today's situation

The township of Yang Song has the typical Chinese rectangle form with strict separation of the different living functions (spheres). In general, the whole township is divided into two areas:

The northern part is mainly composed of new settlements, public places and living areas. The government is also developing the industrial and service zone in this part.

The south of the township is characterized by an older village structure and cultivated land. The older houses will be demolished and replaced by new houses and apartments, mainly for the resettled rural population.

A new villa area is under construction<sup>11</sup> as well in the northern part of the township.

The construction of the middle level school will be finished at the end of 2002 or the beginning of 2003.

### 2.3 Future developments

According to the planning of the Yang Song Government, the number of inhabitants will increase from 21.000 to 50.000 in the year 2010, because of:

- Further development of the industrial sector: workers will settle in Yang Song;
- Beijing citizen are being attracted to Yang Song by offering them new modern housing opportunities and a leisure environment.

The actual land use plan is valid for 10 years, from 2001 to 2010. In the different chapters of the recent land use-plan, the next steps for further development of the urban infrastructure, new settlements, entertainment options and a development of the industrial area are given in detail. The plan splits further developments into two time phases: The first phase from 2001 - 2005 is focused on the building of new settlements and the development of the industrial area in the north and west of the township. In the second phase from 2006 - 2010 the 15 villages will be combined to nine. Six villages are meant to be central villages. They will be equipped with the basic public utilities, and also a kindergarden and a school. Another important goal is to improve agricultural production in these villages. The 2010-plan lists the following development goals for urban infrastructure:

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<sup>10</sup> After several interviews with different competent authorities, it was apparent that the engineers and planners of the different departments only work for their specific job, and sometimes do not communicate and cooperate sufficiently close with each other.

<sup>11</sup> According to Mrs. Deng, investment and construction are handled between three cooperating construction companies (one from Singapore, one from Beijing and one from another Chinese province.)

Area (land Use)	2000 (ha)	2010 (ha)
Road	7.5	96.76
Railway	3.37	3.76
Public Places	9.26	30.46
Storage & Industry	5.16	5.16
Greenland for Protection	0	195.77
<b>Total</b>	<b>25.99</b>	<b>331.52</b>

As a Model township Yang Song has to reach or even to set economical and environmental standards. To attract further investments, first priority is to improve the urban infrastructure. In principle, further development of industry and housing is meant to be left and handled through investments by the private sector. At present the Yang Song Government is offering to develop a construction-plan for a new housing area in the northwest of the township, namely the Feng Ri Yi and Feng Heng Yi Ou area. The total area is 1018 mu, the construction area is 400 mu. In this district, 3000 people are planned to be settled. However, until October 2002 none of the construction companies or developers has applied for an investment in the area so far.

Good construction planning in the township has an important effect on the economics and functioning of the future wastewater system. For example, in Europe, costs for the sewerage pipeline or transport system alone are on average up to 70% of the total costs for sewerage plus treatment plant; and this even in more densely populated rural and peri-urban areas. Spending the largest percentage of investment into wastewater infrastructure just for transport and storage, even with combined sewerage systems, and still having overflows persist and only very limited reuse options, does not satisfy. Seeing present cost structures, it is a valid alternative to implement new semi-centralized and on-site sanitation systems with a major nutrient and water reuse structure.



*Villa area under Construction*

## 2.4 Model and Eco-Model Cities

Yang Song was named by the Ministry of Construction as a demonstration township for the small town construction across the country, and it was listed as one of the national pilot towns concerning comprehensive reforms in 1999.

In the whole of China one major developmental objective and policy is to stop widening, or even reduce the economic “development” or modernization gaps between rural and urban areas. In the case of Yang Song, the Chinese government started a pilot-project specifically for rural and urban ecological planning. Up to now, the government is looking for suitable regulations and rules for ecological city constructions, concepts based on proven or fully new regulations and laws for lasting environmental protection.

The Chinese Government makes a difference between Model townships and Eco-Model-Cities. The target of the Model Township is mainly to develop the economic sector. Major requirements for Eco-Model Cities and ecological city construction are given in the following table.

Tab: Criteria's and requirements for eco-model cities

No.	Item	Requirements (or some Yang Song data, w)
1	Quantitative examinations of urban environmental comprehensive improvement	Ranks top in the last three years continually
2	Named as "the National Sanitary City"	Has passed the examination for National Sanitary City
3	Index of the environmental protection Investment	> 1.5% of the city
4	Per capital GDP	>10,000 Yuan per Person
5	Economy Increasing Rate	> Average National Increasing Rate
6	Population increasing Rate	< National Planned Target
7	Energy Consumption for per GDP unit	< National average
9	Air Pollution Index	API< 100 by using automatic and consecutive air Monitoring systems
10	Compliance rate of the water quality at the source area for the center-supplied drinking water	> 96%
11	Compliance rate of water quality in functional zones	100% and no worse than water quality Grade V in urban area
12	Average value for district environmental noise	< 60 dB (A)
13	Average noise value for main roads	< 70dB (A)
14	Coverage of natural reserves	> 5% of the city
15	Green coverage of constructed area	>30 %
16	Treatment rate of the urban domestic wastewater	> 50%
17	Compliance rate of the industrial wastewater discharge	100%
18	Gas utilization rate in urban area	> 90%
19	Central heating rate	Only suitable for cities in north china
20	Disharmful disposal rate of domestic solid waste	> 90%
21	Comprehensive re-use rate of industrial solid waste	>70 % and no any discharge of industrial Waste
22	Coverage smoke and dust controlled area	> 90%
23	Coverage of compliance rate of environmental noise	> 60%
24	Information related to regular meetings on environmental protection hold by the City CP Committee and/or City Government	> One times per year
25	Independent environmental protection Institutional structure	Establish/complete the independent environmental protection institutions
26	Public satisfaction rate for urban environment	Survey for not less than 0.01 % (extremely low) of the on populace and satisfaction rate >60%
27	To implement the plan on the abatement of the total amount of the pollutant discharge, to vote any project with the new potential pollution just by environmental protection issue and to include the environmental protection into social and economic development plan	Related plans or documents are in accord with the requirement of the examination for the model City to complete the abatement plan on time

## 3 Urban and Rural Water Supply

### 3.1 Sources, Quantities and Qualities

According to a government leaflet the water quality is up to Grade II in Yang Song by China's national standard. Chao Bai River reached the first standard according to "China Water pollution Law" (see appendix). Yang Song heavily relies on the groundwater resources, this even though they are as well the only source for drinking water supply.

#### 3.1.1 Groundwater

Groundwater can be found in 4 layers. The first layer is located in the depth of 18 - 19 meters, but water quality does not meet the drinking water standard. Potable groundwater, according to the national standards for drinking water supply, is derived from a depth of more than 100 meter. Over the past years, the groundwater level is decreasing about 1.5 meters per year [4]<sup>12</sup> forcing the waterworks to dig deeper by the years (see waterworks). The groundwater extracted by the waterworks, meet the country's drinking water standard. <sup>13</sup>"The quality of the groundwater is reported to be constant over the last years. [4] The main critical values in the groundwater are total hardness and nitrate-nitrogen [B4]. There are no limiting regulations for groundwater withdrawal for the water works, and no organized groundwater recharge takes place in the area [4]. The interview partner had no information about any planning or promoting measures from higher-level institutions and ministries for these purposes.

#### 3.1.2 Surface water

In the area of Yang Song 3 rivers are located, with their springs in the northern mountain area. Chao Bai River at the east border of the TS, Huai River in the west and Yan Qi River. Currently all 3 riverbeds are dry. Yan Qi River is reported to have been dry since long time. The others run out of water since approximately 1999, due to 3 dry years (see climate) and to the building of reservoirs in the upriver course.



*Dry riverbed of Chao Bai River, August 2002*

<sup>12</sup> Literature research and statements of the Ministry of water resources can prove the statement. Official Beijing Envir. Report, 1998: The level of phreatic water increased 0.4m by average, and the level of confined groundwater increased 0.65 m by average

<sup>13</sup> The water quality can fit the standard of country level, which has 40 indexes, but cannot get to the world level, which has 90 indexes. The revised drinking water standard for China promulgated in 2001 sets 90 indexes, close to WHO guidelines



*Dry riverbed of a village*

The Huai Rou reservoir is located on the western side of Huai Rou city and the other reservoir is in Miyun County (see appendix: map). Both have to guarantee the water supply for Beijing city and for the surrounding farmlands. However, extra water for Beijing means less for the surrounding county and their Townships. To get this contradiction into a sustainable balance is one of the long-term objectives of this project.

*The Miyun reservoir, which presently supplies about 80% of the drinking water of Beijing city [<http://www.gtz.de/china/english/resourceslist.htm#>, 03.10.2002], is facing two severe problems: Firstly, the water quality of the reservoir has been threatened by evidence of tourism development and agriculture. Secondly, the water level is shrinking because of the drought conditions, extraction for Beijing water supply, and the reduction of yearly inflow through the construction of upstream reservoirs in other provinces. [[www.china.org.cn](http://www.china.org.cn); 06.10.2002]*

### **3.1.3 Rainwater**

The climate in Beijing area is semi-humid, with a cold, dry winter, low rainfall in spring and heavy rainfall during summer. The average precipitation is 600-700 mm per year, of which about 80 percent falls during June and September (see climate). The value is slightly higher than the Beijing city average, because of the mountains in the hinterland of Huai Rou County.

In the whole township rainwater is collected in rainwater pipes. In village areas the sewers are placed at one side of the smaller streets, and all the main streets in the town are sewerred along both sides. The rainwater is transported and discharged into the nearby rivers or infiltrates into the ground. There are no specific applications and technologies for its further utilization, for example for irrigation.

## **3.2 Water protection**

According to the YS-2010-plan, the township will reach the following goals:

- Huai river has to reach the second level for water quality according to “Beijing city surface water discharge standards”
- Chao Bai River has reached the first level, and it must follow the law No 14 of “Beijing City water pollution Law”
- Groundwater has to reach the second level of the national standard

- Strict controls of a timely implementation of the above objectives is demanded

In the planning maps, the river borders are under protection, 100 m along both sides. These “protection” areas are green belts, planted with trees and bushes. There exist no further strict regulations, for example discharge or disposal prohibition for those areas. In the Yang-Song development plan, a groundwater protection area is set along the Chao Bai River, spreading 2 km wide to each side. In the groundwater protection area it is prohibited to discharge pollutants directly into the groundwater. But the regulation doesn't consider infiltration and runoff from soils like fertilizer, pesticides and manure pollution.

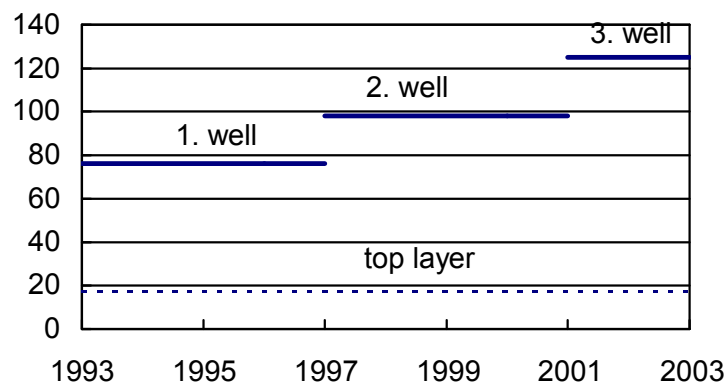
### 3.3 Today's and future use

#### 3.3.1 Waterworks

In Yang Song area there are 2 waterworks with a total number of 42 wells. The major one supplies water to the town and 2 neighboring villages and the other serves the supply of the villages<sup>14</sup>. Additionally, there are pump-stations for specific use, for example for the water park.

- **Village:** The village waterworks are under the responsibility of the village committee. The village waterworks supplies water to 6 villages, with 9 wells only to extract water for irrigation purpose in agriculture. They are located in a depth of 30 m. Drinking water is derived from the depth of 150 meter.

- **Town:** The town waterworks is owned by the Beijing Freshwater Cooperation<sup>15</sup>, based in Huai Rou county/city. They are also responsible for construction of the water supply pipes in cooperation with the Bureau of Construction. The lowering of the groundwater level forced the waterworks of the town in the last years to build new and deeper wells. The first well, built in 1993, was located in 76 meters depth, but now it is filled with sand. The second well was built in 1997, in a depth of 98 meters. The actual third well pumps the groundwater from a depth of 125 m under ground. To dig a new well, the waterworks would have to apply for permission from The Bureau of Water Resources in Huai Rou. [4]



<sup>14</sup> There have been different reports about the number of waterworks for the village. Waterworks reported 1, village committee reported 2. The wells for agriculture and pump-stations

<sup>15</sup> The company is associated to the local government, but not controlled by it.

The waterworks only add Chlorine to the water for disinfections [4]. One worker monitors the water quality once a week, the county's epidemic prevention station is checking occasionally. To reach drinking water quality according to the new standards, the waterworks have requested additional equipment.

### 3.3.2 Today's water supply

The two waterworks together have a total capacity of 15.000 t/day. [5]<sup>16</sup> The township's waterworks supplying capacity is 550 t/hour. The following table shows the average water supply by the town waterworks

Average amount of the township	2000-3000 m <sup>3</sup> /d
Maximum (in summer)	5000-6000 m <sup>3</sup> /d
Minimum (in winter)	1000 m <sup>3</sup> /d.
Household and green together	1000 m <sup>3</sup> /d.
Green (summer)	500 m <sup>3</sup> /d
	16.000-
17.000m <sup>3</sup> /month	
Industry	2700-2800 m <sup>3</sup> /d

The agricultural sector is not included, because the town waterworks does actually not serve the farmers. Farmers receive their water from the lower wells in the villages. The water withdrawal of water through the agricultural sector is not yet measured, so there are no data available.<sup>17</sup>

### 3.3.3 Future water supply

The township has to increase its own capacity of water supply to meet the water demand for the increasing number of population. For this reason the town waterworks is planning to build a sedimentary basin to enhance the capacity of supplying water. [4] This shall be realized in the next 1-2 years. Until 2006 the waterworks company will not build a new well.<sup>18</sup> According to the YS-2010-plan, the capacity will increase to 21.000 m<sup>3</sup>/day from a northern station (this is the waterworks of the town).

### 3.3.4 Water consumption/demand

- **Households:** The average/specific amount of household water consumption is not known by the water works [4]. The consumption is checked once a month by the company to calculate the household's water fees and payment. Based on the interviews, the average water consumption can be estimated as:

Household:	2-3 m <sup>3</sup> /person/month	= 60-100 l/person/d
Village household:	1-1.5 m <sup>3</sup> /person/month	= 30-50 l/person/d

<sup>16</sup> In the township folder the supplying capacity is 20.000 m<sup>3</sup>/day [1], but compared with the town waterworks data this value seems to be too high

<sup>17</sup> In China: estimated water distribution of total use: agriculture 86%, industry accounts for 8% and domestic use, 6%. [[http://www.jhuccp.org/pr/m14/m14chap2\\_2.stm](http://www.jhuccp.org/pr/m14/m14chap2_2.stm), /03.10.2002]

<sup>18</sup> Report from the Water works [4]: "The capacity can still cover the water demand."

The following table displays the calculations of water utilization based on planning documents and our interviews. The calculations from the YS-2010 year-plan are statistical values<sup>19</sup>.

*Tab: Calculations of water use*

	Planning [5]		Interview
	2002	2010	2002
Population	21.000	50.000	
Average water consumption per person	230 l/day	280 l/day	
Households per person	100 l/day	150 l/day	2-3 m <sup>3</sup> /month = 60-100 l/day
Villagers per person	90 l/day		1-1.5 m <sup>3</sup> /month = 30-50 l/day
Industry	120 m <sup>3</sup> /day = 120.000 l/day		
Water supply (Capacity)	15.000 m <sup>3</sup> /day	21.000 m <sup>3</sup> /day	2000-3000 m <sup>3</sup> /day 550 m <sup>3</sup> /h

In the town, the households are equipped with flushing toilets and sewer system, so water consumption and demand will be higher than in the village, where the sanitation consists of simple toilets or latrines. The household water demand is mainly for washing water (see chapter sanitation). For this reason, village water consumption will stay constant in future years, while the household (means town inhabitants) demand will increase with improved sanitary conditions and life standard.

- **Water Park:** In the middle of Yang Song Town there is a water park, covering a total area of about 100 mu. The water level will be filled at night, with water from a special pump station next to the lake. The fountain is operating with a water cycle (pumping).



*Water Park*

<sup>19</sup> The water utilization derived from the interviews differs from the planning value. But taking losses, for example through defect water pipes, a higher demand in the summer, and utilization of water for other purpose (street cleaning), into consideration, the calculated / agreed value seem to be appropriate.

- **Greenbelts:** The irrigation of the greenbelts in the town is done with groundwater, derived from the network. In the summer months the daily demand can increase up to [5]

500 m<sup>3</sup> /day

Or 16.000-17.000 m<sup>3</sup>/month

### 3.4 Implemented water saving measures

Facing a serious water scarcity, the area of Beijing is forced to save water. The Water Saving Office<sup>20</sup> set limits to water consumption for industry and institutions. Any additional consumption gets charged a special price for temporary use (see water pricing).

It is the task of the local government and village committees to implement water saving measures for the population<sup>21</sup>. In the village the population consumes less water and already use greywater-recycling options for toilet flushing (see sanitation). Here further water saving can hardly be achieved. In town, inhabitants have been motivated to save water in recent years. Interviewed households reported, that they are using washing water from the kitchen to swap the floor for example. But there are no water saving devices for reducing the toilet's flushing water. There is a big potential in the town for additional or other water resources instead of groundwater utilization, for example for irrigation of the greenbelts and the water park.

In the agricultural sector there is no control for water withdrawal, if taken from the higher wells. Water saving technologies are sprinklers, now in use on 15.000 mu farmland and greenhouses<sup>22</sup>.

Exact figures of the effect of water saving methods on the overall water consumption cannot be collected in Yang Song at this point in time, these effects are set off by the construction of new buildings and increasing numbers of township population with changing sanitary habits and conditions (with water for flushing toilets, comfortable showers, improving living standards, etc).

### 3.5 Water Pricing

The pricing on water in Yang Song totally depends on the fixed prices of the Beijing Price Agency. The pricing is divided into five categories:

Village <sup>23</sup>	1 Yuan/m <sup>3</sup>
Township	2 Yuan/m <sup>3</sup>
Industry	2.9 Yuan/m <sup>3</sup>
Restaurants	3.8 Yuan/m <sup>3</sup>
Temporary usages	3.8 Yuan/m <sup>3</sup>

The price has to cover the cost for water supply and its administration. As reported by our interview partner, the collected fees do not cover the costs of operation, neither necessary investment (new wells, equipment for water treatment, water quality control).

<sup>20</sup> In recent years the office belongs to the Freshwater cooperation (=water supply company), it is now attached to the Ministry of Water Resources.

<sup>21</sup> The main motivation for the population of water saving will not be cost reduction, due to very low water prices. Successful measures have to be ordered by higher authorities.

<sup>22</sup> 3000 mu farmland get the water from drainage

<sup>23</sup> The waterworks reported that there are difficulties with the collection of the water fees. The villagers, being served by the TS waterworks, are not willing to pay. First because the villagers think, the prices are too high, and not affordable. Secondly, the villagers are of the opinion, the water belongs to them, and they don't need to pay.

The government has to give the waterworks financial aid to work and to minimize the daily expenses. In the future the water price also has to charge the wastewater treatment costs, including wastewater plant and drainage construction, its operation and maintenance.

The disadvantages of fixed prices without flexibility often lead to a lack of consideration of the local situation.

### 3.6 Strategic proposals

A strategic proposal for environmental protection of the water resources is presented in the YS-2010 plan for the fields of water quality and for the protection of river and groundwater. 24. For the other fields the following proposals can be made:

**Groundwater protection:** Because Yang Song heavily relies on its groundwater resources as the main fresh water source; the protection of this resource and a guarantee of future water supply should be a major environmental goal.

The following achievements should be made:

- Prevention of pollution from wastewater discharge, industry, etc
- Prevention of pollution from agriculture (soil infiltration, manure, etc)<sup>25</sup>
- Prevent over extraction (control limitations)
- Control of water consumption and wastewater discharge in the different sectors

**Water saving:** Water saving and recovery activities are already implemented (see previous chapter) in Yang Song, but everyone should be aware of the growing scarcity of groundwater resources and be motivated by the government to further reduce water consumption instead of a further increase, which sometimes results from improved sanitation. In addition, lower water consumption reduces the sewage production and its treatment costs as well. The following measures appear imperative:

- Promote more efficient water utilization techniques and practices (in particular for agriculture and not only because of seasonal droughts)
- Further reduce “wasteful” water consumption in industry, households, the public sector etc.
- Further increase the reuse rate of rain and waste water

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<sup>24</sup> Responsible for ecological planning is the Environmental Protection Bureau on the county and provincial level. The Yang Song government can set itself further regulations for industry, f.e. Water consumption and wastewater discharge

<sup>25</sup> A high nitrate-nitrogen content in the groundwater is mostly a result of uncontrolled nitrogen discharge from agriculture activities like husbandry and over-fertilization

## 4 Sanitary situation

### 4.1 Historical development

**Wastewater:** The wastewater was discharged for a long time into the nearby rivers<sup>26</sup> or infiltrates at the source. With the construction of the main roads and the coverage of new residential areas wastewater and storm water sewers were included. In the villages as well, new streets from concrete were completed with rainwater drainages.

**Solid Waste:** Before the opening of the landfill, handling of municipal and village wastes was the same: organic wastes were mainly used to feed the pigs. Plastic waste and other leftovers were either brought to various wild disposal sites or burned with permission of the Government.

### 4.2 Today's situation

#### 4.2.1 Wastewater

- **Villages:** Village households produce less wastewater, due to their lower fresh water consumption. There is no blackwater discharged. Additional household water for example from washing and cleaning, and overspill from the toilet and other public facilities, is just flowing out of the building/house/courtyard and infiltrates into the ground. There is no special drainage for this water, only an open chute/gutter in the soil.



*Greywater discharge outside village houses*

There is no sewer or drainage system in most of the villages, though they are not connected to the main network; for the standard sanitary system this is not demanded neither.

- **Town:** Domestic wastewater from households, public facilities, public toilets and restaurants is collected in the sewer. There are 3 pipes, each with a diameter of 0.8 m. The left one is for household wastewater only, the right one for storm water. The middle one is for combined wastewater or a stormwater overflow. The construction will be finished by the end of the year 2002.

<sup>26</sup> For the town it was Yin Quai river



*Main sewers leading to the future wastewater facility*

There are no official data about wastewater quantities, but they can be estimated and calculated at about 80%<sup>27</sup> of the total water consumption.

Total	~180 l/person
Household	~ 80 l/person

The wastewater consists mainly of household wastewater and sanitary wastewater from the local industries. The paper mill is not allowed to discharge its water. The composition of the discharged wastewater was controlled and analyzed on May 17, 2002.<sup>28</sup>

	TN	TP	CODcr	BOD5	SS
09:00	33.1	12.6	263	141	89
11:00	35.9	14.7	221	118	92
13:00	42.8	19.6	427	250	125
15:00	45.6	22.6	466	255	134

There is no facility for the treatment of wastewater in Yang Song Township, not even simple treatment steps like screens, settlers, and sedimentation/collection tanks. With the construction of the sewer system, and the dry status of the river, the wastewater is now flowing from the existing sewer pipes onto the fields next-door. The fields, which are used to cultivate corn and trees, are now flooded with wastewater, with a water level up to 20-30 cm.

<sup>27</sup> 80% is the value given in the 2010 year plan

<sup>28</sup> The results can not be considered, because of insufficient analysis:

- Not representing a full day,
- Not all items!
- Analysis matter!
- Units!
- Location of measurement, extraction
- Climate conditions are missing :outside temperature, rainfall, others
- Only concentration, not amount
- No numbers of samples, method of sampling,



*Wastewater discharge to field*



*Uncontrolled wastewater discharge at new sewer*

#### **4.2.2 Solid Wastes:**

**Villages:** The households collect their solid wastes at home and have to bring it to collection points. These collection points can be found all over the village, with distances of about 300- 400 m located close to the street, or in the back of public toilets. Some of them are closed boxes, some open concrete places. The size/capacity is about  $(1.5*1*0.5=)$  0.8 -1 m<sup>3</sup> for the boxes, and  $(3-4*1*0.7=)$  2- 2.5m<sup>3</sup> for the concrete places. They are emptied, when they are full.



*Village collection point*

In the garden village with a population of 516 inhabitants, 3-4 m<sup>3</sup> wastes is collected per day. Amounts of daily/monthly waste generation per person are not known exactly.<sup>29</sup> <sup>30</sup>. The waste mainly consists of organic waste, residues from food and courtyard farming, and a high percentage of ashes<sup>31</sup>; problems arise from increasing amounts of plastic waste (plastic bags, packages). One worker does the collection and transportation of the waste to the landfill in the morning. He is equipped with an open cart (pushcart) and is responsible for the collection of waste, transportation from the collection point to the disposal point and maintenance of the disposal site. Each village has a waste disposal site, located 1-2 km outside of the village. The site is an open pit with a size of about 5-6 mu and a depth of 4-6 meters.



*Village landfill*

The burning of waste is not allowed anymore.

<sup>29</sup> Assumption: The generation rate is equivalent to collection rate.

<sup>30</sup> Waste generation rates in low-income countries ranging between 0.4 to 0.9 kg/capita/day. For medium income 0.5 to 1.1 kg. Rate for China's urban population: 0.79 kg/capita/year [the World Bank: solid waste management in China]

<sup>31</sup> The population's heating source (energy) is firewood and coal. Traditional Chinese village houses have a central bed, so called Kang, with heat coming from an oven outside the house.

**Town:** Responsible for waste collection in the township is the Bureau of Sanitation. There are 2 drivers and 2 waste collectors. The waste collectors mainly have to clean the streets from dust, collect market refuse and to maintain and empty the public dustbins. The area covered by this service is the township and 4 villages near town.

There are 449 dustbins in that area, altogether for municipal waste<sup>32</sup>. Size: height 1 m, diameter:-0.9 m (capacity= 0.63m<sup>3</sup>), equipped with a lid, but they are mainly open.



*Dustbins*

According to the 2010-plan each household produces<sup>2</sup>

<p>1.1 kg waste / person/day Total amount of MSW: 30t/day</p>
-------------------------------------------------------------------

In the town and the 4 associated villages, daily collection rate is about 33:

<p>40t /day</p>
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[9] from households, public dustbins, market waste and including non-hazardous wastes<sup>34</sup> from the local industry.

The waste is brought to the landfill, about 2 km northeast of the TS. The landfill is under operation since 1998. It covers a total area of 28 mu. There are 2 persons working on the landfill, responsible for maintenance and operation.

<sup>32</sup> There are dustbins belonging directly to households, or apartment houses. For apartment blocks, there are 4 - 5 dustbins necessary.

<sup>33</sup> According to gtz: 5t/day is equal to 15.000-20.000 inhabitants, 20 t/day is equal to 60.000-80.000. 40t/day is a comparable high value. If the amount is correct, then there must be a high portion of construction and Industrial waste

<sup>34</sup> According to the leader of the industrial development zone there is no hazardous waste, only waste similar to household refuse.



## 4.3 Future planning

### 4.3.1 Wastewater treatment

The Township government plans to build a wastewater treatment facility approximately 2 km in the south- west of the town. The design is not fixed, as well as the starting time. The area depends on the space demand of the chosen technology.

The facility should treat the household wastewater, combined wastewater (storm water from overflow) and industrial water as well. According to the Government there is no polluting (non-hazardous) industry in Yang Song, they only discharge sanitary (domestic) wastewater<sup>35</sup>. Only 2 companies are not allowed to discharge: a factory for producing cardboard in the south of the township and a garment factory (wool processing).<sup>36</sup> The paper factory owns a big pit to stabilize their wastewater, and the garment factory treats the wastewater themselves.

The total number of connected households and industries is hardly to be estimated, due to strong relations to the future population and industrial development of Yang Song Township. Connected to the plant are the TS itself, the industrial district, and Yang Song Zhuang village and half of Zhang Zi Kou village, both located aside of the Township. Other nearby villages as well is to be connected in the future, simultaneously with street and sewer construction.

The treatment capacity should reach the following quantities:

I. stage	2000 t/day
II. stage	5000 t/day.

According to the YS-2010-Plan the capacity is calculated to be 15.000 m<sup>3</sup>/day, but it seems to be too high compared to the water supply.

Financial calculations expect a total investment needed of 10.000.000 Y. One quarter of this will and can be given by the Government. The affordable land will be given for free.

<sup>35</sup> The government declares, not to allow the settlement of high polluting industry in the township or to stipulate private wastewater treatment ("if they invest a lot of money, they will have enough to treat wastewater on their own").

<sup>36</sup> *The wastewater composition has never been controlled (strictly), but the government is seriously concerned about the wastewater discharge quality.*

The Government is looking for a BOT model, maybe in combination with solid waste, sludge and manure treatment, with benefits from sales as soil conditioner or fertilizer for farm and garden demand.

The following criteria will be important when designing an improved WWTP:

- Cost: less expensive than previously discussed options
- Reduction of the area demand
- Reduction of the maintenance needs
- Fulfill all discharge standards, and keep the river quality at grade II

#### **4.3.2 Wastewater reuse**

The reuse of treated wastewater is not included in the present planning. But the Government thinks about using it for irrigation purpose. It is also possible to use it for the irrigation of the green belts and in the water park. Treating of wastewater requires different technologies and expertise if wastewater and sludge is to be reused in agriculture or fishery. If the re-use of by-products becomes part of the strategy, then the involvement of other appropriate agencies or individual expertise for this purpose may become necessary.

#### **4.3.3 Solid Waste**

According to the planning of the Sanitary Bureau [6]:

- The government has the intention to buy a new car at the end of the year, to increase waste collection capacity to up to 80 t/day.
- 4 people will be employed: two for driving and collecting the waste with the new car; the other two will be sanitary workers.
- The number of public dustbins is not going to be increased. Only new dustbins for the new houses/apartment blocks (depending on the number of new houses/blocks) are planned to be provided.
- The landfill will cover a total surface area of 35 mu.<sup>37</sup>

According to the 2010-Plan for Yang Song [5] for municipal solid waste management the following aims should then be reached:

- The waste from industry (and household) should be treated first before being discharged
- Sanitary standard of non-hazardous waste disposal should be fulfilled.
- The majority of the waste produced should be reused
- Collection and Transport should be done in closed system or cars

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<sup>37</sup> Report from Sanitary bureau; "This will be enough to dispose of the waste in the next 6-8 years".

#### 4.3.4 Sanitation

- **Village:** The sanitary situation in the village is an “on-plot systems”<sup>38</sup>, with standards differing according to the household income and village financial situation.

The poor villagers still have only simple latrines and public toilets. The latrines are pits outside of the houses or in the courtyard. They are either built from bricks or - even more basic - surrounded only with straw mattresses.



*Village latrines*

The households empty the pit themselves when it is full, and use the “compost” heap in their own backyard garden, or dispose of it on the nearest fields. Sometimes farmers will come to collect the faeces, but not in regular time intervals. The retention time in those latrine pits depend on the size of the pit<sup>39</sup>. The washing facilities are very simple in the courtyard of the houses, where the fresh (drinking) water is collected in a small basin. The greywater is sometimes used for cleaning the house, but mainly it will be discharged outside.

More affluent houses have a separate sanitary room. The room is a wet booth, where shower and toilet water are collected together. The toilets are squatting toilets. Households sometimes use collected greywater (from cleaning the courtyard and house) for toilet flushing. In these cases, the black water is collected in sedimentation tanks under the toilets.

In 3 villages of the area, the “rich” villages, the village committee provided special toilet equipment for the households (see Annex), donated by the Sanitary Bureau in Beijing. The committee paid to the families for the toilet construction a singular financial support of 200Y. These toilets are equipped with a special device to collect the greywater (shower water) of the wet booth for toilet flushing. The faeces, urine and greywater are collected in a three-chamber pit underground. This equipment consists of very simple devices and materials, because the households have to install the equipment and

<sup>38</sup> *On-plot system: safe disposal of excreta takes place on or near the housing plot; pit latrines and septic tanks]*

<sup>39</sup> *Latrines cannot be considered sanitary. A “safe” retention time can not be guaranteed in most cases*

construct the necessary chambers themselves.



- **Town:** The town houses, apartment houses, industrial buildings are all equipped with flushing toilet system. In the new houses the families have modern sitting toilets, and in the older houses the squat toilets are still common. The bathroom is a wet booth room. The sanitary equipment for the new apartment houses are chosen by the investor, or in case of villas the owner can decide about a specific design.<sup>40</sup>

#### 4.3.5 Faeces collection

The faeces/urine collection is done either by the farmers directly for utilizing the nutrient rich mixture as fertilizer on their fields<sup>41</sup> or by a private faeces collection company. The company provides a convenient collection service, for which the village households have to pay 10 Y/m<sup>3</sup><sup>42</sup>. The collection is done with a truck (see picture); according to 2010-plan there are now 2 trucks for this purpose. The faeces are then sold to those farmers with more cultivated land, which mostly do more professional farming.

<sup>40</sup> Especially in case of the villas: the houses have the necessary water pipes and ports, the owner chooses his preferred equipment (with or without bath tube, shower, etc.)

<sup>41</sup> In the rural areas of China the rate of human excreta utilization is 93.7% [source: <http://www.ias.unu.edu/proceedings/icibs/ecosan/liu01.html>, 04.10.2002]

<sup>42</sup> One village household reported to pay about 40 Y/year



*Truck for faeces collection*

In general, the company or the farmers come to the households in regular intervals. In “high-season” they come more often, because of higher fertilizer demand. As well, the households call the company or farmers to empty their pit once it is almost full.

For the utilization of faeces and urine in agriculture there are no respective regulations and strict controls regarding health risks, pathogen minimization and fertilization rate (like for irrigation water). Faeces are allowed to be used for class II and III soils and for special vegetations and crops. Responsible is the Bureau of Agriculture. The WHO guidelines and other independent surveys describe transmission of worm infections as the greatest risk in relation to wastewater. Worm eggs and helminthes are well removed from effluent by sedimentation, but accumulate in the bottom sludge. Long retention times of 1 to 3 years in septic tanks and anaerobic filters provide sufficient protection against helminthes infection in practice. Therefore, frequent sludge removal carries a higher risk.

According to the 2010-Plan the following goals should be achieved:

- In a step-by-step approach until the year 2010 no more hazardous waste is to be landfilled
- Public toilets are to be built in densely centralized district and commercial areas. Distance 300-500 m, in other areas more than 3 toilets every 1 km<sup>2</sup>
- 2 cars for faeces collection, serving 10.000 people, in the future increase to 5 cars

## 5 Strategic ecosan-oriented proposals

With the development of industry as well as urbanization and rural civilization, Yang Song Township in line with other developing townships in China is facing a huge environmental challenge, particularly in waste and wastewater treatment. As Yang Song is seeking for a wastewater treatment plant, the intention is to find a suitable technology. The ecosan approach for Yang Song township aims at closed-loop orientated solutions. This means not only a purification of wastewater and its discharge, ecosan concepts recover a maximum of potential resources: the utilization as irrigation water, the utilization of nutrients from urine and faeces, the reuse of products from the treatment processes as a fertilizer, soil conditioner and energy.

The proposals are attempting for a holistic approach that consider local conditions, including environment, agriculture and sanitation. Important factors like the availability of resources, the demand of water, water pricing, the demand of fertilizer, utilization rate of night soil, rate of sanitation are included.

In the following chapters the strategy of water and wastewater treatment and for the nutrient recycling will be summarized:

### 5.1 How does wastewater harm the environment?

Domestic wastewater contains mainly Carbon, Nitrogen, Phosphorus and pathogen bacteria causing epidemic contagious diseases, like cholera, typhoid fever, etc.

**Carbon:** If a surface water, e.g. a lake, is overloaded with Carbon containing organic substances, bacteria incorporate this molecules together with dissolved Oxygen and “burn” them to CO<sub>2</sub> with their respiration, so as to gain their energy to live. This leads to a massive shrinkage of Oxygen in the water. Fishes don't have enough Oxygen for their respiration anymore, and a massive fish dying is the consequence: the lake is eutrophied. The final consequence of this process is, that due to the lack of Oxygen in the water, anaerobic processes are starting in the sediment and spreading in the entire lake. The lake starts to smell evil and becomes a toxic environment for higher animals: The lake is hypertrophied.

**Nitrogen, Phosphorus:** Nitrogen and Phosphorus are nutrients and the major compound of fertilizers. Plants and algae are fixing CO<sub>2</sub> from the atmosphere for their organic molecules and growth via photosynthesis. In most cases, organic molecules are containing Nitrogen and/or Phosphorus. Thus, plants and algae need these nutrients for the fixation of CO<sub>2</sub> from the atmosphere. In most natural eco-systems, nutrients are the scarcity factor for plant and algae growth. If a lake is overloaded with nutrients, a mass growth of algae and water plants is the consequence, leading thus to a massive input of Carbon into the lake, with the same consequences as described above.

**Pathogen bacteria:** If fecal wastewater gets into natural surface waters, which serve humans as a drinking water source, spreading of diseases are the trivial, but unfortunately often happening consequence. Especially in countries with a chronic lack of water and a poorly developed infrastructure, this simple fact leads annually to millions and millions of dead humans.

## 5.2 What is domestic wastewater?

Domestic wastewater is a mixture of very different part streams. The following graph shows the composition of raw domestic sewage:

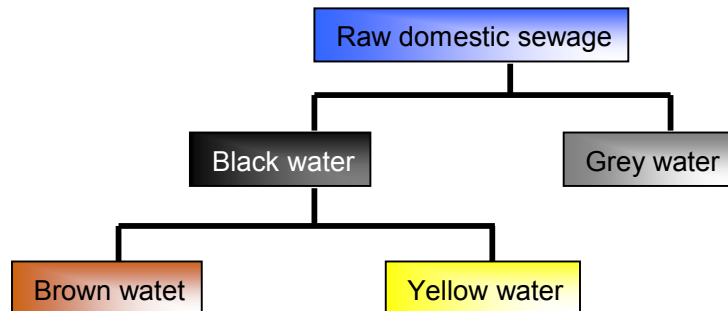


Fig.: The composition of raw domestic sewage

The term **Grey water** defines the waste water of all domestic sources, like showers, bath-tubs, wash-basins, laundries, kitchens, etc., except the waste water from toilets and urinals. It can be purified with little technical effort up to highest quality standards. Local laws and quality standards define the kind of re-usage.

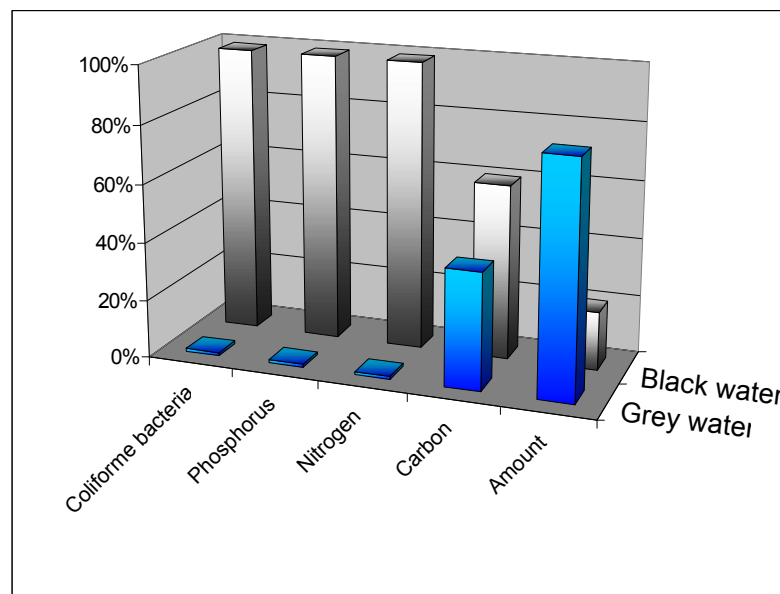
**Black water** defines the fecal wastewater of toilets and urinals. Black water contains all nutrients and pathogen (coliforms) bacteria. Black water is composed of brown and yellow water, which can be separately collected and drained with so called urine-separating toilets.

**Yellow water** is the term of diluted or undiluted urine. If urine is diluted with water, urine calculus is precipitating and clogging drainage pipes. Thus, the flushing of urine with water has to be avoided.

**Brown water** is the term of the fecal drain of urine-separating toilets. It contains nearly the total amount of pathogen (coliforms) bacteria.

The following figure shows the different composition of gray water and black water (from normal flush toilets):

The diagram indicates, that the small amount of black water contains the total amount of pathogen bacteria, and nearly the total amount of nutrients (Nitrogen and Phosphorus). With the separation of black and gray water, the catch of the nutrients and the pathogen bacteria in a small water amount becomes possible.

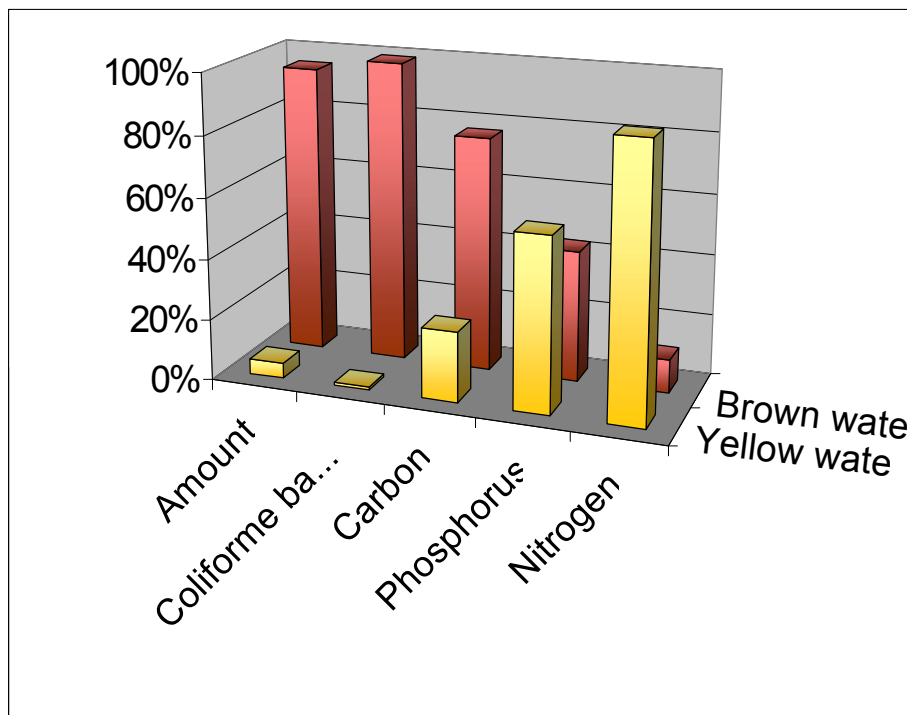


It is obvious, that black- and gray water are very different wastewaters, and that a separation of this waste waters streams makes sense. The following table shows the daily substance amounts, discriminated into their different sources:

Table: Source of the contaminants C, N and P						
Parameter	Tot. Carbon		Tot. Nitrogen		Phosphorus	
Source	g/(PE*d)	%	g/(PE*d)	%	g/(PE*d)	%
Grey water	15	40	> 0,2	> 1	-	-
Feces	17	46	1,5	11	0,6	43
Urine	5	14	12,2	88	0,8	57
Sum	37	100	13,9	100	1,4	100

With urine-separating toilets, black water can be discriminated into yellow water and brown water. This two part streams are very different as well. The following diagram shows the composition of brown and yellow water:

Fig.: The composition of brown and yellow water



The diagram shows, that nearly 90 % of the Nitrogen and over 60 % of Phosphorus are concentrated in the small amount of yellow water. On the other hand, the total amount of pathogen bacteria and over 70 % of the Carbon are concentrated in the brown water. With the separation of this part streams, the separation of nutrients from pathogen bacteria and Carbon becomes possible.

### 5.3 Proposed Water/wastewater Concept:

The water concept focus in particular on water saving, rainwater infiltration, reuse and a discharge control to protect the water resources.

#### **Water saving:**

Water saving is possible for the areas households, industry and farming. For further details see strategic proposals for the water sector.

#### **Rainwater infiltration:**

As rainwater is collected in separate pipes, and precipitation takes mainly place in the summer months, a separation from municipal wastewater is promising. This will minimize the capacity of the plant, and secondly benefit the recharge of the groundwater.

#### **Discharge control:**

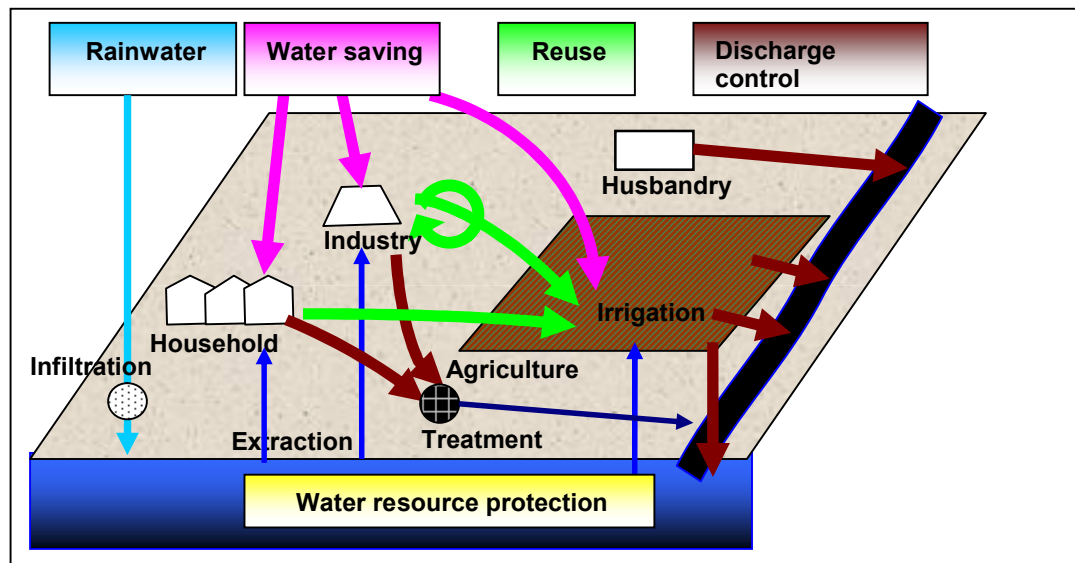
For water resource protection, especially of the groundwater, a discharge control is very important. For the future treatment plant the effluent has to be controlled. Additionally the control of non-point pollution sources from agriculture activities, like fertilizer overspill and infiltration of manure from animal husbandry, that are responsible for nitrogen eutrophication in the water ways, It should be carried out by the Environmental Protection Department of Huai Rou county, and supported by measures of the Yang Song Government. With the construction of a treatment plant, the effluent control must be carried out regularly (daily). Regulations are listed in the appendix.

#### **Reuse**

There is a big potential in the town for additional or other water resources besides groundwater. Especially in the case of irrigation, groundwater can be substituted by greywater, process water from industry, rainwater and in the future by treated wastewater. In the summer months, when demand for irrigation water is very high, the green belts and the water park can benefit from recycled water. A crop, plants and especially flower irrigation with pre-treated wastewater is possible.<sup>43</sup>

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<sup>43</sup> The WHO has promulgated hygienic standards for reuse of water applied on crops, and public lawns etc. In China irrigation with wastewater has to fulfill the 'national Standards for irrigation water quality [GB5084-92]' that are considering the type of irrigation area, and type of crops.



*Water concept*

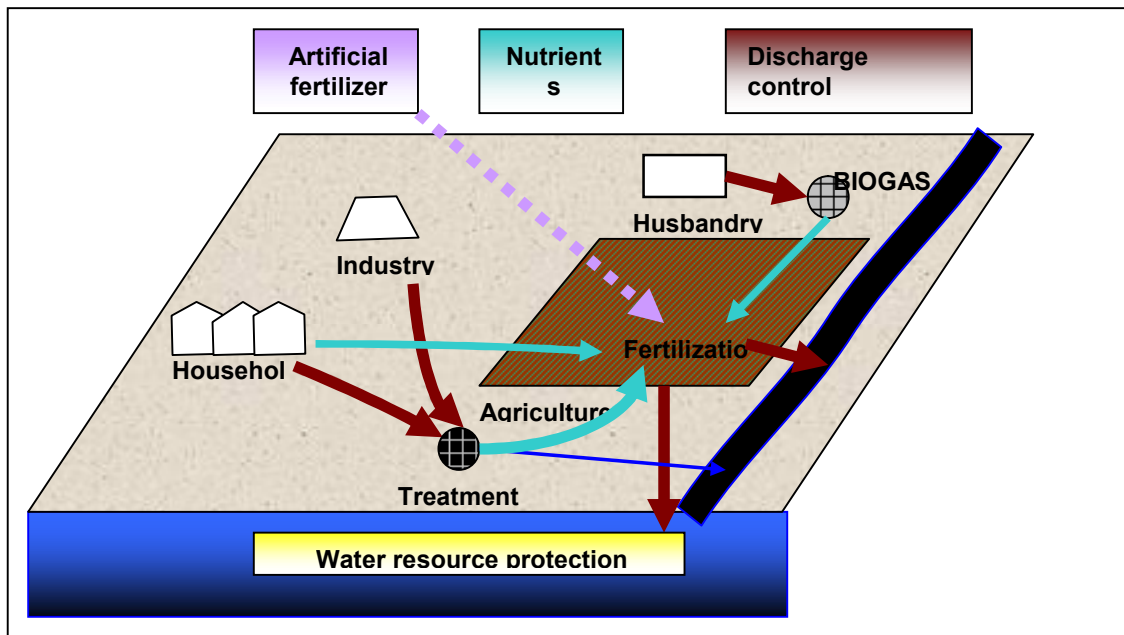
#### 5.4 Nutrient concept:

The nutrient concept emphasizes the recovery of nutrients from wastewater. The nutrients benefit to local agriculture and can support - and to a certain degree substitute - artificial fertilizer.

In the villages the utilization of faecal sludge from latrine pits and septic tanks is still common, and the intention is to guarantee a safe utilization, by approved technical designs, which in particular allow for sufficient storage time.

For the town, a construction of a common wastewater plant will eliminate and not recover nutrients. In addition thus resulting large amounts of sludge has to be disposed of. In ecosan concepts the production of soil conditioner and nutrient recovery from the treatment process are important factors. Sludge produced by a modern sewage treatment plants proposed can be used after treatment. Composting the sludge will control most pathogens and, if properly marketed, can contribute to the economic feasibility of the treatment plant. However, the agricultural application rate of composted sludge should be carefully calculated. The build-up of toxic metals in the soil can be neglected, because for Yang Song only household water and no hazardous components are to be considered.

According to the agricultural law, treatment of animal manure before use in agriculture will now be now required. As Yang Song has large husbandry farms a biogas treatment does here appear to be the most promising and economical option. This would as well allow for sanitation of several waste fractions, which might be critical. In addition, as well energy recovery with renewable energy, from the main energetic portions of waste and wastewater could thus be secured and contribute to climatic and energy balance. The treatment of the separately collected organic waste fraction from municipal waste can be included, preferably in the biogas plants or on separate composting piles that could also compost the faecal sludge.



*Nutrient concept*

## 5.5 Practical Proposals

In the following there will be some practical and technical proposals. For a better understanding we build up a matrix dividing the different areas: village, residential area, and industry, and with respect to the development planning: into existing, new and planned structure. There are proposals made for the sanitary equipment and for the treatment of wastewater streams. For the wastewater recommendations it is indicated, in which cases the township can obtain fertilizer and irrigation water. For the sanitary equipment it is shown, where water saving and water reuse can be achieved, and where the concepts integrate vacuum toilets and a greywater/blackwater separation. In the following, a short description of the Decentralized wastewater treatment system (DEWATS) is included, which seem to be a very feasible solution for Yang Song.

### 5.5.1 Recommendations for existing residential areas

These houses are already equipped with all necessary sanitation facilities and greywater collection. Comprehensive changes will be hardly possible, but for further restoration and rehabilitation work ecosan solutions should be respected. To permit a decentralized reuse of the wastewater, combined „Decentralized Wastewater Treatment Systems“ as developed by CEEIC (Chengdu) and HRIEE (Hangzhou) are here recommended.

For on-site wastewater effluent improvement, additional anaerobic filter chambers could be constructed for the villa area, which is already under construction, treating wastewater after existing septic tanks. The future inhabitants can decide about their sanitary equipment, for example UDS (urine-diversion-System) can be one appropriate solution.

### 5.5.2 Recommendations for new residential areas

Separated black water/greywater collection systems and decentralized wastewater systems with a secondary treatment should be implemented. On-site treatment of black

wastewater by baffled septic tank with up-flow anaerobic filter is one of the feasible alternatives with promising high cost-benefit efficiency. After pre-treatment, treated black wastewater is discharged through vacuum sewers into sludge post-treatment biogas stations where the organic solids fraction from the Municipal Solid Waste (biocomp as implemented by tbw) are added and then the effluent should be earthed in sludge decomposition lagoons and/or can be used directly as liquid soil conditioner.

Grey wastewater is collected into decentralized community's treatment plant, that consists of Imhoff tank / waste stabilization ponds or constructed wetland, integrated into the greenbelts.

For the collection of greywater from a number of further existing or newly constructed village households there are also alternatives to the conventional sewerage system. These are also more suited to small communities, and they are simplified sewerage and settled sewerage. If this household breeds animals, the well-known simple Chinese biogas systems with toilette connection (or integrated in existing Greenhouses („4 in 1 model“)) seem to be the best sanitary village solution.

### **5.5.3 Decentralized wastewater treatment system (DEWATS)**

Since late of the 80's, biogas septic tanks were firstly developed in Sichuan province of China, which were later called Low Maintenance Waste Water Treatment System (LOWMATS) in the 90's, and now also called Decentralized Waste Water Treatment System (DEWATS) in the world. This kind of technology is now being extended not only in China but also in the other parts of the world, especially in the developing countries.

The main function of the system is to treat domestic wastewater of small cities, towns and townships in a decentralized way. It is designed based on the technologies of biogas works, drainage works and sanitation works, which is a combination of a biogas digester and a small two stage waste water treatment plant. The system is usually built with bricks and reinforced concrete in structure, which is low in cost and can be afforded by the user

In terms of environmental, economic and social benefits, the DEWATS system has many advantages in the treatment of wastewater, which is feasible in decentralized towns and townships like Yang Song. DEWATS is a kind of biogas works with anaerobic digestion technology, which is a combination of environmental engineering, biological engineering and renewable energy engineering for sustainable ecological development. The main advantages of the system is:

- Less expensive, cheap with long service life;
- No need of land;
- low maintenance;
- Meet the discharge standards, keep river quality grade II
- Recovery of biogas

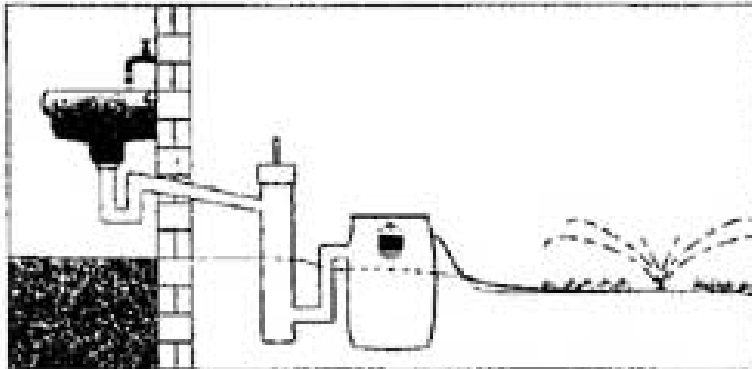
It is recommended that DEWATS is an appropriate technology for the medium and small cities and townships which have no sewage plants as well as some suburbs of big cities, which have no sewage pipeline networks. The main object of the system is to remove organic pollutants, pathogens and parasite eggs with recovery of biogas as fuel.

Practices have shown that DEWATS has many advantages in contrast to the sewage plant. Since the DEWATS system is treating domestic wastewater in a decentralized way,

the principle of building the system is: “ Those who need wastewater treatment will be obliged to build the system (DEWATS); those who build the DEWATS will invest and benefit.” The capacity of the system and investment depends on the quantity of permanent residents and the mobile population as well as their retention time for one building or various buildings. And the investment is related to the capacity of the DEWATS. If the volume is bigger the investment is relatively higher and vice versa. The investment is normally born by the user or beneficiary without government subsidy.

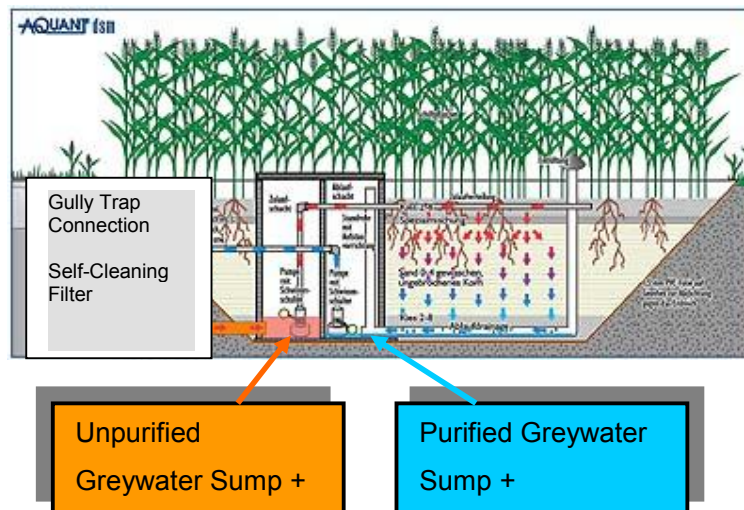
#### 5.5.4 Direct Greywater Distribution system

The Greywater enters via the Gully traps and Self Cleaning Filter the Greywater Collection Sump. In the Greywater Collection Sump is a Submersible pump. The intermittent in feed of the Greywater into the Reed Bed is regulated several times per day



by the Submersible pump. In the Reed Bed the Greywater seeps through the constructed wetland from the top to the bottom, in other words vertical. At the bottom of the Reed Bed is a drainage pipe that collects the purified Greywater and delivery the purified Greywater to a sump. From the sump the purified Greywater is pumped with a submersible pump direct to the Irrigation field and/or to another storage tank. The pump works automatically and is controlled by a floating level switch that will stop and start the pump.

#### 5.5.5 Reed Bed - the Greywater Treatment and Distribution system



The soil in a Reed Bed (wetland construction) is made up of a fixed mixture of sand and gravel of various grain sizes. The water is purified through disintegration process with the soil particles during the percolation process through the ground. In this way the water

has attained the desired quality (European Union- Quality of Bathing Water 76/160) when it has reached the outlet.

Chemical researches of wastewater prove that vertical as well as horizontal filters with ground composition of sand and gravel face less hydraulic problems than systems with ground composition of silt and clay (e.g.. rooted ground systems). In consequence Reed Beds using a mixture of sand and gravel also achieve significantly superior flow off rates and purification. The nutrient removal through the plants – usually some sort of reed – as well as the oxygen charge through the gas channels of the swamp plant's roots is relatively insignificant. Nevertheless the plants improve the total system through their isolating function during the winter as well as the rotation (and resulting improvement of the hydraulics of the ground).

As in technical wastewater treatment plants the goal of purifying Wastewater/Greywater with a Reed Bed is first of all the removal of carbon compounds, nitrogen compounds and phosphorus. The water is also supposed to be cleansed of pathogenic as well as non-pathogenic microorganisms. It takes no special measures for constructed wetlands to eliminate a considerable portion of the in fed nutrients and to even exceed the required basic cleansing significantly. The living soil provides favorable circumstances for the bacteria to convert the organically attached nitrogen to ammonium, nitrate and finally atmospheric nitrogen and thus to extract it from the water. The phosphorus retained in a Red Bed accumulates in the soil. A small surface area usually provides a high purification performance due to the generally intermittent method of operation. Vertical Reed Beds are known to achieve high CSB disintegration results and an almost complete nitrification.

<p>Surface area</p> <p>Blackwater = 4 – 5 m<sup>2</sup> per inhabitant</p> <p>Greywater = 1 – 1.5 m<sup>2</sup> per inhabitant</p>
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#### **5.5.6 Vacuum Sewerage Systems (Outdoor Sewage Collection)**

Waste water collection systems with great cost advantages and technical benefits for municipalities where topography is difficult. Some main advantages

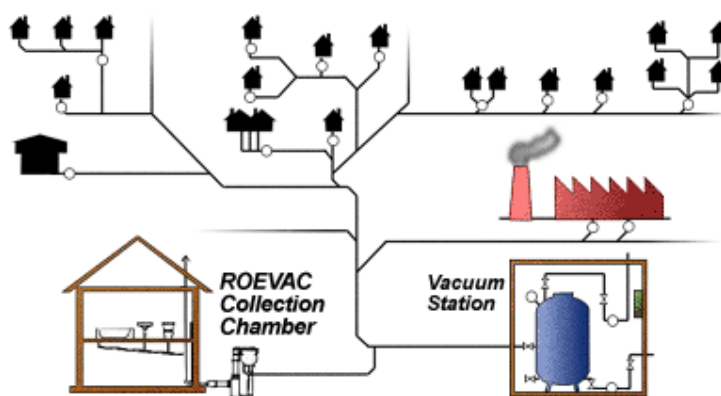
- Small diameter pipes of PVC or PE reduces costs
- Reduced installation costs, due to narrow and shallow trenches
- No manholes required, due to maintenance free sewer lines
- Upgrade transportation, crossing of obstacles possible
- Exfiltration impossible, thus ideal for water protection areas
- Installations of water supply and vacuum sewer in the same trench allowed
- No sediments, no odor
- Electricity and pumps located at a single point (central vacuum station)

Vacuum Sewerage lends itself ideally to flat terrain, briefly where difficult terrain means an installation program with conventional gravity and pumping stations becomes expensive. The Vacuum Sewerage System has major advantages and should be considered especially for:

- Insufficient natural slope, i.e. flat countryside
- Poor subsoil conditions (i.e. unstable soil or rock, high groundwater table)
- Obstacles to the sewer route (utilities, waterways)
- Aquifer protection zones
- Seasonal operation (e.g. in holiday resorts)
- Minimal space for infrastructure installations (e.g. historical townships, narrow streets)
- Frequently flooded areas

Vacuum sewerage systems consist of

- The vacuum station, where the vacuum is generated,
- The vacuum pipeline system,
- Collection chambers with collection sumps and
- Interface valve units.



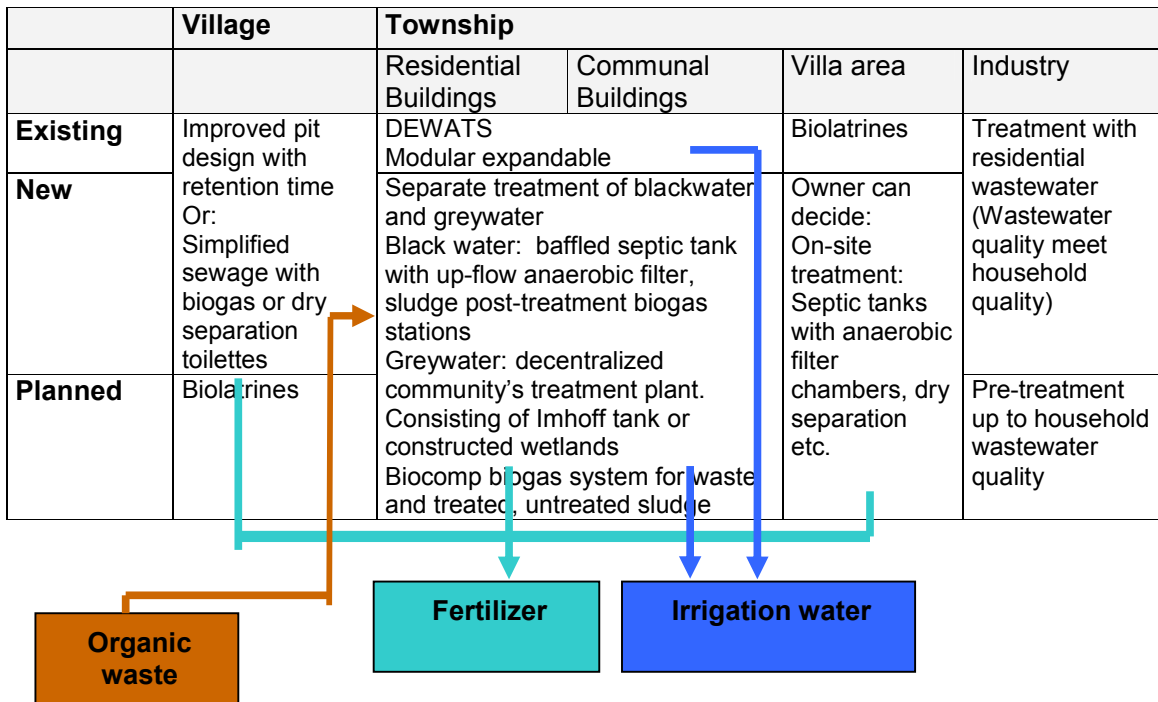
Batches of wastewater are driven by air streaming from the collection chambers towards the vacuum station. In contrast to conventional gravity sewerage systems with intermediate pumping stations, the pressure within the vacuum system is maintained below atmospheric pressure. The interface valve units are operated pneumatically - no electricity for the operation of the valves is needed.

### 5.5.7 Urine Separating Toilet

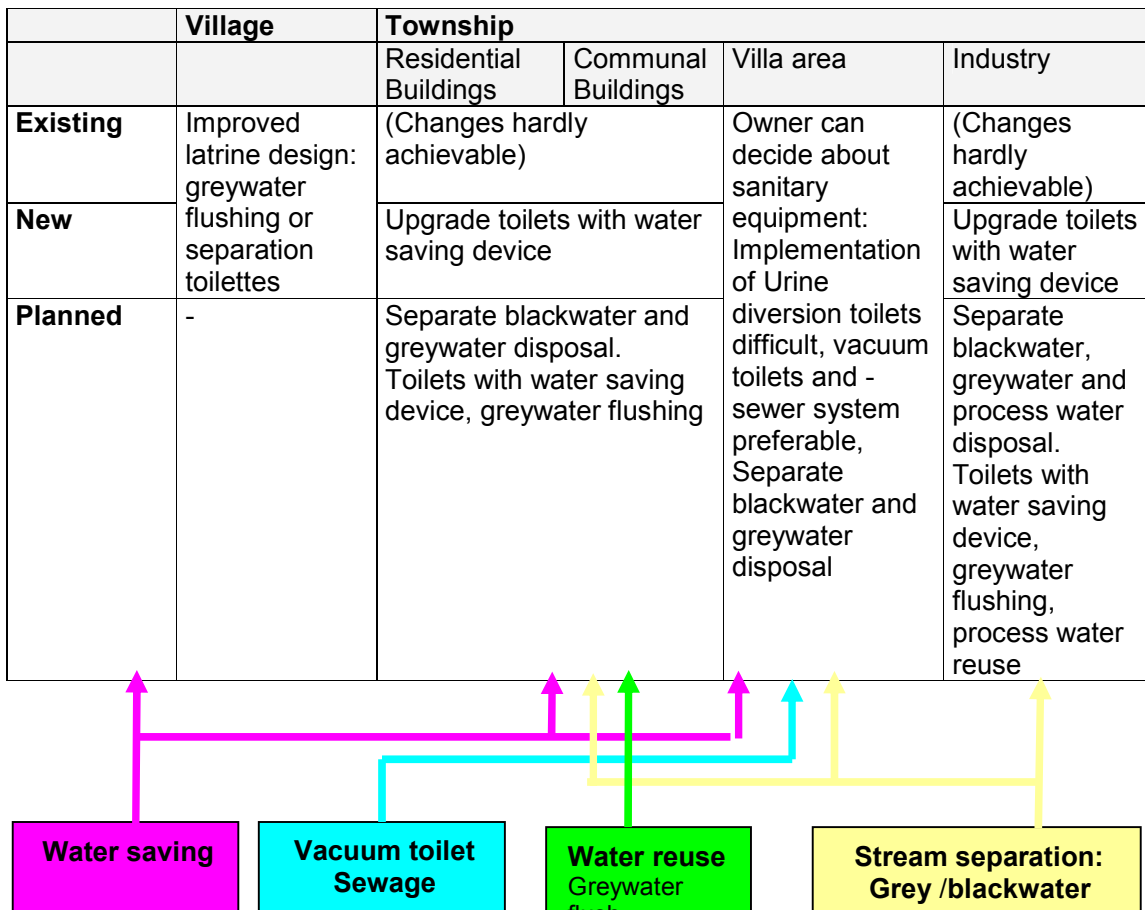
Toilet bowl (arrow points to urine drain) Ecological sanitation concepts require sophisticated toilets with such technical features as: (1) Reduction of toilet flush water consumption, (2) Undiluted urine separation as a way to recycle human waste into agricultural fertilizer, (3) Comfort, easy handling and a modern design. Urine is a valuable fertilizer containing nutrients such as phosphate, nitrogen and potassium. Faeces can be combined with biological wastes for use in biogas reactors.



**5.5.8 Summarized recommendations for the wastewater treatment**



**5.5.9 Summarized recommendations for sanitary equipment**



# 6 Appendices

Yang Song 2001



Yang Song 2010

