3 DEWATS – Sustainable treatment of wastewater at the local level

Private and public entities are faced with the following situations:

- national and regional development plans require the wastewater connection of peri-, semi-urban and rural settlements to treatment facilities, which meet discharge standards
- new housing and real estate developments do not get clearance without approved wastewater-treatment systems
- schools, hospitals, hotels and public facilities face public pressure, due to surface-water pollution
- small and medium enterprises unable to treat wastewaters adequately are closed down by public authorities

Only a few of the households – well as public and private entities, that require wastewater treatment can be serviced by conventional sewage and wastewater-treatment systems. The rapidly growing demand can only be met with the assistance of other technical solutions, which should ideally fulfil the following criteria:

- suitable for very diverse local conditions and versatile in application
- provide reliable and efficient treatment of domestic and process wastewater
- require only short planning and implementation phases
- moderate investment costs
- limited requirements for operation and maintenance

It is evident that decentralised wastewater solutions, which fulfil these criteria, have to become an integral part of comprehensive wastewater strategies, complementing other approaches.

3.1 DEWATS – a modular system approach to ensure efficient wastewater-treatment performance

"Decentralised Wastewater Treatment Systems" (DEWATS) were developed by an international network of organisations and experts. In this handbook, the term DEWATS may be applied in singular or plural form, refering to a single specific system, to the modular systems approach or the whole range of systems, as the case may be. The approach incorporates lessons learned from the limitations of conventional centralised and decentralised wastewater-treatment systems, thereby assisting to meet the rapidly growing demand for on-site-wastewater solutions. DEWATS are characterised by the following features:

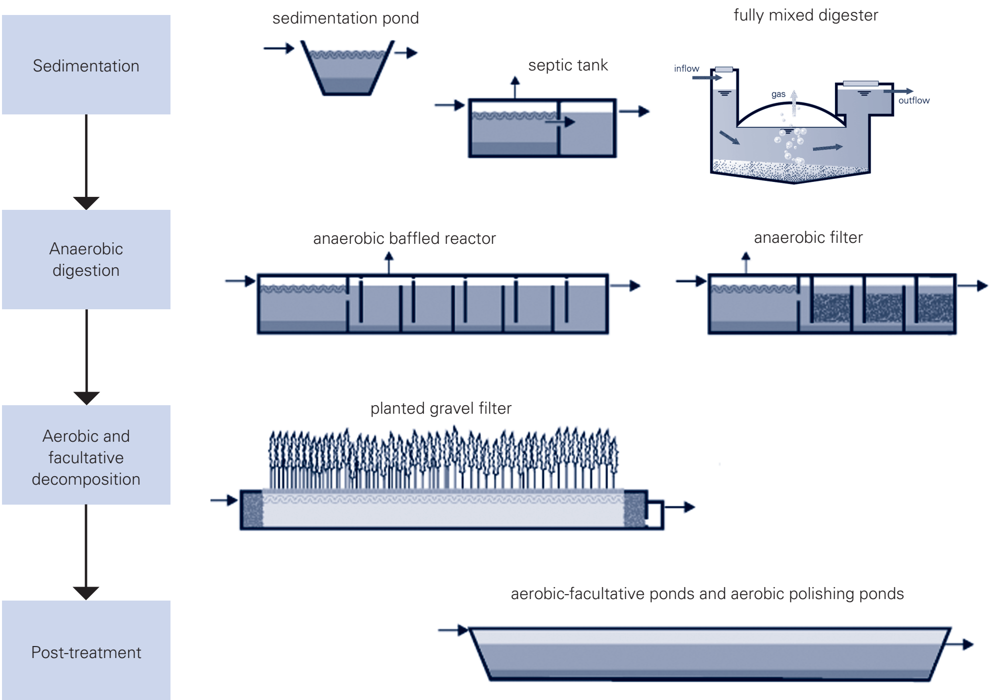
- DEWATS encompass an approach, not just a technical hardware package, i.e. besides technical and engineering aspects, the specific local economic and social situation is taken into consideration
- DEWATS provide treatment for wastewater flows with close COD/BOD ratios from $1m^3$ to $1000m^3$ per day and unit
- DEWATS can treat wastewaters from domestic or industrial sources. They can provide primary, secondary and tertiary treatment for wastewaters from sanitation facilities, housing colonies, public entities like hospitals, or from businesses, especially those involved in food production and processing.
- DEWATS can be an integral part of comprehensive wastewater strategies. The systems should be perceived as being complementary to other centralised and decentralised wastewater-treatment options
- DEWATS can provide a renewable energy source. Depending on the technical layout, biogas supplies energy for cooking, lighting or power generation
- DEWATS are based on a set of design and layout principles.
  Reliability, longevity, tolerance towards inflow fluctuation, cost efficiency and, most importantly, low control and maintenance requirements

- DEWATS usually function without technical energy inputs. Independence from outside energy sources and sophisticated technical equipment provides more reliable operation and, thereby, fewer fluctuations in effluent quality. Pumping may be necessary for water lifting
- DEWATS are based on a modular, technical configuration concept. Appropriate combinations of treatment modules can be selected, depending on the required treatment efficiency, costs, land availability, etc.
- DEWATS units are quality products. Though they can be constructed form locally available materials and can be implemented by the local workforce, high quality standards in planning and construction have to be met. For sound DEWATS design a good comprehension of the process of wastewater-treatment is essential
- DEWATS require few operation and maintenance skills. While most operational tasks can be carried out by the users, some maintenance services might require a local service provider. In some cases, both operation and maintenance can be delivered by a service provider
- DEWATS can reduce pollution load to fit legal requirements. Like all other wastewater-treatment systems, generated solid waste (sludge) must be handled, treated and disposed of in accordance with hygiene and environmental standards
- DEWATS consider the socio-economic enviroment of a given location. Neglecting these conditions will result in the failure of the technology

3.2 DEWATS – a brief insight into technical configuration

Typical DEWATS combine the following technical treatment steps in a modular manner:

- primary treatment – in sedimentation ponds, settlers, septic tanks or bio-digester
- secondary treatment – in anaerobic baffled reactors, anaerobic filters or anaerobic and facultative pond systems
- secondary aerobic/facultative treatment – in horizontal gravel filters
- post-treatment – in aerobic polishing ponds



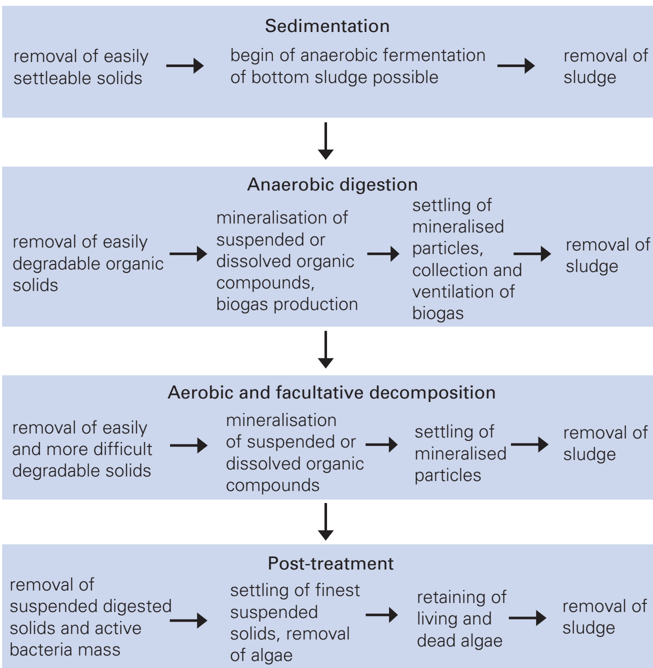
Picture 3_1: DEWATS configuration scheme

3 DEWATS – Sustainable treatment of wastewater at the local level

The selection of appropriate technical configuration depends on the:

- volume of wastewater
- quality of wastewater
- local temperature
- underground conditions
- land availability
- costs
- legal effluent requirements
- cultural acceptance and social conditions
- final handling of the effluent (discharge or reuse)

DEWATS rely on the same treatment processes as conventional treatment systems:



Picture 3_2: Typical succession of treatment processes within DEWATS

3.3 DEWATS – good practice examples/applications

In recent years, DEWATS have been implemented at many different locations by various institutions. Gathered experience shows that each location demands its own approach. Below, a number of "good practice examples/applications" of DEWATS are presented. These are not meant to be exhaustive; they highlight different aspects of DEWATS implementation.

3.3.1 DEWATS/CBS – Community-Based Sanitation Programme in Alam Jaya, Tangerang, Java, Indonesia

Alam Jaya is a slum in the middle of an industrial area in Jakarta. Most residents work in the nearby factories. Due to a high migration rate, social structures are weak. The level of infrastructure development is low. Housing is poor with insufficient water supply.

Sanitation facilities in the settlement are totally insufficient in terms of quality and quantity. Wastewater is discharged into the environment without any treatment, posing a permanent threat to human health.

Picture 3_3: Housing in Alam Jaya

3 DEWATS – Sustainable treatment of wastewater at the local level

Bina Ekonomi Sosial Terpadu (BEST - Institute for Integrated and Social Development), a Tangerang-based non-profit organisation, has been promoting "Community Sanitation Centres" (CSC) since 1999. The centres provide basic sanitation facilities, such as toilets, bathrooms, a laundry area and "water points". The total wastewater flow is treated in a DEWATS. Until 2008, 33 Community Sanitation Centres have been implemented in the Tangerang and Surabaya areas, serving 14,800 users and treating 1,197m³ of wastewater per day.

Picture 3_4: Typical sanitation facilities in Alam Jaya

Picture 3_5: New Community Sanitation Centre in Alam Jaya

An intensive discussions process within the community preceded the decision to build a Community Sanitation Centre:

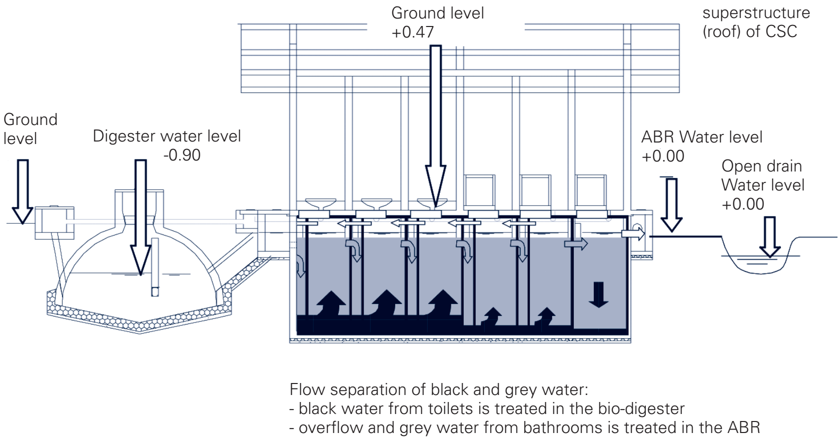
- the residents' desire for on-site toilets could not be met, due to the small size of the houses and plots
- the residents already use public toilets
- there was great interest in a reliable "water supply point"
- residents expressed their willingness to pay for water-supply and sanitation services

Picture 3_6: Toilet at the CSC in Alam Jaya

The wastewater of the residents of the Alam Jaya quarter RT 02 RW 06 (65 households with 325 people) has the following parameters:

Source of water	domestic
Volume	37.5m³/day
Daily peak-flow hours:	16h
COD, influent:	743mg/l
BOD, influent	391mg/l
HRT in baffled tank	30h
Minimal digester temperature	30°C
Specific organic load (BOD_5):	0.34kg/(m³ x d)
Number of up-flow chambers	6 chambers
Volume of baffled reactor	49.39m³
COD, effluent	137mg/l
BOD_5, effluent	62mg/l

Table 2:
Data of Alam Jaya plant. in 2003, the construction cost were 167 Mio. IDR or 20,000 US$. Operation cost = 444,000 IDR or 55 US$/month. Users pay per use.



Picture 3_7:
Section of Community Sanitation Centre (CSC) in Alam Jaya with toilets and bathrooms

3.3.2 DEWATS/CBS – Community-Based Sanitation Programme in Ullalu Upanagara, Bangalore, India

Ullalu Upanagara is a peri-urban slum, located south-west of Bangalore, with 3,569 households and 17,325 people of different ethnic groups. The socio-economic situation of the residents is critical: inadequate basic amenities, high unemployment, low literacy. Women in particular face social hardship within their families and the community.

The weak socio-economic conditions are reflected in the infrastructure development. Access to reliable drinking-water supply, to proper housing and to clean sanitation is virtually non-existent. Only 21% of the households have their own toilet. The residents defecate openly – hindered by recent fencing.

Grama Swaraj Samithi (GSS), a local NGO, has been working in Ullalu Upanagara in the field of preventive health care since the 1990s. Since 2001, GSS has been promoting Community-Based Sanitation within the community. In close collaboration with the residents and local authorities, the construction of two sanitation centres was decided on. The implementation process was carried out as a pilot-programme, to test the application of participatory, administrative and technical instruments of the Community-Based Sanitation programme for the area.

Picture 3_8: Infrastructure is poor in Ullalu Upanagara

The participatory planning process resulted in the following layout of the overall complex:

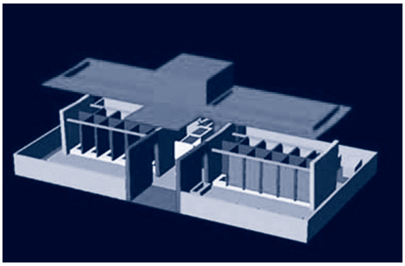
- 2 separate sections – one for women, one for men
- 11 toilets and 1 bathing unit per section
- 12 laundry facilities – 8 for women, 4 for men
- fresh-water consumption:
  – $11.5m^3$ per day
  – water connection and supply assured by Zilla Panchayat
  - use of rainwater harvesting tank during the rainy season
- source and quantity of effluent:
  – toilet and bathing wastewater: $7.5m^3$ per day
  – laundry wastewater: $4.0m^3$ per day
- low maintenance:
  – no piped water in toilets and bathing units
  – minimum electrical devices
- security
  – female and male sections visibly separated
  – entrance area for control and collection of service charges

Picture 3_9: Community Sanitation Centre under construction

Construction costs of the sanitation centre including DEWATS in 2004:

• sanitation unit:	INR	550,000	(US$ 11,875)
• DEWATS-unit:	INR	1,000,000	(US$ 21,590)
• bore well and electrical power connection:	INR	275,000	(US$ 5,940)
• land value:	INR	1,280,000	(US$ 27,640)
• total cost per complex:	INR	3,105,000	(US$ 67,045)

Picture 3_10:
Newly inaugurated sanitation centre. Initially designed for 750 users per day, today over 1,000 visitors due to a nearby bus station.



Picture 3_11:
Computer drawing of a sanitation unit

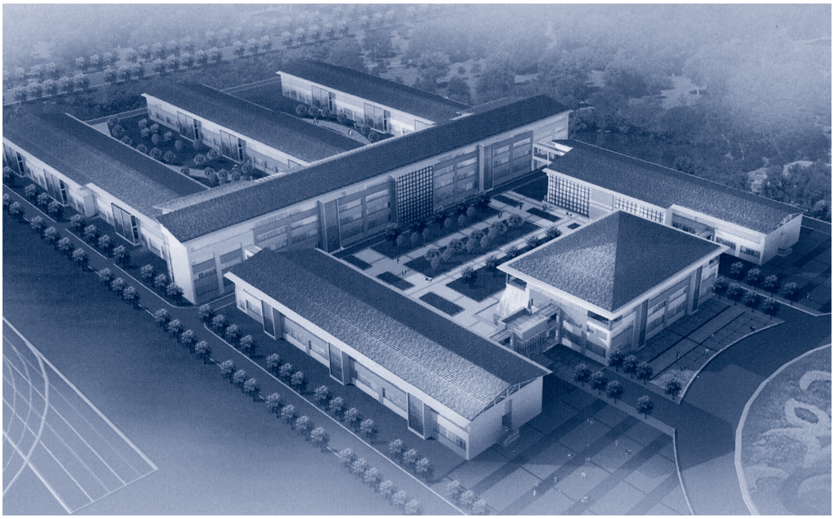
Picture 3_12:
The Community-Based Sanitation programme was closely planned in collaboration with the future "users”

3.3.3 DEWATS at public institutions – Sino-German College of Technology, Shanghai, China

The Fenxian campus of the Sino-German College of Technology at East China University of Science and Technology is located an hour's drive from Shanghai. It is an engineering college and its campus was planned for 6,500 teachers and students (no accomodation).

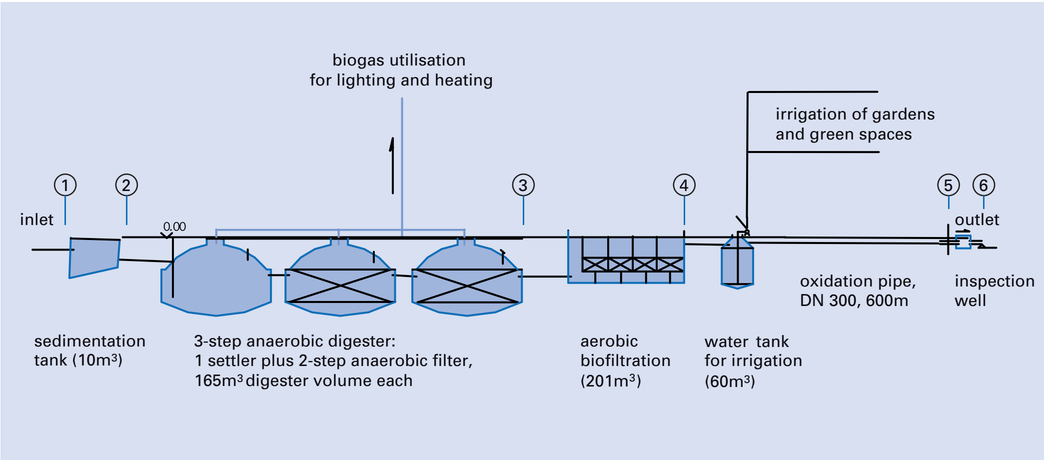
The challenge for the school's authorities was to find a reliable and efficient solution for treating their wastewater in accordance with the Environmental Standard GB/T 18921-2002 (2nd stage). Tight budget constraints for initial investment and operation restricted the possible wastewater-treatment options.

The campus wastewater consists of toilet effluent from the teaching buildings, as well as polluted water from machinery-maintenance processes. The DEWATS technical configuration had to consider therefore oil, NH_3-N, grease and swarf, besides the normal parameters of COD and BOD_5.

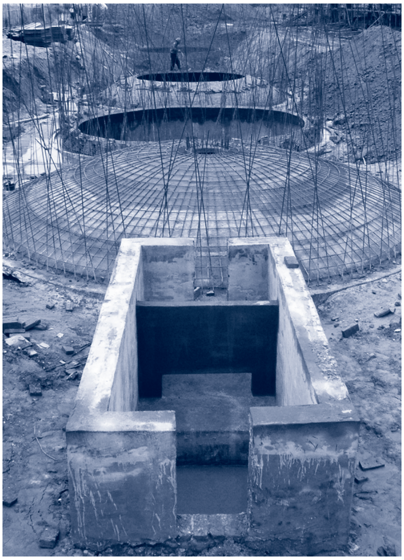


Picture 3_13: View of the college campus

The chosen DEWATS consists of a module for grease separation and sedimentation, a three-step anaerobic digester with filter, an underground sand filter (biofiltration) and an irrigation tank. Operation started in September 2004. The effluent is used to irrigate compound gardens, while biogas is used to light campus street lamps and water heating. The project costs were calculated at 960,000 RMB (US$ 115,942).



Picture 3_14:
Schematic drawing of the DEWATS solution at the Sino-German College of Technology in Shanghai, Fengxian District



Picture 3_15:
View of campus buildings and biogas street lights

Picture 3_16:
DEWATS under construction

The effluent of the plant shows that the required discharge standards are met:

Sample Point	Inflow 1	Sedimentation tank 2	3-step anaerobic digester 3	Aerobic sand filter 4	Aerobic oxidation pipe 5	Inspection well 6	Required legal standard
Daily waste-water flow [m³]	146.25	146.25	146.25	146.25	146.25	146.25	
Capacity [m³]		10	495	195	5	1	
HRT [h]			81	32	0.8		
COD_{cr} [mg/l] *(removal rate)*	800	720 *(10%)*	108 *(85%)*	91.8 *(15%)*	87.21 *(5%)*	87	100
BOD_5 [mg/l] *(removal rate)*	400	360 *(10%)*	39.6 *(89%)*	31.68 *(20%)*	28.5 *(10%)*	28.5	30
SS [mg/l] *(removal rate)*	200	180 *(10%)*	90 *(50%)*	45 *(50%)*		45	150
NH_3-N [mg/l] *(removal rate)*	80		40 *(50%)*	16 *(60%)*	14.4 *(10%)*	14.4	15
Oil [mg/l] *(removal rate)*	20	10 *(50%)*				10	15

Table 3:
Water-treatment data (analysis by local environmental protection bureau)

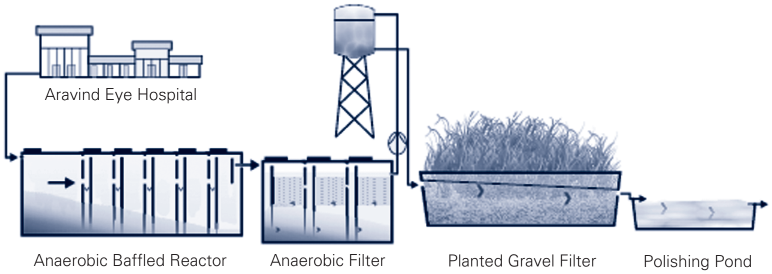
3.3.4 DEWATS at public institutions – Aravind Eye Hospital in Thavalakuppam, Pondicherry, India

The Aravind Eye Hospital in Thavalakuppam belongs to the Tamil Nadu-based Aravind Eye Care System. The philosophy of the Aravind System is to provide services to the rich and poor alike, while achieving financial self-sustainability. This is achieved through high-quality, large-volume care and efficient management.

The hospital in Thavalakuppam has the capacity to treat 750 in patients (600 free admissions and 150 paid) and an additional 900 out patients. 300 paramedical staff are housed in 26 residential quarters.

Due to the water scarcity in the region, the hospital management expressed strong interest in a wastewater-treatment solution, that permits the reuse of treated water.

The chosen DEWATS solution was designed to treat approximately 307m³/d of domestic wastewater from toilets, bathrooms and kitchens. Water reuse (due to high water scarcity) and efficient land use had the highest priority in treatment-process selection.



Picture 3_17: Schematic drawing of the DEWATS at Aravind Eye Hospital

The effluent of the DEWATS-plant irrigates a garden with 300 trees planted in avenues, 250 coconut trees, 50 mango trees and 4,200m² of lawns, covered with Korean grass and flowering plants. In 2004, the hospital was honoured with the Pondicherry Government's award for the best garden. Construction started mid 2002, start of operation was February 2003. Construction cost are 10 Mio INR (200,000 US$).

Picture 3_18: Polishing pond of Aravind Eye Hospital's DEWATS. Through reuse of treated waste-water, Aravind Eye Hospital saves annually 100,000m^3 of freshwater.

Picture 3_19:
Horizontal filter with *canas indica, reed juncus* and papyrus plants

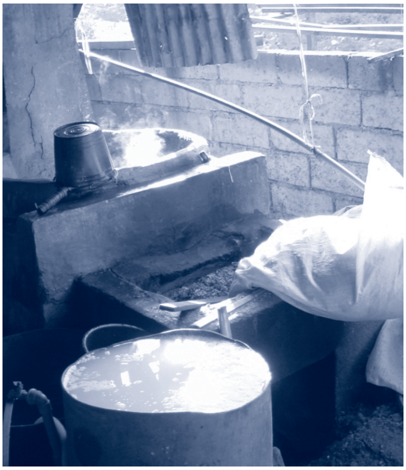
Picture 3_20:
Baffled reactors are used as a parking lot

3.3.5 DEWATS/SME-Cluster approach – Kelempok Mekarsari Jaya small-scale industry cluster, Denpasar, Bali, Indonesia

Mekarsari Jaya is a small-scale industry cluster in Pucuksari Selatan, Banjar Batur, Denpasar. It consists of 54 entrepreneurs, engaged in tofu production and chicken slaughtering. At the same time, Mekarsi Jaya is a settlement area for migrants from other parts of Indonesia. Due to the poor infrastructural conditions, the area is considered a "slum" by the local residents.

Wastewater from domestic and industrial sources is generally discharged to nearby "dead water" channels without any treatment. But recently enforced environmental regulations, mean that enterprises are forced to treat their wastewaters before discharge.

The project was planned and implemented by BaliFokus, a Denpasar-based NGO. Due to the settlement structure and topographical condition of the area, the implementation of a central treatment unit for Mekarsari Jaya faced major technical obstacles. In order to meet the legal requirements of the authorities, it was decided to implement two DEWATS in the area. While one system in Northern Pucuksari serves 11 tofu-processing units and 5 chicken-slaughter houses, a second system in Southern Pucuksari Selatun serves 7 processing plants.



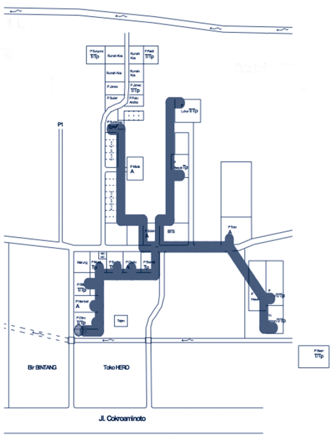
Picture 3_21: Tofu processing causes high water pollution in Mekarsari Jaya

Picture 3_22: Domestic and industrial wastewater is discharged to channels without treatment

Wastewater analysis shows high loading of the wastewater:

- Northern unit – 50m³/d wastewater influent with a BOD of 7,000mg/l and COD of 11,000mg/l.
- Southern unit – 20m³/d wastewater influent with a BOD of 5,000mg/l and COD of 8,000mg/l.

Topography and settlement structure (densely populated) were the decisive factors for technical plant layout. A bio-digester, followed by an anaerobic filter, were found most suitable to treat the highly loaded wastewater.

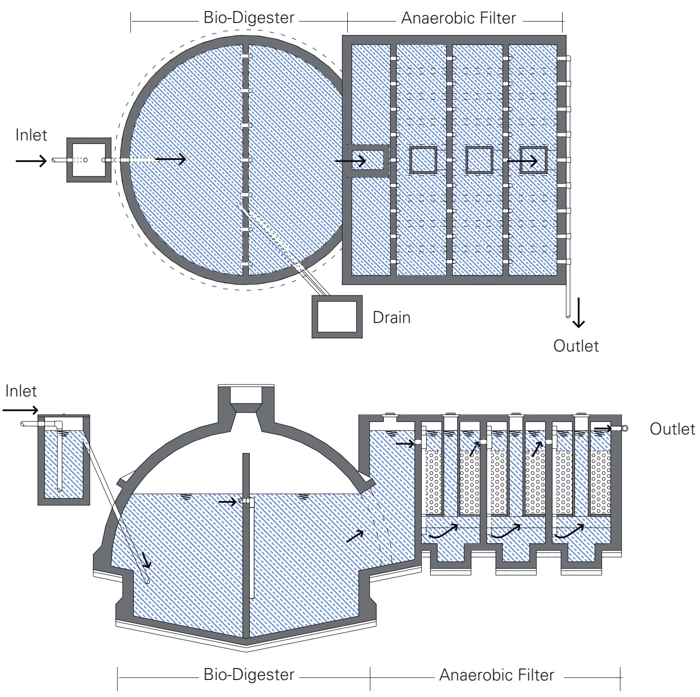


Picture 3_23: DEWATS treats wastewater from several industrial units (sewerage system= blue lines)

The following data characterises the DEWATS solution of the northern unit:

Source of water	domestic
Volume	50m³/d
Daily peak-flow hours:	12h
COD, influent:	11,000mg/l
BOD_5, influent	7,000mg/l
HRT in anaerobic filter	17.5h
Minimum digester temperature	30°C
Number of up-flow filter chambers	3 chambers
Volume of baffled reactor	36.45m³
COD, effluent	335mg/l
BOD_5, effluent	191mg/l

Table 3a: Characteristics of a DEWATS solution for small scale food processing industry and settlement at Mekarsari Jaya (northern unit). Start of construction: 09'2003 Start of operation: 04'2004 Construction cost: 112 Mio. IDR (US$13,500)



Picture 3_24: Technical layout and view of the DEWATS unit at Mekarsari Jaya (northern unit)

3.3.6 DEWATS/SME – Alternative Food Process Private Ltd. Bangalore, Karnataka, India

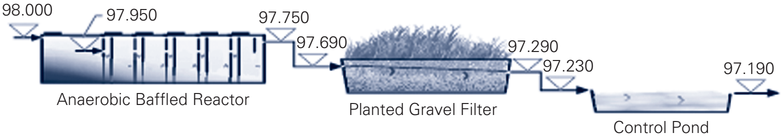
The food-processing unit is located in the suburbs of Bangalore city. The company operates a gherkin-processing plant, where selected gherkins are washed, prepared, pickled and stored over a period of 12 days before export.

The company caters semi-finished products to leading brands. High quality production and adherence to delivery standards of international markets are the top priority. The company employs around 100 people and handles 8 to 10 tonnes of gherkins per day.

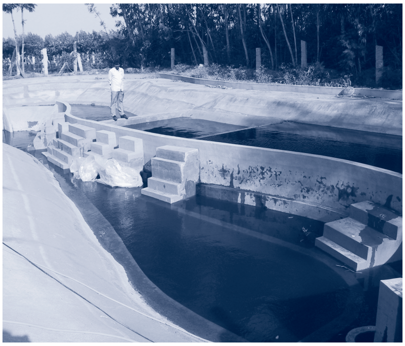
Picture 3_25 and 3_26: The products of Alternative Food Process Private Ltd. meet high delivery standards for national and international markets

The treatment of 29.1m³/d organic wastewater (COD 800 / BOD 400mg/l) is required. Due to water shortages in the area, water reuse is desirable.

To find the best treatment solution, a comprehensive analysis of the different wastewater streams was undertaken. By handling certain wastewater streams separately, the right treatment solutions could be applied to each situation:

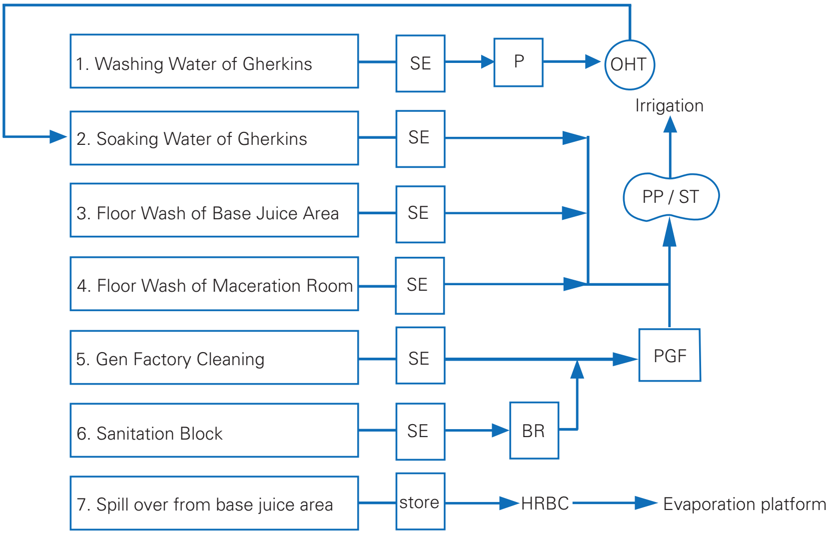


Picture 3_27: Schematic drawing of the DEWATS at Alternative Food Process Ltd.



Picture 3_28:
The anaerobic filter under construction

Picture 3_29:
View of polishing pond with shallow sections for better UV-disinfection and multi-levels for better aeration



Picture 3_30:
System layout (SE: Settler, BR: Baffle Reactor, PGF: Planted Gravel Filter, ST: Storage Tank, PP: Polishing Pond, HRBC: High-rate Brine Condenser (evaporation), OHT: Overhead tank, P: Pump)

3.3.7 Infrastructural development in rural China – Longtan Village, Danleng County, Szechuan Province, China

The Chinese government aims to improve rural livelihood by promoting the enhancement of rural infrastructure through different public programmes. Road construction, housing, electricity provision, biogas utilisation, water supply and wastewater schemes – as well as solid-waste management – are part of multiple village modernisation programmes.

Longtan Village has a population of 965 people living in 262 households. Agricultural production on approximately 56.7 ha of land is the main income source for the residents. Traditionally, paddy and oil seeds were cultivated. However, economic reforms have brought significant changes to Longtan: the village has begun market production of oranges, grapes and oil seeds, while raising 1,250 pigs in 2005. In this year, a household's average annual income was about 3,113 RMB per person (US$ 420).

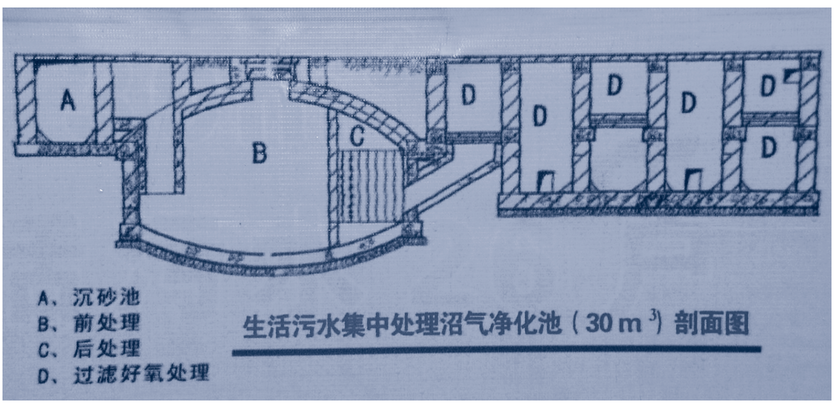
Public authorities in rural China have the challenge of meeting legal wastewater discharge standards. New air-quality standards have also been issued, demanding a different treatment of rice-harvest residues, which were traditionally burned. As a result, decentralised wastewater-treatment systems are promoted. A combination of anaerobic and of aerobic-treatment units is applied to treat animal dung, human faeces and residues from agricultural production. Biogas provides a renewable-energy source, while slurry can be used in organic farming.

Picture 3_31: DEWATS treats human faeces and agricultural residues

Picture 3_32: DEWATS-generated biogas is used for multiple purposes, such as water heating

The village's development plan stipulates that 120 households should be connected to biogas units, each with a volume of 10m³. Rice residues are processed in a chaff cutter before being emptied into the digesters. Bio-digesters with a volume of 3.5m³ are mandatory for households without paddy production. Where possible, homes are connected to one of two DEWATS plants in the village. The treated wastewater is discharged into the open drainage system, which crosses the village.

Picture 3_33:
Infrastructural development programmes aim to modernise Chinese villages

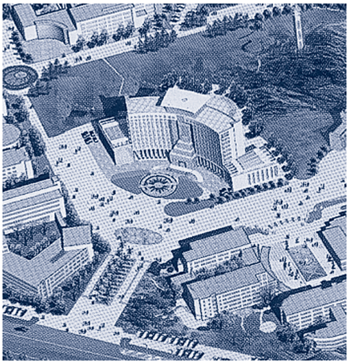


Picture 3_34
DEWATS – settler, bio-digester, anaerobic baffled reactor and horizontal filters (not shown)

3.3.8 DEWATS in integrated municipal planning – Wenzhou University, Zheijang Province, China

Since the 1980s, the government of Zhejiang Province has been promoting DEWATS, particularly in urban areas, which are not connected to centralised systems. Today, many of the province's sources of domestic wastewater, such as public toilets, apartment buildings, schools, hospitals and universities are served by these treatment systems. Apart from domestic applications, decentralised wastewater-treatment solutions are applied at small- and medium-scale enterprises, like slaughterhouses, food processing and animal-husbandry units.

The Wenzhou New Energy & Environmental Design Institute (WNEEDI), an Institute of the Rural Energy Office Wenzhou, is active in the dissemination of innovative renewable-energy and ecological wastewater-treatment projects (biogas plants, DEWATS, solar thermic systems, hydro rams) within the city and Wenzhou County. WNEEDI started by promoting biogas plants 50 years ago and has slowly shifted its main activities to wastewater treatment in urban areas.



Picture 3_35: The central administration building of the University of Wenzhou

Picture 3_36: Arial view of the University of Wenzhou campus

Within this context, WNEEDI was responsible for the planning and implementation of an integrated wastewater concept for Whenzhou University, the first university run jointly by the government and business. In 2005, the university had approximately 10,000 students.

The DEWATS implemented at the University campus are viewed as the ideal long-term solution. The treatment facilities will grow incrementally, in line with the addition of new buildings and the overall growth of the campus.

Today, the university uses multiple DEWATS, with a total reactor volume of about 90,000m³. Nearly all buildings, including the dormitories, have their own primary treatment unit, which connects to shared, secondary treatment units. Units of approximately 20 different treatment volumes, ranging from 40 to 800m³, have been implemented.

All systems consist of pre-treatment in fixed dome biogas modules. Two to four digesters are usually connected in series. After anaerobic treatment, the wastewater is aerobically treated by flowing over cascades. Final treatment is provided by two to four horizontal-flow sand filters in series.

Implementation is carried out by contractors, specialised in decentralised wastewater treatment. To ensure gas-tight construction of biogas domes, certification of the building contractors is required. The local Rural Energy Offices are responsible for certification; Wenzhou County has eight certified contractors.

Picture 3_37:
The project team tests the treatment performance.

Picture 3_38:
Construction of the anaerobic filter (in front)