Report on
Case Studies of ecosan Pilot Projects in India

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Supported by

ACTS, Navsarjan Trust, IWWA, GTZ and seecon gmbh

in the context of the

Innovative Ecological Sanitation Network India (IESNI)

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ABOUT THIS REPORT

This report is ment to provide information on the present state of ecosan pilot projects that are supported by ACTS, Navsarjan Trust, IWWA (Indian Water Works Association), GTZ (German Agency for Technical Co-operation) and seecon gmbh in the context of the Innovative Ecological Sanitation Network India (IESNI).

This report is to be considered a preliminary draft, summarizing information and outlining concepts for the collection, treatment and reuse of flowstreams (blackwater, yellowwater and greywater) at the following ecosan pilot projects:

- ecosan pilot project „ACTS Eco-friendly Public Toilet Centre in Rajendra Nagar, Bangalore".
- ecosan pilot project „Navsarjan Trust Vocational Training Institute *Dalit Shakti Kendra*",
- ecosan pilot project „Navsarjan Trust Primary Schools Project",

Enclosed please find reports on the following ecosan prefeasibility studies:

- ecosan prefeasibility study "Adarsh Vidyaprasarak Sanstha's College of Arts & Commerce, Badlapur",
- ecosan prefeasibility study „International Centre of Ecological Engineering at the University of Kalyani",
- ecosan prefeasibility study „ACTS Rayasandra Campus for Higher Education, Bangalore",
- ecosan prefeasibility study „Eco-friendly Public Toilet Centre at Virar Science Garden",
- ecosan prefeasibility study "Collection, Treatment and Reuse of Wastewater Collected from the Desert Areas along the Banks of Bhima-River in Pandharpur City",

For updates and the latest information on ongoing and upcoming ecosan pilot projects in India, which are implemented in the context of the IESNI, please see:

- GTZ-ecosan webpage (http://www.gtz.de/ecosan/) and
- seecon gmbh webpage (http://www.seecon.ch/).

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1.1 Water and sanitation crisis in India and South Asia

In 2002, according to the WHO/UNICEF Joint Monitoring Programme for Water Supply and Sanitation (JMP) Report 2004, 16% of the 1,480 million population in South Asia lacked access to „improved“ drinking water and 64% lacked access to „improved“ sanitation (table 1). Household connections, public standpipes, boreholes, protected dug wells, protected springs and rainwater collection are considered “improved” sources of drinking water; connection to a public sewer or septic system, pour-flush latrines, simple pit latrines and ventilated improved pit latrines (VIP-latrines) are considered to be “improved” sanitation. [1]

WHO/UNICEF projects the „improved“ drinking water and sanitation coverage in South Asia to be 96% and 55% in 2015, respectively. [2] The attained coverage to meet the MDG targets is 86% and 60%, respectively. Therefore South Asia is likely to meet its drinking water target, but fail in meeting the sanitation target. In order to meet the sanitation target in South Asia an additional 115,000 people per day would have to be provide „improved“ sanitation in 2002 – 2015 (table 2).

table 1: Change in drinking water and sanitation coverage from 1990 to 2002 in South Asia

country	year	population			improved drinking water coverage			improved sanitation coverage		
		total (thousands)	urban [%]	rural [%]	total [%]	urban [%]	rural [%]	total [%]	urban [%]	rural [%]
Afghanistan	1990	13,799	18	82	-	-	-	-	-	5
	2002	22,930	23	77	13	19	11	8	16	5
Bangladesh	1990	109,402	20	80	71	83	68	23	71	11
	2002	143,809	24	76	75	82	72	48	75	39
Bhutan	1990	1,696	5	95	-	-	-	-	-	-
	2002	2,190	8	92	62	86	60	70	65	70
India	**1990**	**846,418**	**26**	**74**	**68**	**88**	**61**	**12**	**43**	**1**
	2002	**1,049,549**	**28**	**72**	**86**	**96**	**82**	**30**	**58**	**18**
Iran	1990	56,703	56	44	91	98	83	83	86	78
(Islamic Republic of)	2002	68,070	66	34	93	98	83	84	86	78
Maledives	1990	216	26	74	99	100	99	-	100	-
	2002	309	28	72	84	99	78	58	100	42
Nepal	1990	18,625	9	91	69	94	67	12	62	7
	2002	24,609	15	85	84	93	82	27	68	20
Pakistan	1990	110,901	31	69	83	95	78	38	81	19
	2002	149,911	34	66	90	95	87	54	92	35
Sri Lanka	1990	16,830	21	79	68	91	62	70	89	64
	2002	18,910	21	79	78	99	72	91	98	89
South Asia	1990	1,174,590	29	71	71	90	66	19	54	7
	2002	1,480,287	33	67	84	94	80	36	66	24

(source: [1])

Sanitation coverage in India increased from 12% in 1990, the baseline for the MDG targets, to 30% in 2002, broken into 18% and 58% for rural and urban areas, respectively. But coverage needs to grow to 56% of the much higher 2015 population, if India is to meet its MDG sanitation target. Based on population and coverage data in 2002 (population: 1,049,549,000; coverage: 30%) and a prospected population of 1,260 million in 2015, the additional population to be served „improved" sanitation is 82,000 per day to meet the MDG sanitation target in 2015.

table 2: Daily increase in population to be served to meet the MDG target on water supply and sanitation in 2015

country	projected population (medium variant) in 2015 (thousands) [3]	MDG attained coverage [1]		daily increase needed in people served 2002 - 2015 to meet the MDG targets	
		water supply [%]	sanitation [%]	water supply	sanitation
Afghanistan	41,401	no data	no data	-	-
Bangladesh	168,158	86	62	8,000	7,000
Bhutan	2,684	no data	no data	-	-
India	**1,260,366**	**84**	**56**	**33,000**	**82,000**
Iran (Islamic Republic of)	79,917	96	92	3,000	3,000
Maledives	416	100	no data	> 50	-
Nepal	32,747	85	56	2,000	2,000
Pakistan	193,419	92	69	9,000	11,000
Sri Lanka	22,293	86	60	1,000	1,000
South Asia	1,801,401	86	60	64,000	115,000

1.2 Millenium Development Goals (MDG)

Approved by 189 governments in September 2000, the Millennium Development Goals (MDGs) provide a clear agenda to improve the lives of the world's poor. First laid out in the UN Millennium Declaration, the MDGs were amplified by the 2002 World Summit on Sustainable Development in the Johannesburg Plan of Implementation, which set out targets to be achieved by 2015.

With particular regard to water issues the goal 7 („Ensuring Environmental Sustainability") has set itself the target to „Halve by 2015 the proportion of people without sustainable access to safe drinking-water and sanitation" with 1990 as a baseline. [4]

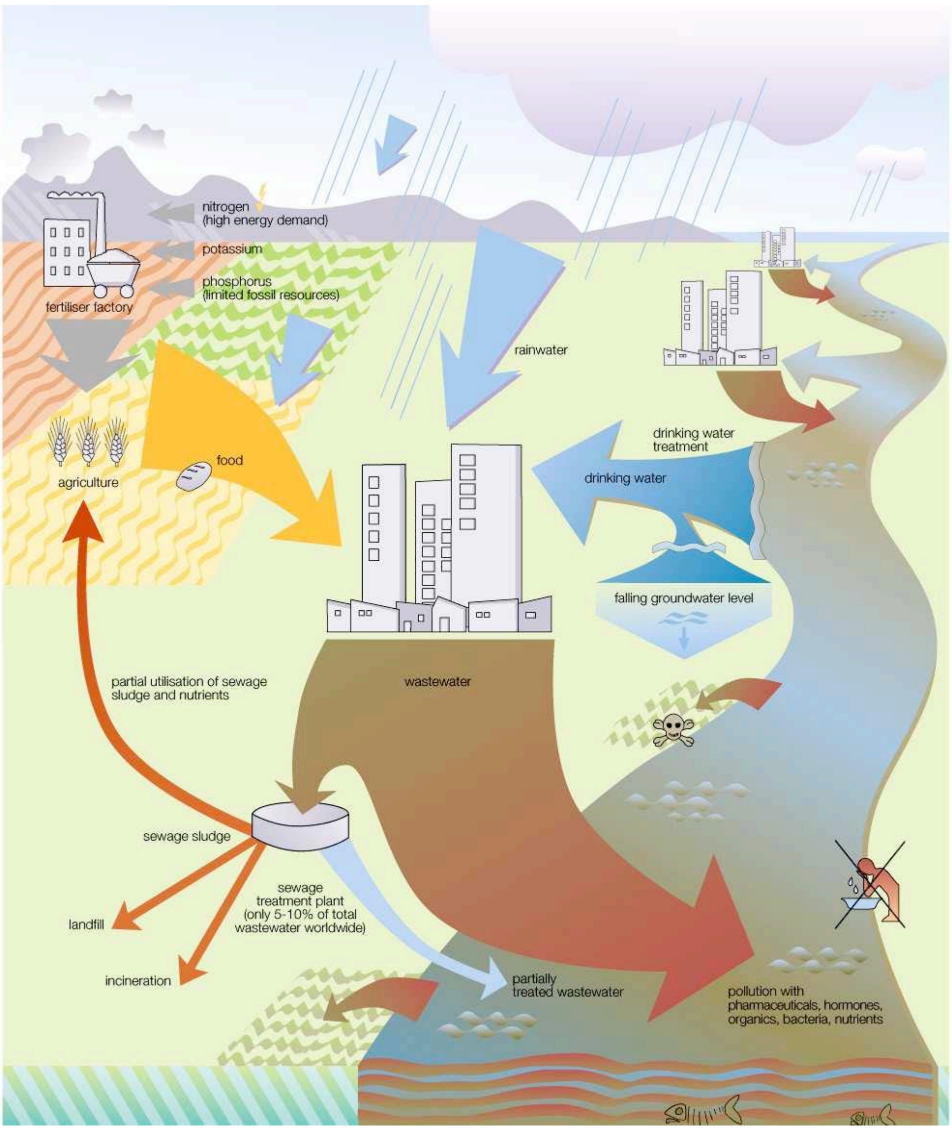
Improved water and sanitation will speed the achievement of all eight MDGs, helping to: eradicate extreme poverty and hunger; achieve universal primary education; promote gender equality and empower women; reduce child mortality; improve maternal health; combat HIV/AIDS, malaria and other diseases; ensure environmental sustainability; and develop a global partnership for development. [2]

1.3 Ecosan - an approach to human dignity, community health and food security

Limitations of conventional wastewater management systems

Although increasing criticism has been levelled at conventional forms of central wastewater management systems for ecological and economic reasons, those systems i.e. a combined system with postconnected multistage wastewater treatment facilities, are widely used all around the globe today. figure 1 schematically illustrates the main limitations of conventional wastewater management systems such as: [5]

- Unsatisfactory purification or uncontrolled discharge of more than 90 % of wastewater world-wide;
- Pollution of water bodies by organics, nutrients, hazardous substances, pathogens,



(source: GTZ-ecosan)

figure 1: Limitations of conventional wastewater management systems

pharmaceutical residues, hormones, etc;

- Unacceptable health risks and spread of disease;
- Severe environmental damage and eutrophication of the water cycle;
- Consumption of precious water for transport of waste;
- High investment, energy, operating and maintenance costs;
- Frequent subsidisation of prosperous areas, and neglect of poor settlements;
- Loss of valuable nutrients and trace elements contained in excrement through their discharge into water bodies;
- Impoverishment of agricultural soils, and increased dependence on chemical fertilisers;
- Predominance of combined central systems, resulting in problems with contaminated sewage sludge;
- Linear end-of-pipe technology.

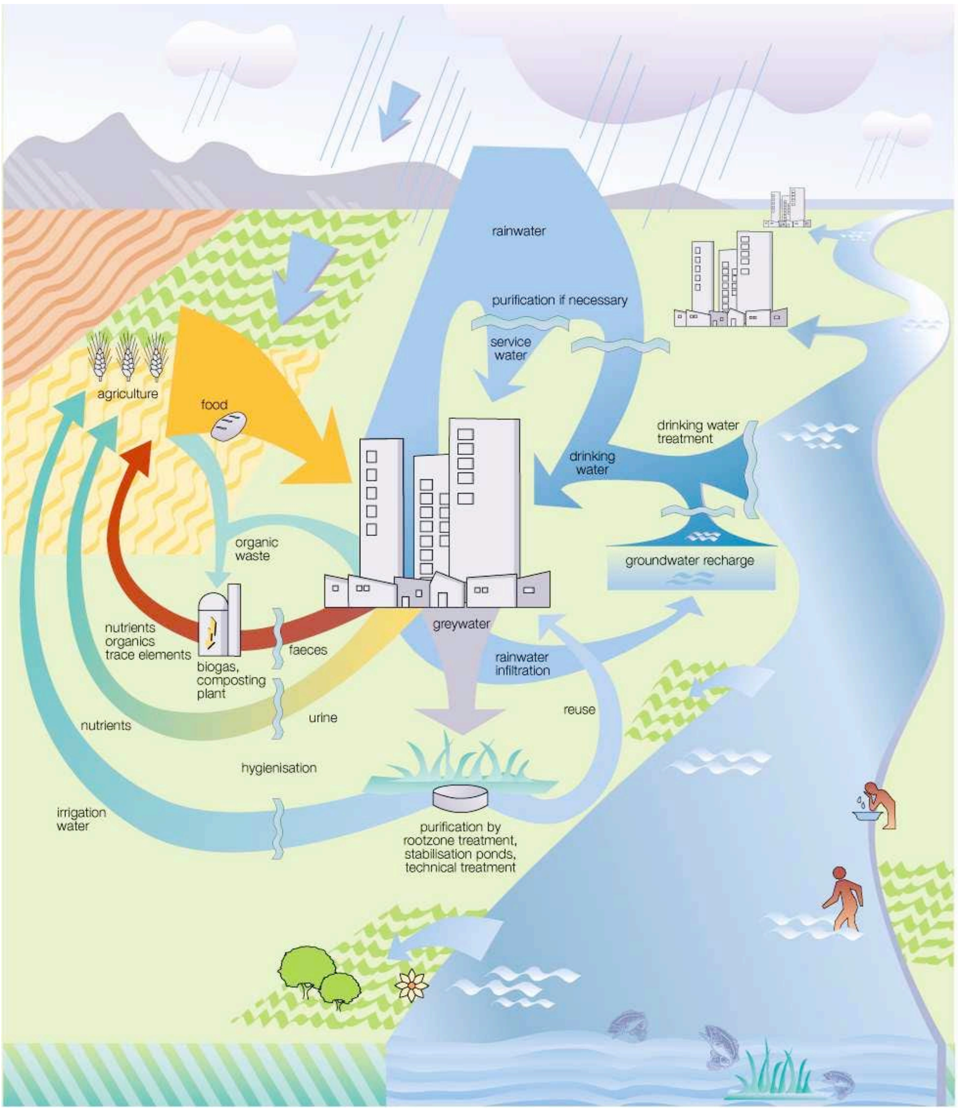
Advantages of ecollogical sanitation systems

To overcome drawbacks of the so called „end-of-the-pipe“ sanitary systems, which are based on the modern misconception that human excreta are simply wastes with no useful purpose and must be disposed of, and in order to meet the MDGs and achieve sustainability in the field of sanitation a new paradigm is needed. Ecological sanitation, or „ecosan“ for short, is this new paradigm in sanitation that recognises human excreta and water from households not as a waste but as resources that can be recovered, treated where necessary and safely used again. Tailored to local needs, ecological sanitation systems, ideally, enable a complete recovery of nutrients in household wastewater and their reuse in agriculture. In this way, they help preserve soil fertility and safeguard long-term food security, whilst minimizing the consumption and pollution of water resources.

Ecosan is a holistic approach to sanitation and water management, representing a break with the too often poorly performing end-of-pipe technologies of the past, and recognising human excreta and domestically used water as a resource that should be made available for reuse. As an integrated alternative, a hallmark of ecosan is its interdisciplinary approach that goes beyond the narrow disciplines of domestic water supply and technological considerations to address issues such as agriculture, sociology, hygiene, health, town planning, economics and small business promotion, institutional administration, and so on. Such an approach also makes a large contribution to the integrated management of water and other natural resources. figure 2 illustrates the main advantages of ecosan systems such as: [5]

- Improvement of health by minimising the introduction of pathogens from human excrement into the water cycle;
- Promotion of recycling by safe, hygienic recovery and use of nutrients, organics, trace elements, water and energy;

- Resource conservation, through lower water consumption, substitution of chemical fertilisers and minimisation of water pollution;
- Preference for modular, decentralised partial-flow systems for more appropriate cost-efficient solutions;
- Possibility to integrate on-plot systems into houses, increasing user comfort, and security for women and girls;
- Contributes to the preservation of soil fertility;
- Improvement of agricultural productivity and hence contributes to food security;
- Promotion of a holistic, interdisciplinary approach (hygiene, water supply and sanitation, resource conservation, environmental protection, urban planning, agriculture, irrigation, food security, small-business promotion,);
- Material-flow cycle instead of disposal.



(source: GTZ-ecosan)

figure 2: Advantages of ecollogical sanitation systems

1.4 The Innovative Ecological Sanitation Network India (IESNI)

The Innovative Ecological Sanitation Network India (IESNI) was established through a joint initiative of GTZ (German Agency for Technical Co-operation), the Indo-German Bilateral Project on Capacity Building and Training (IGBP-CB&T) in Maharashtra State, which aimed at capacity building and training in the field of watershed development and agricultural extension management and local as well as international partners in April 2004.

Being a voluntary network, the IESNI aims to promote the development, implementation, evaluation and dissemination of socially and culturally acceptable, sustainable, hygienically safe and ecologically sound sanitation approaches for India and other activities such as the organisation of joint workshops.

Workshops, seminars and conferences organized in the scope of the IESNI:

- Start-up workshop (April 2004, Pune);
- "2nd workshop on ecological sanitation" organized by IESNI in co-operation with GTZ (March 2005, Pune);
- Seminar on "Drinking Water and Sanitation Problems of Urban Areas" organized by IWWA Ahmedabad Centre (June 2005, Ahmedabad);
- „International Conference on ecosan" organized by the Indian Water Works Association (IWWA) in association with the International Water Association (IWA), GTZ Germany, the Government of Maharashtra, the Municipal Corporation of Greater Mumbai and All India Institute of Local Self Government (November 2005, Mumbai);
- Workshop on "Environmental Considerations for Residential Complexes and Ecological Sanitation" organized by IWWA Goa Centre (March 2006, Panaji);
- National workshop on "Ecological Sanitation" organized by IWWA Guwahati Centre (May 2006, Guwahati);

2 PILOT PROJECT "ACTS ECO-FRIENDLY PUBLIC TOILET CENTRE, RAJENDRA NAGAR, BANGALORE"

2.1 About ACTS

ACTS (an acronym for Agriculture, Crafts, Trades and Studies) was founded in July 1979 in Bangalore, India. Starting small in a two-bedroom house, today it has spread all over India and is known internationally. Although based on the Christian faith and its principles, the services of ACTS have extended to all, regardless of caste or creed. ACTS, in partnership with other likeminded institutions, today represents a synergy that is innovating a number of educational, environmental and health programmes.

2.2 Aims of the project

Before 2001 the majority of households in Rajendra Nagar, a huge slum with inhabitants of different caste, religion and race, did not have their own toilets and residents had access to only one functioning communal toilet. As the lack of toilets is only one indication of the appalling living conditions for many thousands of slum dwellers, particularly women, the establishment of a public toilet centre was considered to be a matter of very great urgency. Sexual harassment and rape had been an associated problem as women so far had been forced to defecate in the open field before dawn or after dusk. [6]

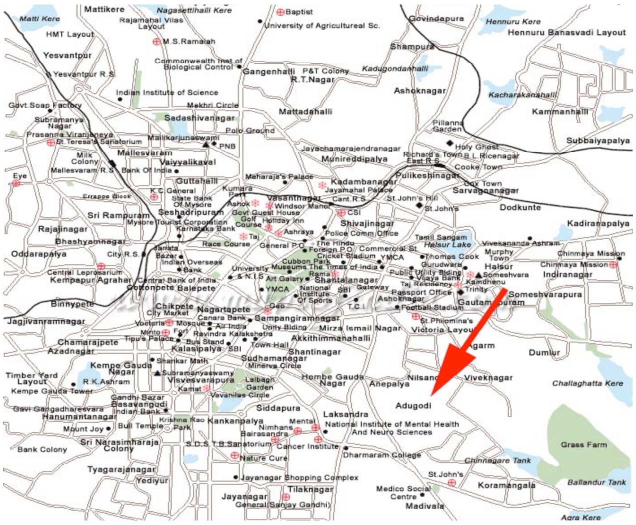
The objectives of establishing an eco-friendly sanitation project in Rajendra Nagar had been manifold: [7]

- Improving living conditions in the slum, minimizing the risk of disease spreading during monsoon flood periods and increasing women's security;
- Recycling of nutrients and organics due to the collection, treatment and reuse of urine and faeces for production of fertilizer and compost, respectively;
- Generation of income for the development of the slum by charging for the use of the toilet, selling of fertilizer and agricultural produce (e.g. bananas);
- Finally changing attitudes of people and encouraging them to consider human urine and faeces as a valuable resource

2.3 Location, general conditions and project history

ACTS established an eco-friendly public toilet centre in Rajendra Nagar, Bangalore, (figure 3) and a processing and reuse site for source-separated flowstreams (brownwater and yellowwater) at the ACTS Rayasandra Campus for Higher Education, which is about 12 km from the toilet centre, with technical support by seecon gmbh.

(source: Maps of India, version 4.0)



(source: Maps of India, version 4.0)

figure 3: District map of Karnataka State (left) and location of ACTS public toilet in Bangalore city (right)

Planning of the eco-friendly sanitation project started as early as June 1999. Start of construction and inauguration of the public toilet centre were in March 2000 and mid of 2001, respectively. In July 2005 planning for the upgrading of the toilet centre, implementation of a mechanized logistics system and an improved treatment concept for brownwater started. The new system was put into operation on November 24th, 2005. The "ACTS Eco-friendly Public Toilet Centre" was closed down in January 2006, as demonstration project phased-out and the lease agreement with the local Government expired.

ACTS submitted a proposal to the local authorities, suggesting extension of its services to the community and offering to operate and maintain the eco-frienldy public toilet centre in Rajendra Nagar for a further period. From all the lessons learned there would be further improvements at the toilet centre if a 2nd project phase would be granted.

Independ of the extension of the sanitation project in Rajendra Nagar, experiences gained during the demonstration phase are now studied and will be applied for the upscaling of the sanitation project in Bangalore and its surroundings, focusing and aiming on providing socially and culturally acceptable, hygienically safe and sustainable sanitation facilities to the unserved.

2.4 Technologies applied

Implementation of the eco-friendly sanitation project in 1999

In 1999, the eco-friendly public toilet centre was designed in such a way that squatting slabs were raised about 1.5 metres above ground level and drilled with 3 holes for the separate collection of feces, urine and water used for primary washing hands (see figure 4).

(source: seecon gmbh) (source: seecon gmbh)

figure 4: ACTS Public Toilet Centre in Rajendra Nagar (left) and squatting slab providing 3 holes for source-separate collection of water used for primary washing hands, urine and feces (right)

Collection of urine and feces (including some anal cleansing water) was done in barrels that were stored in compartments below the squatting slabs. Once a day the barrels were picked up and conveyed to the ACTS Rayasandra Campus for Higher Education. Faecal matter was co-composted with waste paper and biodegradable waste; urine was applied as nitrogen-rich liquid fertilizer to banana plantations after storage.

Water used for primary washing hands was drained to an infiltration bed infront of the toilet block and any surplus of water that didn't trickle away was collected in a subsurface collection tank that was emptied when full.

Upgrading of the eco-friendly sanitation project in 2005

Although the ACTS eco-friendly demonstration toilet was successfully in operation for many years, the originally designed logistics and processing concept was often discussed to constitute not only a cultural, but also a hygienic problem. Hence a socially and culturally more acceptable, sustainable and hygienically safe collection, transportation and processing scheme was developed and implemented with support by GTZ and seecon gmbh in 2005.

The objectives of grading-up the collection, transportion and processing scheme have been:

- As the originally designed logistics concept was often discussed to constitute not only a cultural, but also a hygienic problem, the upgrading should bring about considerable improvement in such conditions;
- Improving the collection and logistics scheme in such a way that shifting of drums (urine and brownwater) is abandoned;
- Replacing the priviously used composting trenches by a biogas plant for the hygienically safe treatment of brownwater and recovery of biogas;

- Using of biogas as a substitute to LPG (Liquid Presurized Gas) in cooking;
- Providing treatment capacity for the upscaling of the sanitation project.


(source: ACTS)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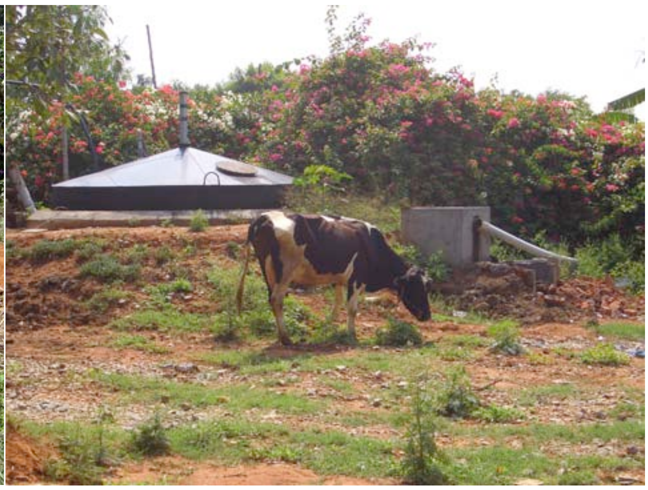

(source: seecon gmbh)

figure 5: Upgrading of ACTS eco-friendly sanitation project (clockwise from top left: evacuation of brownwater with newly installed vacuum system; emptying of urine collection tanks; application of urine on banana plantations; biogas plant for the hygienically safe treatment of brownwater; sludge drying beds; use of biogas in cooking)

With the improved pump and haul system, holding tanks replaced the barrels for source-separate collection of urine and brownwater. Transportation was done with the existing truck, which was equipped with a vacuum suction unit for evacuation of brownwater and a self-priming pumping system for emptying of urine tanks (figure 5).

The composting trenches at the ACTS Rayasandra Campus for Higher Education were dismantled and Suma Khadi Gramodyoga Sangha, a local NGO, did designing and construction of a new biogas plant for the hygienically safe treatment of brownwater and recovery of valuable energy in form of biogas. The floating-drum type biodigester is provided a water jacket and has a reactor capacity of ca. 40 m^3 (inner diameter: 3,80 m; hight: 3,70 m).

Subsequent treatment of the digested slurry was done in sludge drying beds. Biogas produced was used as a substitute to LPG in cooking (figure 5).

Any surplus of washwater that wasn’t taken up by the planted infiltration bed infront of the public toilet centre was drained to a nearby municipal sewer.

2.5 Lessons learnt from the demonstration phase

After 5 yeas of successfully running an eco-friendly sanititation project in Rajendra Nagar, Bangalore, the following stories of success and lessons learnt can be presented:

- Planning an eco-friendly sanitation project is not a green-desk-job but needs stakeholder involement. Awareness raising programs, capacity building and regularly follow-ups are to be considered crucial for the successful implementation and operation of such a project.
- Special attention has to be given to social and cultural factors. Thus special focus had been given to awareness raising and capacity building of women, as they would play an important role in the overall process. To enable a breakthrough local women got alongside the planning team.
- The initial stages when people had to be guided with visual demonstrations on how to use the toilet properly were quite hilarious as well as frustrating.
- We soon overcame resistance. But over the five years there was growing acceptance and then although two more public toilets were built close to this toilet, people continued using the eco-friendly toilet.
- Although dealing with the poor we took care to provide proper electricity, sufficient water and kept it very clean by washing the floor regularly, which did the people appreciate. We learned that those must not be sacrificed especially as we are talking about ecosan.
- Upgrading our facilities was a constant desire. We saw the importance of listening to the needs of the users, as well as the comments of visitors. Gradually we saw the difference tiled walls and floors would make and this was provided.

- One of our struggles was manual handling of the drums with urine and faeces. We heard complaints from outsiders and responded. We designed our mechanized system. But even this did not give us a 100% solution. This time it was the bad odour emitted as soon as the system was turned on.
- Treatment of faeces started with basic composting but could not avoid some actual contact with faeces as workers operated. Although obtaining high-grade manure and finding this very useful in various situations, we looked at other options and considered biogas production. The mechanised system serves the collection and discharge very well and biogas production has been commendable. We are now looking at upgrading this mechanised facility for optimal usage both for collection as well as discharge into the biogas system. Minimising of odour is a priority.
- The eco-toilet started because of the request of women and we gradually learned what a boon it was for them. Most of our toilet-users comprised of women, especially the younger groups. We learned that this was because of the privacy and absolute safety they lacked in other facilities.
- We are now seeing that sufficient numbers of toilets as well as urinals need to be provided as especially women seem embarrassed to stand in queues.
- One practical concern has always been both the quality as well as the quantity of water we provided. We are now looking into this matter.
- The right personnel makes the big difference. We did not experience any theft of drums, buckets or damage to any systems within the toilet because the two wardens who were taking care of the toilet performed their duties very sincerely and were always available at the toilet premises. They needed to be motivated (not through money) but just through good interpersonal interaction.
- The slogan "ecosan - an approach to human dignity, community health and food sequrity" is clearly implemented by the project: The project shows a positive impact on the dignity and health of the toilet users and the urine and the faeces are successfully used to produce high quality food (bananas) and biogas.
- "Closing the loop" in terms of nutrients-cycles between urban areas (consumer areas) and rural areas (production areas) is feasible and opens new economical options.
- A strong local organizational embedding and a good long-term management of the ecosan-technology are key prerequisites for a successful and sustainable project operation. Wherefore a strong local project partner and manager is crucial for the project.
- Communication plays an important role to prevent misunderstandings and political problems. Involvement of "critical voices" helps to develop the projects efficiently. Public or individual concerns have to be considered as deciding inputs for project planning, improvement, adjustment, etc.

- The project development has to consider and synthesise relevant political, institutional and technical issues into an integrated system and communication design.
- Even generating income and workplaces the project depends on external financial support. This problem could be solved developing new contracting systems involving and obligating the local authorities (private-public-partnership approach).
- Long-term experiences and international embedded research are very important: After 5 years of project operation, communication the project reached a national and international recognition.
- Failures are unavoidable and have to be considered essential elements of the learning process.

2.6 Cost-revenues analysis

In connection with the phasing-out of the demonstration project in Rajendra Nagar and the intended upscaling of the eco-friendly sanitation project a cost-revenues analysis based upon experiences gained during the last five years of sucessfully running an eco-friendly public toilet centre in a slum area and assumptions in regard to capital costs, operation & maintenance requirements, travel costs, the fertilizer equivalent of human excreta, the nutritional requirements of banana plants and the income generation by collection of user fees and selling of bananas was conducted.

The findings of this analysis, which are summarized in table 3 and presented in detail below, indicate that running a large scale eco-friendly sanitation project, which is relying on a pump and haul service system for collection and transportation of source-separated flowstreams, can be economically viable under certain conditions (e.g. optimizing frequency of service runs, collection of user fees, reuse of biogas as a substitute to LPG, reuse of recyclates in agricultural production and selling of produce, etc.).

Capital costs

Estimated capital costs for construction of 5 numbers of 12-seated public toilet centres comprising two independent enclosures for ladies and gents that provide lavatories, urinals and washbasins are Rs. 2,250,000 to Rs. 3,000,000 (without interesst, but including costs for a small borewell for water supply). Construction of biogas plants (3 plants having a digester volume of 60 m^3 each) for the hygienically safe treatment of source-separated faecal matter is estimated to be ca. Rs. 1,000,000. Provision of large capacity tanks for storage of urine before its application as liquid fertilizer to agricultural land is estimated to cost Rs. 300,000. Costs for 2 trucks that have to be equipped with vacuum suction units (one for hauling of urine and brownwater each) are estimated to be Rs. 3,000,000.

Recurring costs

Considering a round-trip distance of ca. 40 to 50 km per day, operation (fuel, insurances, maintenance, road taxes, etc.) of 2 suction trucks will be about Rs. 315,000 to Rs. 500,000 per year.

table 3: Estimated capital costs, recurring costs and revenues for an upscaled sanitation project

	without interesst [INR]	with interesst [INR]
capital costs:		
5 toilet centres	2,250,000 – 3,000,000	3,150,000 – 4,500,000
treatment facilities (biogas plants, large capacity urine storage tanks)	1,300,000	2,800,000 – 3,180,000
2 trucks equipped with vacuum suction units	3,000,000	5,400,000 – 6,000,000
total	**6,570,000 – 7,320,000**	**11,350,000 – 13,680,000**
recurring costs:		
operation of vehicle (fuel, insurance,taxes, maintenance, …)	315,000 – 500,000	315,000 – 500,000
wages (caretakers, drivers, aids to drivers, plantation manager, …)	440,000	440,000
O&M of toilet block	50,000 – 80,000	50,000 – 80,000
land lease and banana suckers	170,000	170,000
total	**975,000 – 1,190,000**	**975,000 – 1,190,000**
income:		
user fees	360,000 – 730,000	360,000 – 730,000
savings due to use of biogas as a substitute to LPG in cooking	515,000 – 620,000	515,000 – 620,000
selling of banana	940,000 – 1,600,000	940,000 – 1,600,000
savings due to use of humanure instead of chemical fertilizers and selling of compost	170,000 – 770,000	170,000 – 770,000
total	**1,980,000 – 3,690,000**	**1,980,000 – 3,690,000**

1,000 INR = 16.78 € (as per 03/08/2006)

Wages (10 caretakers @ Rs. 2,000/person,month; 1 driver @ Rs. 4,000/month; 1 aid to the driver @ Rs. 2,000/month; 1 plantation manager @ Rs. 4,000/month; 1 aid to the plantation manager @ Rs. 2,000/month; administration charges) will arise to about Rs. 440,000 per year. Annual operation and maintenance costs (electricity bills, expenses on cleaning utensils and soap for washing hands, etc.) of the toilet centres are calculated to be Rs. 50,000 to Rs. 80,000. Annual costs for renting of 5 hectares of agricultural land in the surroundings of Bangalore and for acquisition of banana suckers are Rs. 170,000.

Income

Annual revenues of the toilet centres are estimated to be Rs. 360,000 if half the number of users of toilets makes payments @ Rs 1/use (use of urinals shall be for free). At present costs of Rs. 425 per cylinder of LPG (@ 14,2 kg), savings due to use of biogas as a substitute to LPG in cooking are calculated to be ca. Rs. 460,000 to Rs. 620,000 per year. Based upon an average yield of 25 t/ha [8] to 35 t/ha [9] (@ 3,000 plants/ha) and a market price of Rs. 750 to 900 [10] per Quintal (=100kg) of Bananas (Robusta Variety) the average income per year is estimated to be Rs. 940,000 to ca. Rs. 1,600,000. Annual savings due to the use of humanure (urine and compost) instead of chemical fertilizers and selling of compost will arise to Rs. 170,000 to Rs. 770,000.

3 PILOT PROJECT "NAVSARJAN VOCATIONAL TRAINING INSTITUTE *DALIT SHAKTI KENDRA*"

3.1 About Navsarjan Trust

Navsarjan Trust, an Ahmedabad based NGO, was established in 1989 to help eliminate discrimination based on caste (includes gender), assure equality of status and opportunities and ensure the rule of law, not of castes.

Traditionally working with Dalits, but also tribals and other poors all over Gujarat, Navsarjan Trust has come to realize that education coupled with imparting skilled training could help in the economic empowerment of the Dalit community. Thus the necessity of establishing a suitable training system was felt. With financial support from the Swiss Agency for Development and Co-operation (SDC), a vocational training institute called "Dalit Shakti Kendra", or DSK for short, was established in 1999 to provide Dalit youth technical training in various fields such as vehicle driving, maintenance mechanic, textile design, basic and advanced computer, police training, furniture making, tailoring, motor rewinding, fabrication, electrician, still photography and videography, mobilephone repair, etc and link them up with institutions for financial assistance for self-employment.

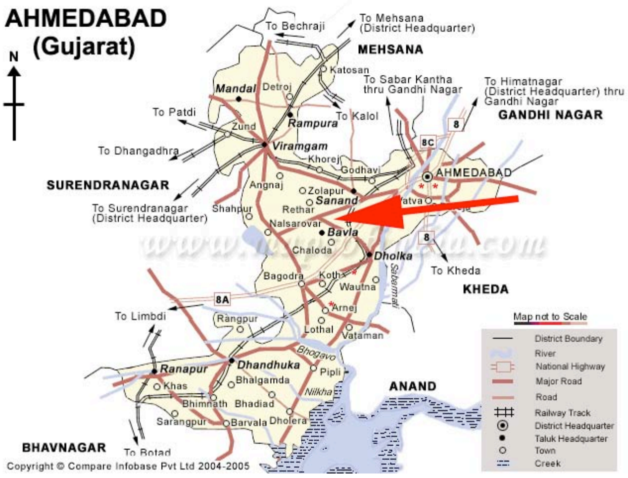
3.2 Aims of the project

In order to find technological solutions that can help in the elimination of manual scavenging practices, which is a caste based occupation in india and a source of discrimination, and to help in the improvement of sanitation (specifically in rural areas), Navsarjan Trust aims to develop, implement, evaluate and disseminate socially and culturally acceptable, sustainable and hygienically safe sanitation, treatment and reuse concepts for human excreta (urine and feces) and greywater.

Concepts and technologies implemented at "Dalit Shakti Kendra" shall provide Navsarjan Trust first-hand experiences on ecologically sound sanition and the knowledge for further dissemination of ecosan in Gujarat.

3.3 Location, general conditions and project history

The vocational training institute "Dalit Shakti Kendra" was established on an eight-acre land in Nani Devti village and is located about 30 km southwest of Ahmedabad City at Sanand-Bavla-Road (figure 6).



(source: Maps of India, version 4.0) (source: Maps of India, version 4.0)

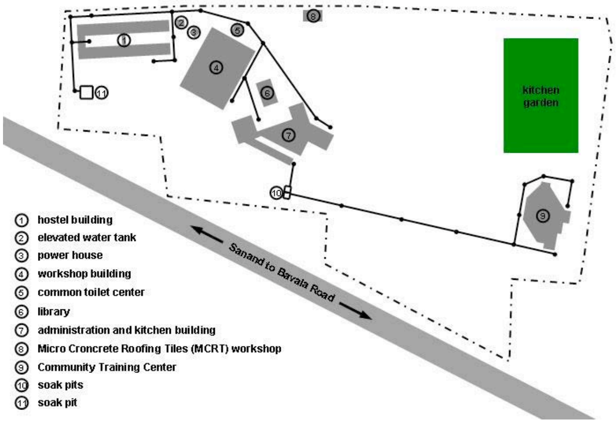
figure 6: District map of Gujarat State (left) and map of Ahmedabad district (right) depicting the location of the Navsarjan VTI "Dalit Shakti Kendra"

The vocational training institute (figure 7) comprises several buildings amongst them an administration and kitchen building, a workshop building, a common toilet centre, a Community Training Centre and a hostel that can accommodate up to 240 students.

(source: seecon gmbh)

figure 7: View of Navsarjan vocational training institute „Dalit Shakti Kendra"

A sketch map of Dalit Shakti Kendra illustrating the originally implemented sanitation scheme is depicted in figure 8. Wastewater produced at the administration and kitchen building, the workshop building, the common toilet centre and the hostel was drained to a soak-pit infront of the hostel. Wastewater from an individual toilet at the administration and kitchen building and from the Community Training Centre (ground floor level only) was drained to a soak-pit next to the administration and kitchen building. Water used for washing dishes was discharged to the open field next to the washstands. Water spent for washing clothes and bed sheets was discharged to the environs behind the hostel building.



(source: seecon gmbh)

(source: seecon gmbh)

figure 8: Sketch map of "Dalit Shakti Kendra" (left) and pic of the soak-pit infront of the hostel building (right)

Drawbacks and objections to the originally implemented wastewater management concept:

- Overflowing of the existing soak-pit at the hostel, especially in monsoon season, constituted to unhycienic conditions due to breeding of mosquitos in the stagnant waters and unpleasant smell.
- Discharging water used for washing dishes to the open field next to the stands leat to unpleasant smell.

3.4 Technologies applied

To overcome unhygienic conditions related to malfunctioning of the main wastewater disposal facility (soak-pit at the hostel) and to meet the needs of extension of the institute, a sanitation concept comprising the following components was developed:

- Night-soil based biogas plant;
- Urine-Diversion Dehydration Toilets;
- Common urinal centre for ladies and gents;
- Treatment/reuse of greywater from new bathroom cum laundry facilities;
- Treatment/reuse of kitchen water;
- Treatment/reuse of water spent on washing dishes;
- Treatment/reuse of greywater from the Community Training Centre.

3.4.1 Night-soil based biogas plant

A new common sanitation complex comprising 22 toilet cabins (11 for females and males each) and an adjoint biogas plant for the hygienically safe treatment of blackwater and recovery of valuable energy in form of biogas has been constructed. The biodigester shall not only receive blackwater, but also manure of some 5 to 10 buffaloes, which will be kept on the campus for milk production.

The toilet cabins and facilities for washing hands are arranged in 2 semi-circles, providing access to the night soil based biogas plant that is located in the centre point of the sanitation complex. Blackwater from the ladies and gents toilets is collected in 2 separate hoppers that drain the water to the biogas plant. An additional chamber is provided for mixing of animal manure and water.

In order to keep dilution of blackwater low, specially designed squatting pans (so called "pour-flush" pans) made of ceramic that require a little amount of water for flushing excreta and that are equipped with a seal („P-trap"), as shown in figure 9, have been installed.

Digested slurry will be collected in a subsurface basin, before being pumped to elevated sludge drying beds. The dried sludge shall be applied as soil amendment to the kitchen garden or plantations.

The biogas will be used as a substitute to LPG (Liquefied Petroleum Gas) in cooking.

Greywater that is collected from washbasins at the toilet centre will be directly used for gardening purposes. The greywater shall be applied to elevated flowerbeds, ornamental gardens, etc. without any pre-treatment. Distribution of greywater shall be done in mulch-filled absorption trenches; discharge to the greywater gardens shall happen about 2 inches above the surface of mulch into which it will quickly disappear. Perimeter bunds shall keep additional surface run-off water from entering the reuse facility.

Design assumptions:

- number of possible users: ca. 300 persons per day (students, staff members, variable number of guests attending workshops/meetings)
- specific blackwater production: ca. 3.5 litres per person per day (incl. urine, feces, cleansing and flushwater)

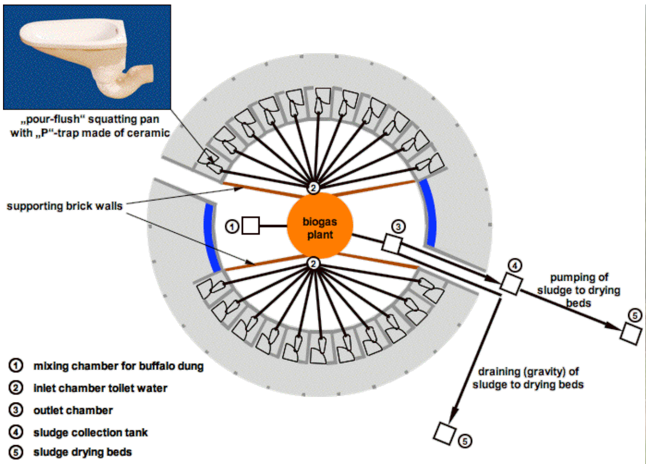
Based upon these assumptions total blackwater production is calculated to be ca. 1,000 litres per day (1 m^3/d). In addition some 100 to 200 litres per day (depending upon the number of buffaloes) of diluted buffalo manure will be fed to the biogas system.

Design of biogas plant:

A floating-drum type biodigester that is provided with a water jacket has been constructed. The reactor capacity of the biogas plant is ca. 28 m^3 (inner diameter: 2,75 m; hight: 4,80 m).

The general design of the biodigester is depicted in figure 19 to figure 22.

More detailed information on the design of the new sanitation complex is given in figure 23 to figure 28.



(source: seecon gmbh)

(source: seccon gmbh)

(source: http://www.ruralsanitation.com/)

(source: seecon gmbh)

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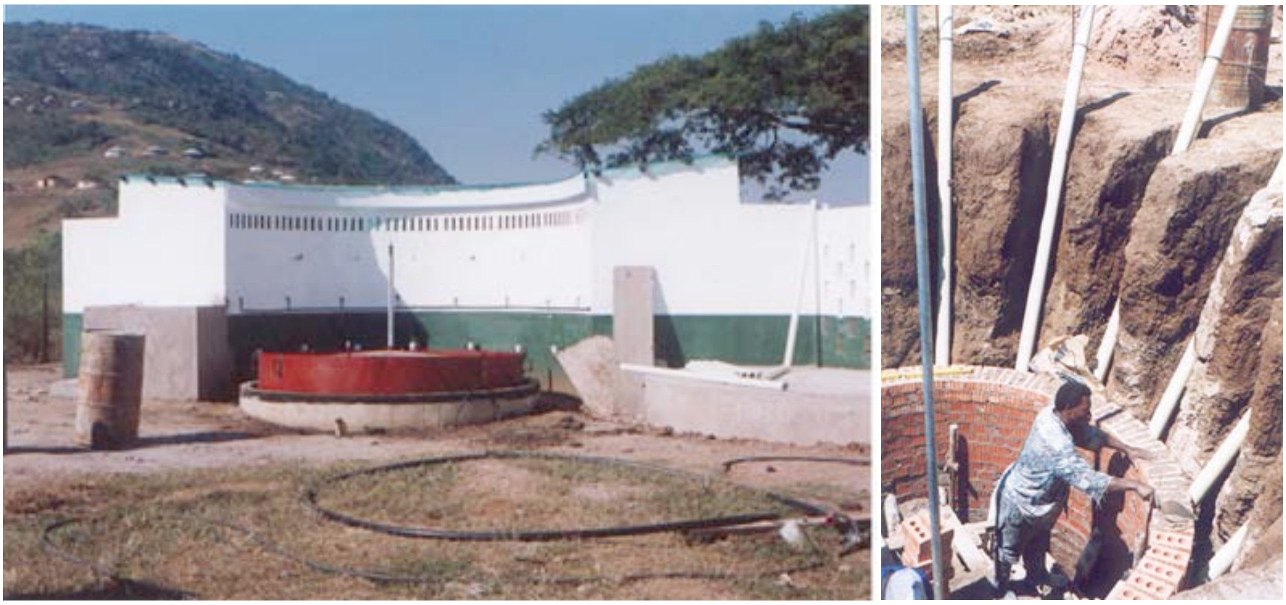
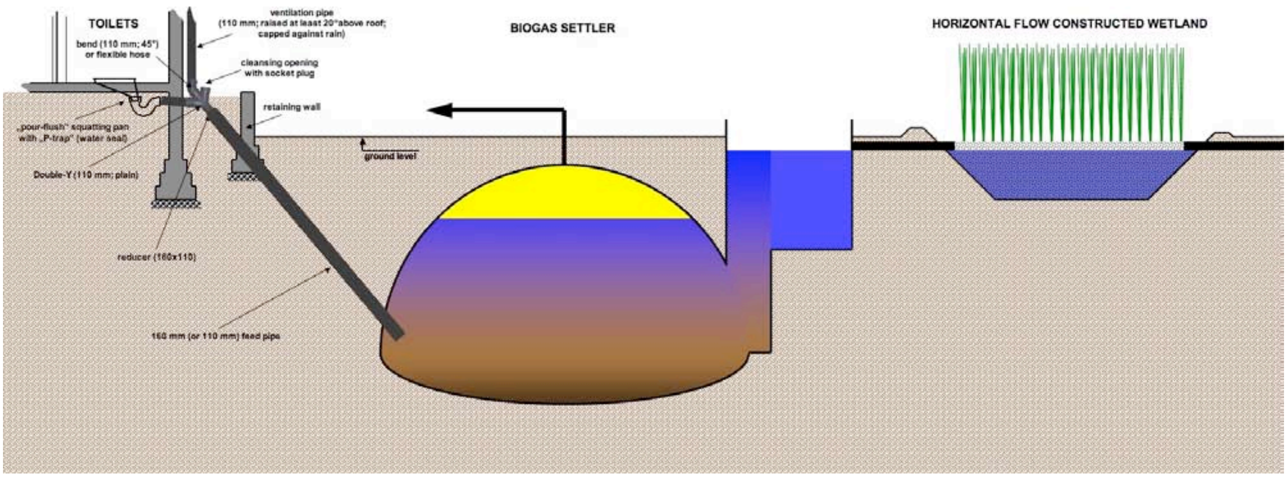
figure 9: Night-soil based biogas plant [clockwise from top left: conceptual sketch of toilet linked biogas system; view of new toilet block; top view of hoppers and biogas plant (under construction); rear view of toilet cabins depicting individual blackwater disposal pipes (before refilling with soil and landscape gardening); picture of “pour-flush” squatting pan with water seal (“P”-trap)]



(source: http://www.solarengineering.co.za/Update/Myeka%20BGD%20Pics/gallery_biogasmyeka_htm1.htm)



(source: seecon gmbh)

figure 10: Proposed design of toilet-linked biogas system [clockwise from top left: view of semi-circular shaped toilet complex and floating-drum type biogas plant at Myeka High School, South Africa; view of individual, steep sloped feed pipes (under construction); conceptual sketch of toilet linked biogas ("biogas settler") system]

Comments on the design:

If in future, construction of a circular shaped sanitation complex is discussed and there are no other restrictions regarding the design, I do recommend going for a semi-circular design as shown in figure 10. Having 2 independend toilet-linked biogas units (one for ladies and gents each) may be required, if total number of toilet cabins to be provided exceeds maximum number of cubicles to be arranged in a semi-circle.

The semi-circular arrangement of toilet cubicles has the following advantages over a circular design:

- Each toilet can be individually linked to the biogas plant (or any other kind of anaerobic treatment facility such as biogas settlers - sometimes also refered to biogas septic tanks -, etc.) via a steep sloped feed pipe.
- Going for a 2 anaerobic treatment units (each being roughly half the size of a common one) may be more expensive than going for a single treatment unit only, but individual feed pipes having a steep slope will reduce change of blockages.
- Going for individual, steep sloped, feed pipes may reduce hight of plinth level and therefore construction costs.
- The anaerobic treatment unit is easily accessible for operation and maintenance (e.g. lifting of drum with a crane).

3.4.2 Urine-Diversion Dehydration Toilets

Two “Urine-Diversion Dehydration Toilets” (see figure 11), which had been designed in a collaboration of Navsarjan Trust and the Massachusetts Institute of Technology (MIT), have been constructed to serve students and staff members as “emergency toilets” during nighttime.

Installation of specially designed and prefabricated squatting pans made of R.F.P. (reinforced fibre plastic) facilitates source-separate collection of urine, feces and anal cleansing water.

Designs of Urine-Diversion Dehydration Toilets developed in the scope of the IESNI are depicted in figure 29 to figure 36.

3.4.3 Urinal centre

The existing toilet block, which is situated behind the workshop building, will be converted into a common urinal centre, providing separate enclosures for ladies and gents and facilitating source-separate collection of urine for application in agricultural production (e.g. kitchen garden, etc.) after storage.

Source-separated urine will be collected in a subsurface tank outside the building and pumped to storage cum hygienisation tanks when full (see figure 37 and figure 38).

Design assumptions:

- number of possible users: ca. 300 persons per day
- specific urine production: ca. 1 to 1,2 litre per person per day
- cleansing water contribution: ca. 0,2 litre per person per day

Based upon these assumptions the total amount of urine and washwater to be collected is calculated to be ca. 350 to 450 litres per day. Therefore yellowwater production is expected to be about 2,500


(source: seecon gmbh)


(source: seecon gmbh)

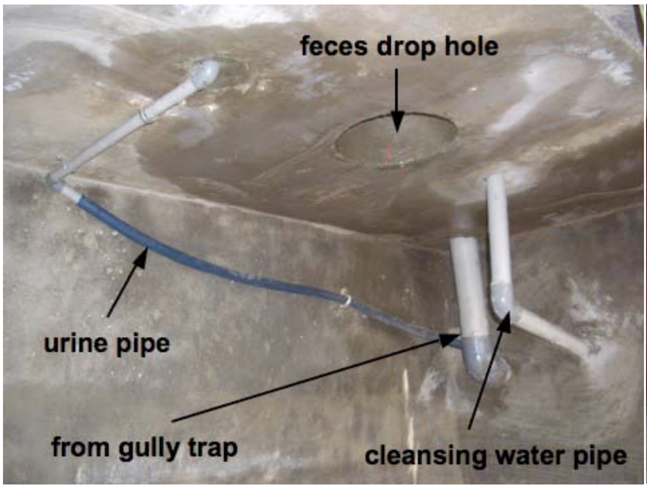


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figure 11: Urine-Diversion Dehydration Toilet [clockwise from top left: view of Urine-Diversion Dehydration Toilet designed by a team from the Massachusetts Institute of Technology; view of squatting pan that allows source-separate collection of urine, feces and cleansing water; top view of toilet cubicle; view of piping system below squatting slab]

to 3,200 litres per week. Considering a storage time of 4 weeks, total number of storage tanks has to be 5 with a storage capacity of ca. 3 m^3 each.

Important information:

- The top of the collection tank(s) must be raised above the surrounding ground level to prevent rainwater from entering the tank.
- Discharge of urine to the collection tank(s) mustn't be done from above the liquid level, but urine collection pipes must be extended to the bottom of the tank.
- The urine collection tank(s) shall be equipped with a standpipe and a quick coupling for efficient (minimal spillage) emptying.
- The urine collection tank(s) shall be equipped with a fail-safe overflow that empties into a soak-away.

- Appropriate means of transportation for urine from the source of production to the hygienisation tanks and its application site has to be provided.
- Hygienisation/storage tanks shall be situated above ground level to facilitate complete emptying by gravity flow.

(source: seecon gmbh)

(source: seccon gmbh)

(source: seecon gmbh)

(source: Navsarjan Trust)

(source: seecon gmbh)

figure 12: Treatment/reuse of greywater at the hostel building [clockwise from top left: view of new bathrooms (for male students); outside water tap and buckets for fetching water showering; students doing their laundry; top view of elevated greywater gardens (any surplus of water that is not taken up by the gardens is collecte din the central storage tank); picture of "ladies urinal"]

3.4.4 Treatment/reuse of greywater from new bathroom cum laundry facilities

New bathroom (showers and washbasins) cum laundry facilities have been constructed behind the hostel building to serve students (separate facilities for ladies and gents). The greywater is drained to two elevated greywater gardens for reuse and pre-treatment. Any surplus of water that isn't taken up by the gardens is collected in a central storage tank and reused for irrigation purposes.

Design assumptions:

Calculation of greywater production (female students) is based upon the following assumptions:

- number of possible users: ca. 120 persons per day
- specific water consumption: ca. 50 litres per person per day (showering, washing hair, washing hands, brushing teeth, etc.)

Calculation of greywater production (male students) is based upon the following assumptions:

- number of possible users: ca. 120 persons per day
- specific water consumption: ca. 40 litres per person per day (showering, washing hands, brushing teeth, shaving, etc.)
- laundry: ca. 30 litres per person (twice per week)

Based upon these assumptions daily greywater production is calculated to be ca. 11 to 15 m^3.

Design of greywater gardens and storage tank:

The design (surface area) of the greywater gardens was only done according to space available, no specific hydraulic surface load had been taken into consideration, as any surplus of water that isn't taken up will be collected.

The surface area of the elevated greywater gardens for reuse/treament of greywater from the ladies and gents bathrooms is about 20 m^2 (length: 6.00 m; width: 3.50 m) and ca. 40 m^2 (length: 10.00 m; width: 4.00 m), respectively.

The net storage capacity of the tank is about 19 m^3 (length: 6.00 m; width: 2.00 m; hight: 1,60 m).

Conceptual sketches of the design of the new bathrooms and the elevated greywater gardens are given in figure 39 to figure 43.

3.4.5 Treatment/reuse of kitchen water

Kitchen water shall be reused/treated in a similar treatment cum reuse unit (elevated garden) as has been constructed for greywater collected from the new bathrooms (see figure 44).

3.4.6 Treatment/reuse of water spent on washing dishes

A new stand (figure 13, left hand side) for washing dishes has been built and pre-treatment of water spent on wahing dishes should happen in a vertical flow organic filter. The organic filter media (e.g. rice husk, sawdust, wood chips, coconut fibres, etc.) should retain solids; the liquid phase should be drained to a collection tank and being reused for irrigation of nearby plantations.

Construction of the filter, which should have been raised above ground level, was supposed to be done just besides the washstands to gain most benefit from difference in hights availabe (figure 45). But, fearing that foul odour may be emitted from the filter, construction of the same happend subsurface at some distance.

Construction of the filter tank itself was done according to sketches provided, but the filter, which was designed for vertical flow only, was converted into a horizontal flow filter for reason explained later. Excavations for the collection tank, which was supposed to take up the pre-treated water, had to be stopped about 1.70 metres below ground level as ground water level was hit. A raft was casted and the collection tank constructed. Shifting of the filter tank (inlet now below ground level) and reduced hight of the collection tank would have resulted in a net storage hight of ca. 30 cm only, if the organic material shouldn’t be submerged permanently. To increse storage capacity of the tank, the outlet pipe of the filter was fitted at the same hight as the inlet pipe; to avoid short circuit flow, a baffle was constructed to divert incoming water downwards. But, as the filter tank was designed for vertical flow only it doesn’t even provide sufficient retention time for sedimentation. Providing no treatment whatsoever, it is now strieved for reducing organic pollution of the water as far as possible by asking user to clean their plates with wood ash (from cooking fires) before actually washing the plates.

Using wood ash for removing oil and crease from plates works well, but the present concept depends on good will of all users.

Distribution of the water is done by a solar-operated pump (figure 13, right hand side).

(source: seecon gmbh) (source: Navsarjan Trust)

figure 13: New new stand for washing plates, collection tank in background (left) and solar-operated pump for distribution of water for irrigation purposes (right)

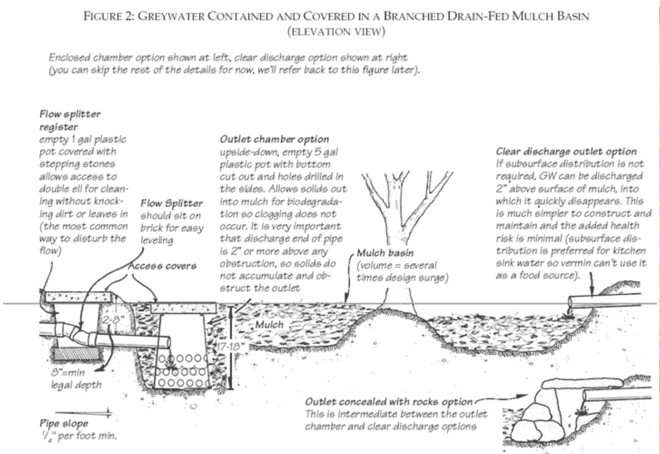
3.4.7 Treatment/reuse of greywater from the Community Training Centre

During construction of the first floor level, which started in beginning of 2004, 2 separate pipings have been laid for source-separate collection of blackwater and greywater.

Treatment of blackwater (from 1st floor level) and mixed wastewater from groundfloor level continues to happen in 2 soak-pits.

Going for a simple reuse scheme for greywater collected from 1st floor level (see figure 14, left hand side) was suggested. Distribution of the water should happen (close to the point of origin) subsurface in mulch-filled absorption trenches with or without pre-treatment in settling tanks.

Greywater gardens have been implemented at the Community Training Centre, but distribution of the water doesn't happen subsurface in mulch-filled absorption trenches, but in shallow furrows (see figure 14, right hand side).



(source: [11])


(source: seecon gmbh)

figure 14: Simple greywater reuse systems using mulch basins (left); view of greywater garden at the Community Training Centre, distribution of the water happens in shallow furrows only (right)

4 ECOSAN PILOT PROJECT “NAVSARJAN PRIMARY SCHOOLS"

4.1 About Navsarjan Trust

Navsarjan Trust, an Ahmedabad based NGO, was established in 1989 to help eliminate discrimination based on caste (includes gender), assure equality of status and opportunities and ensure the rule of law, not of castes.

Traditionally working with Dalits, but also tribals and other poors all over Gujarat, Navsarjan Trust has come to realize that education coupled with imparting skilled training could help in the economic empowerment of the Dalit community. Thus the necessity of establishing a suitable training system was felt. After successfully establishing a vocational training institute (“Dalit Shakti Kendra”) in 1999, Navsarjan Trust launched a primary schools project in 2005.

4.2 Aims of the project

In order to find technological solutions that can help in the elimination of manual scavenging practices, which is a caste based occupation in india and a source of discrimination, and to help in the improvement of sanitation (specifically in rural areas), Navsarjan Trust aims to develop, implement, evaluate and disseminate socially and culturally acceptable, sustainable and hygienically safe sanitation, treatment and reuse concepts for human excreta (urine and feces) and greywater.

Concepts and technologies implemented at the primary schools shall provide Navsarjan Trust first-hand experiences on ecologically sound sanition concepts and the knowledge for the further dissemination of ecosan in Gujarat

4.3 Location, project history and general conditions

So far, primary schools (figure 15) have been established in Dhandhuka taluka, Ahmedabad district; Limbdi taluka, Surendranagar district; and Sami taluka, Patan district.

Construction of schools is done in two stages; for the time beginning focus is given on construction of classrooms and sanitary facilities (figure 15). After completion each school will not only have a total capacity of 210 pupils, but also comprise an administration building, a kitchen building, a workshop building and residential buildings for teachers and staff members.

(source: seecon gmbh)

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figure 15: Sanitary facilities at Navsarjan Primary Boarding Schools [clockwise from top left: view of Navsarjan primary school in Rayka village; sanitation block (toilets, showers, washbasins and laundry facilities); pupils doing laundry; rear view of sanitation block; top view of cubicle used as shower (squatting pan is sealed with a black cover to prevent showerwater from entering either the processing compartment or the urine collection system); view of cubicles used as toilets]

The main units of each school are the classrooms, which double-up as dormitories for pupils (and temporarily also for teachers) as schools are conceptualized as boarding schools.

Applying a socially and culturally acceptable, sustainable and hygienically safe sanitation concept that helps in saving and reusing of water was considered utmost important as all schools are located in areas prone to water scarcity and non of the schools is supplied piped water. Drinking water has to be hauled by trucks from the nearest village or has to be lifted from an open well, respectively.

To keep water consumption as little as possible, going for urine-diversion vermicomposting toilets was discussed. Applying the so called "3-hole system" for the separate collection of urine, feces and cleansing water, which was first introduced by seecon gmbh at the "ACTS eco-friendly Demonstration Toilet Centre" (figure 16, left hand side) in Rajendra Nagar, Bangalore, was proposed. In order to facilitate harvest of the finished vermicompost, the toilets have been designed to operate in batches and cubicls should double-up as showers during the "resting period". Daily deposits should be made from the "toilets" into the processing chambers, which are situated below the squatting slabs, until they are "full". The worms should then be allowed to complete digestion while the cabin above is used as a shower. A specially designed cover should prevent water used for showering from entering either the processing compartment or the urine collection tanks.

Only after complition of the first toilet centre (at Rayka School) it was learnt that Navsarjan Trust intends to use the sanitary facilities as Urine-Diversion Dehydration Toilets (in India commonly refered to „composting toilets").

Planning of the eco-friendly sanitation concept for the schools started in December 2004. Construction of schools started in 2005 and inauguration of the first Urine-Diversion Dehydration Toilet Centre (at the primary school in Rayka village) was on February 25th, 2006. Sanitary facilities at the boarding school in Katariya village were put in operation in end of July 2006. Construction of sanitation facilities at the primary school in Sami taluka will be finished soon.

4.4 Technologies applied

4.4.1 Urine-Diversion Dehydration Toilets

Although originally designed to be Urine-Diversion Vermicomposting Toilets, it took only small changes to adapt the existing design of the toilets for their use as Urine-Diversion Dehydration Toilets. Considering wet anal cleansing habits, squatting slabs had to be designed to facilitate source-separate collection of urine, feces and cleansing water. As prefabricated squatting pans with a "3-hole system" were not available in the beginning, squatting slabs at Rayka School had to be casted on-site (figure 16, center). The toilets in the other schools are equipped with prefabricated squatting pans made of plastic (figure 16, right hand side), which have been designed by UNICEF, as those pans had been available at the time of construction.

In order to facilitate harvest of the finished "compost" (desiccated feces and cover material), the toilets are designed to operate in batches and cubicls will double-up as showers during the "resting period". Daily deposits are to be made from the "toilets" into the processing chambers that are situated below the squatting slabs. After each use a handfull of cover material (wood ash, saw dust, soil, etc.) has to be sprinkled over the faeces to absorb moisture and help in speeding up dehydration process. If a chamber is "full", the cubicle above is converted into a "bathroom" by providing a specially designed cover that seals the "3-hole system" and therefore prevents water used for showering from entering either the processing chamber or the urine collection system. For the discharge of the greywater (water used for taking a shower) an additional collection system has been provided.

Conceptual sketches of the Urine-Diversion Dehydration Toilet Centres are depicted in figure 46 to figure 48.

Design assumptions:

• total possible number of users:	ca. 220 persons per day (up to 210 pupils and about 10 staff members)
• number of toilet units:	8 (after completion of 2^{nd} toilet centre)
• possible number of users per unit:	ca. 25 - 30 persons per day
• specific feces contribution:	less than 200 [12] to ca. 300 ml [13] per person per day
• desiccated feces:	ca. 0.02 liter per person per day [12]
• cover material (wood ash, soil, …)	ca. 200 ml per person per day

Based on the above stated assumptions/parameters, the amount of desiccated feces and cover material per person per day equals roughly 250 ml. Considering a storage time of ca. 1 year (270 working days per year), the inner volume of each processing compartment must exceed 2,000 litres

figure 16: "3-hole system" at ACTS eco-friendly demonstration toilet in Rajendra Nagar, Bangalore (left), "3-hole system" at Navsarjan Primary School in Dhandhuka taluka (center) and prefabricated squatting pan that allows source-separate collection of urine, feces and anal cleansing water (design supported by UNICEF) (right)

(2 m^3). This calculation doesn't consider volume reduction of faecal matter during the dehydration process.

4.4.2 Urine collection

Urine collected from the urine-diversion squatting pans and urinals (provided for males only) is piped to transportable collection tanks (jerry cans, etc.) that are emptied into a storage/hygienisation tank if full (figure 17). The urine is applied as nitrogen-rich liquid fertilizer to plantations after storage.

figure 17: Urinals for males and transportable collection tank (left) and storage/hygienisation tank (right)

Design assumptions:

Calculation of appropriate size of urine hygienisation/storage tanks is based upon the following assumptions:

- possible number of users: ca. 220 persons per day
- specific urine production: ca. 1,000 to 1,200 ml per person per day
- hygienisation/storage time: 4 weeks

Total number of hygienisation/storage tanks to be provided is 5 with a storage capacity of ca 2 m^3 each.

4.4.3 Treatment/reuse of greywater

Greywater that is collected form bathrooms, washbasins and the laundry area, is drained to a vertical flow filter filled with organics (rice husk). Application of water is done above the surface to facilitate retaining of solids on top of the organic layer; the water trickles through the filter and is collected before being reused for irrigation purposes.

figure 18: Vertical flow organic filter (left) and collection tank for greywater (right)

Design assumptions:

Calculation of greywater production is based upon the following assumptions:

- number of possible users: ca. 220 persons per day
- specific water consumption: ca. 40 litres per person per day (showering, washing hair, washing hands, brushing teeth, etc.)

Based upon these assumptions daily greywater production is calculated to be ca. 9 m^3.

5 PREFEASIBILITY STUDIES

After the International Conference on ecosan, which was organized by the Indian Water Works Association (IWWA) in association with the International Water Association (IWA), GTZ Germany, the Government of Maharashtra, the Municipal Corporation of Greater Mumbai and All India Institute of Local Self Government in Mumbai, India, last November, a number of municipalities in Maharashtra State have desired to take up ecological sanitation projects. For the time being the following prefeasibility studies have been jointly conducted by IWWA, GTZ and seecon gmbh:

5.1 Prefeasibilty Study "Badlapur"

Adarsh Vidya Mandir School is located in Badlapur town, in Maharashtra's Thane district and accommodates a Primary School, a Secondary School, a Junior College and the "Adarsh Vidyaprasarak Sanstha's College of Arts & Commerce".

New sanitary facilities shall be provided to college students and staff members. Two alternatives, one considering the installation of specially designed squatting pans ("pour-flush" pans) made of ceramic that require a little amount of water for flushing only and treatment of blackwater in a biogas plant, the second going for a two-storeyed urine-diversion dehydration toilet block, are discussed at present. The digested sludge/finished compost and the urine to be collected from urinals (provided to female and male students) shall be applied on agricultural plots. Possibility of having cooperation with local agricultural university is being explored.

Enclosed please find the following reports:

- 1st Draft Report on the Ecosan Prefeasibility Study "Adarsh Vidyaprasarak Sanstha's College of Arts & Commerce, Kulgaon" (April 29th, 2006)
- 2nd Draft Report on the Ecosan Prefeasibility Study "Adarsh Vidyaprasarak Sanstha's College of Arts & Commerce, Kulgaon" (July 17th, 2006)
- 3rd Draft Report on the Ecosan Prefeasibility Study "Adarsh Vidyaprasarak Sanstha's College of Arts & Commerce, Kulgaon" (August 28th, 2006)

5.2 Prefeasibilty Study "ICEE at the University of Kalyani"

The International Centre of Ecological Engineering (ICEE) has been set up in the University of Kalyani in order to provide facilities for environmental awareness programme to imparting training to skilled and non-skilled persons, offering courses to students and extending facilities to researchers on the relevant areas of ecological engineering, especially ecological sanitation maintaining a close linked with agricultural production.

A socially and culturally acceptable, sustainable and hygienically safe sanitation concept comprising “Urine-Separation Dehydration Toilets”, collection and reuse of urine collected from the toilets and urinals (both, for ladies and gents) and reuse of greywater for gardening/irrigation purposes has been proposed for the upcoming ICCE-building.

Enclosed please find the following reports:

- 1st Draft Report on the Ecosan Prefeasibility Study ”International Centre of Ecological Engineering at the University of Kalyani, West Bengal” (July 14th, 2006)
- 2nd Draft Report on the Ecosan Prefeasibility Study ”International Centre of Ecological Engineering at the University of Kalyani, West Bengal” (August 27th, 2006)

5.3 Prefeasibilty Study “ACTS Rayasandra Campus for Higher Education”

The ACTS Rayasandra Campus for Higher Education was established in 1997 in Bangalore, India, and comprises the ACTS Academy for Higher Education, separated hostels for female and male students, a guest house, staff quarters, a kitchen cum dining hall and a vocational training institute.

A number of concepts have been elaborated ranging from low-tech to high sophisticated and low-budget to high-budget schemes; amongst them the following schemes/concepts:

- „zero-option“: no changes at all; treatment of mixed wastewater with the existing wastewater treatment scheme comprising a septict tank for retaining of settleable and floatable solids and treatment of the effluent in a constructed wetland cum multi-stage pond system;
- „ecosan light“: installation of urinals for source-separate collection of urine at all buildings; closing down of some toilets; going for a number of „Urine-Diversion Dehydration Demonstration Toilets“ (e.g. at the ACTS Academy for Higher Education Building, the Ladies Hostel and Guest House); going for vacuum based sanitary facilities in one or the other building (treatment of high strength blackwater in the existing biogas plant or a vermicomposting unit); combined treatment of greywater and some blackwater in the existing wastewater treatment plant (septic tank, pond system);
- „ecosan advanced“: separation of all flowstreams at source

Enclosed please find the following report:

- 1st Draft Report on the Ecosan Prefeasibility Study ”ACTS Rayasandra Campus for Higher Education” (June 1st, 2006)

5.4 Prefeasibilty Study "Virar Science Garden"

VIRAR Municipal Council has desired to take up running an eco-friendly public toilet centre at "Virar Science Garden". The toilet centre shall serve stall owners from a nearby market area and passers-by. Construction of a biogas-linked-sanitation centre that facilitates source-separate collection, treatment and reuse of blackwater, yellowwater and greywater is discussed. Codigestion of wet organics from a nearby vegetable market along with the blackwater may be considered. Slurry and urine shall be applied as soil conditioner and nitrogen-rich liquid fertilizer in agricultural production. The greywater shall be used on-site for gardening purposes.

Enclosed please find the following report:

- 1st Draft Report on the Ecosan Prefeasibility Study "Eco-friendly public toilet centre at Virar Science Garden" (May 24th, 2006)

5.5 Prefeasibilty Study "Pandharpur"

Pandharpur, located at the banks of the Bhima-River in Maharashtra's Solapur district, is one of the most important pilgrimage places of the state. Having a permanent population of about 100,000 people and a floating population of ca. 25,000, the town accommodates congregations of several hundred thousand devotees (up to 1 million) on several occasions during the year.
Also makeshift toilets are provided along the riverbanks (also called "desert area") during festival seasons, sanitary situation in general is poor.

A proposal on source-separate collection, treatment and reuse of flowstreams from the riverbanks has been submitted to Pandharpur Municipal Council and Maharashtra Jeevan Pradhikaran (MJP) State Environment Department.

Enclosed please find the following reports:

- 1st Draft Report on the ecosan Prefeasibility Study "Pandharpur" (February 28th, 2006)
- 2nd Draft Report on the ecosan Prefeasibility Study "Pandharpur" (May 31st, 2006)

6 ECOSAN MODULES THAT HAVE BEEN DESIGNED IN THE SCOPED OF THE IESNI, BUT HAVE NOT BEEN IMPLEMENTED

6.1 Individual Urine-Diversion Vermicomposting Toilets

Using "Vermifilter Biotreatment Plants" that have be designed for the treatment of domestic wastewater and are descriped by Mr. S.D. Ghatnekar and Mr. M.F. Kavian [14] and Mr. U.S. Bhawalkar [15] as a point of departure, a urine-diversion vermicomposting toilet system was designed, which allows the combined treatment of faecal matter and cleansing water.

A multi-layer filter and drainage system, which is set horizontally above the bottom of the composting compartments, facilitates solid-liquid separation. On top, a layer of organic material that is inoculated with earthworms retains solids and any surplus of liquid (cleansing water) percolates down the filter. The lowest layer is made up of gravel and drains the percolate to the ajoint reed bed for assimilation and evapotranspiration; over this a layer of sand is added as an intermediate layer.

In order to facilitate harvest of the finished compost, the urine-diversion vermicomposting toilet system is designed to operate in batches. Daily deposits are to be made into one of the two composting chambers that are situated below the squatting slab. One chamber is used until it is "full", the worms are then allowed to complete digestion while the second chamber accepts faecal material. When the second chamber becomes filled, the first chamber is emptied and the process starts all over. Each processing chamber is equipped with a ventilation pipe that runs above the roof, is screened for flies and capped for rain.

The urine is piped to a transportable collection tank (jerry can, etc.); greywater collected from the washbasin is discharged to mulch-filled absorption trenches for subsurface gardening/irrigation purposes.

Design assumptions and design parameters:

Findings from a survey of the relation of vermifiltration area to water use per day for vermiculture

table 4: Relation of vermifiltration area to water use per day

water use [liter/pe,d]	vermifiltration area [m^2/d]	organic loading [kg/m^2,d]	hydraulic loading [m/d]
up to 10	0.10	1.00	0.10
10 - 50	0.15	0.70	0.20
50 - 100	0.20	0.50	0.38
100 - 150	0.25	0.40	0.50
150 - 200	0.30	0.33	0.58

pe: person equivalent
(source: [15])

toilets, which was conducted by Mr. U. S. Bhawalkar, are shown in table 4.

Hydraulic loadings of up to 0.50 m^3/m^2,d with corresponding organic load factors of 0.20 to 0.30 [kg (dry) organics/m^2,d] for centralized wastewater processing facilities and organic load factors up to 1.00 kg/m^2,d for centralized solid bioconversion facilities have been observed. [15]

The design of the urine-separation vermicomposting toilet unit is based on the following assumptions/parameters:

- number of users per day: ca. 10 persons (at the most)
- feces (wet weight): ca. 0.30 kg per person per day [13]
- moisture content: ca. 70 % (66 – 80 %) [16]
- organic matter (dry weight): ca. 90 % (88 – 97%) [16]
- organic load (dry weight): ≤ 1.00 kg organics/m^2,d
- anal cleansing water: ca. 0.50 to 1.00 litres per person per day

Based on the above stated assumptions/parameters, the required vermifiltration area was calculated to be ca. 1 m^2 at minimum.

Provided that the vermifiltration area is 1 m^2 and the maximum amount of water used for cleansing is ca. 10 litres per day, the hydraulic load is calculated to be 10 mm/m^2,d at maximum.

Conceptual sketches of the above described vermicomposting toilet are depicted in figure 49 to figure 53.

6.2 Vermicomposting Unit for High-Strength Blackwater

Using “Vermifilter Biotreatment Plants“ that have be designed for the treatment of domestic wastewater and are descriped by Mr. S.D. Ghatnekar and Mr. M.F. Kavian [14] and Mr. U.S. Bhawalkar [15] as a point of departure, a urine-diversion vermicomposting toilet system was designed, which allows the combined treatment of faecal matter, cleansing and flush water.

A multi-layer filter and drainage system, which is set horizontally above the bottom of the composting compartments, facilitates solid-liquid separation. On top, a layer of organic material that is inoculated with earthworms retains solids and any surplus of liquid (cleansing water and flush water) percolates down the filter. The lowest layer is made up of gravel and drains the percolate to the ajoint reed bed for assimilation and evapotranspiration; over this a layer of sand is added as an intermediate layer. To avoid waterlogging and overflowing of the reed bed during monsoon season, the bed is equipped with a fail-safe overflow to drain any surplus of liquid to a nearby sewer.

In order to facilitate harvest of the finished compost, the vermicomposting system is designed to operate in batches. Daily blackwater production is discharged into one of the two composting chambers that are situated outside the building. One chamber is used until it is "full", the worms are then allowed to complete digestion while the second chamber accepts faecal material. When the second chamber becomes filled, the first chamber is emptied and the process starts all over. Each processing chamber is equipped with a ventilation pipe that runs above the roof, is screened for flies and capped for rain.

To keep blackwater production little, a specially designed squatting pan that is made of ceramic and requires a little amount of water for flushing of excreta shall be installed.

Urine collected from a separate urinal is piped to a transportable collection tank (jerry can, …); greywater collected from the washbasin and shower is discharged to mulch-filled absorption trenches for subsurface irrigation of a nearby plantation.

Design assumptions and design parameters:

Findings from a survey of the relation of vermifiltration area to water use per day for vermiculture toilets, which was conducted by Mr. U. S. Bhawalkar, are shown in table 4.

table 5: Relation of vermifiltration area to water use per day

water use [liter/pe,d]	vermifiltration area [m^2/d]	organic loading [kg/m^2,d]	hydraulic loading [m/d]
up to 10	0.10	1.00	0.10
10 - 50	0.15	0.70	0.20
50 - 100	0.20	0.50	0.38
100 - 150	0.25	0.40	0.50
150 - 200	0.30	0.33	0.58

pe: person equivalent
(source: [15])

Hydraulic loadings of up to 0.50 m^3/m^2,d with corresponding organic load factors of 0.20 to 0.30 [kg (dry) organics/m^2,d] for centralized wastewater processing facilities and organic load factors up to 1.00 kg/m^2,d for centralized solid bioconversion facilities have been observed. [15]

The design of the vermicomposting unit is based upon the following assumptions/parameters:

- number of users per day: ca. 10 persons (at the most)
- feces (wet weight): ca. 0.30 kg per person per day [13]
- moisture content: ca. 70 % (66 – 80 %) [16]
- organic matter (dry weight): ca. 90 % (88 – 97%) [16]
- organic load (dry weight): ≤ 1.00 kg organics/m^2,d
- water consumption: ca. 3 to 4 litres per person per day (cleansing and flushing)

Based on the above stated assumptions/parameters, the required vermifiltration area was calculated to be ca. 1 m^2 at minimum.

Provided that the vermifiltration area is 1 m^2 and the maximum amount of water used for anal cleansing and flushing the toilet is ca. 40 liters per day, the hydraulic load is calculated to be 40 mm/m^2,d at maximum.

Conceptual sketches of the above described vermicomposting toilet are depicted in figure 54 to figure 57.

7 SUPPLIERS

Information on “pour-flush” squatting pans is available from (amongst other sources/suppliers):

http://www.ruralsanitation.com/index.htm

Information on “ladies urinals” is available from (amongst other sources/suppliers):

http://www.ruralsanitation.com/index.htm
http://www.eparryware.com/
http://www.hindwarebathrooms.com/
http://www.cera-india.com/

Information on “biogas settler” is available from (amongst other sources/suppliers):

BORDA
#220, 4th `A` Cross, 3rd Block, HRBR Layout, Kalyan Nagar, Bangalore – 560 043, India
phone: +91-(0)80-25431772
fax: +91-(0)80-25431773
email: borda.india@vsnl.net
email: borda-india@dishnetdsl.net
web: http://www.borda.org

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ISBN 0-9547873-0-7

[13] Patel, I. (2003). Technical Options for Sanitation (1st edition)

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to Treat Waste Water from a Sewage Plant of a Small Town for Irrigating Agriculture, http://www.ifh-homehygiene.org/2003/2events/poster.html, last accessed: 16.02.2006)

[15] Bhawalkar, U.S. (1996). Vermiculture Bioconversion of Organic Residues

[16] Jenkins, J.C. (1994). Humanure Handbook – a guide to composting human manure Jenkins Publishing, Grove City, ISBN 0-9644258-4-X

9 SKETCHES, TECHNICAL DRAWINGS

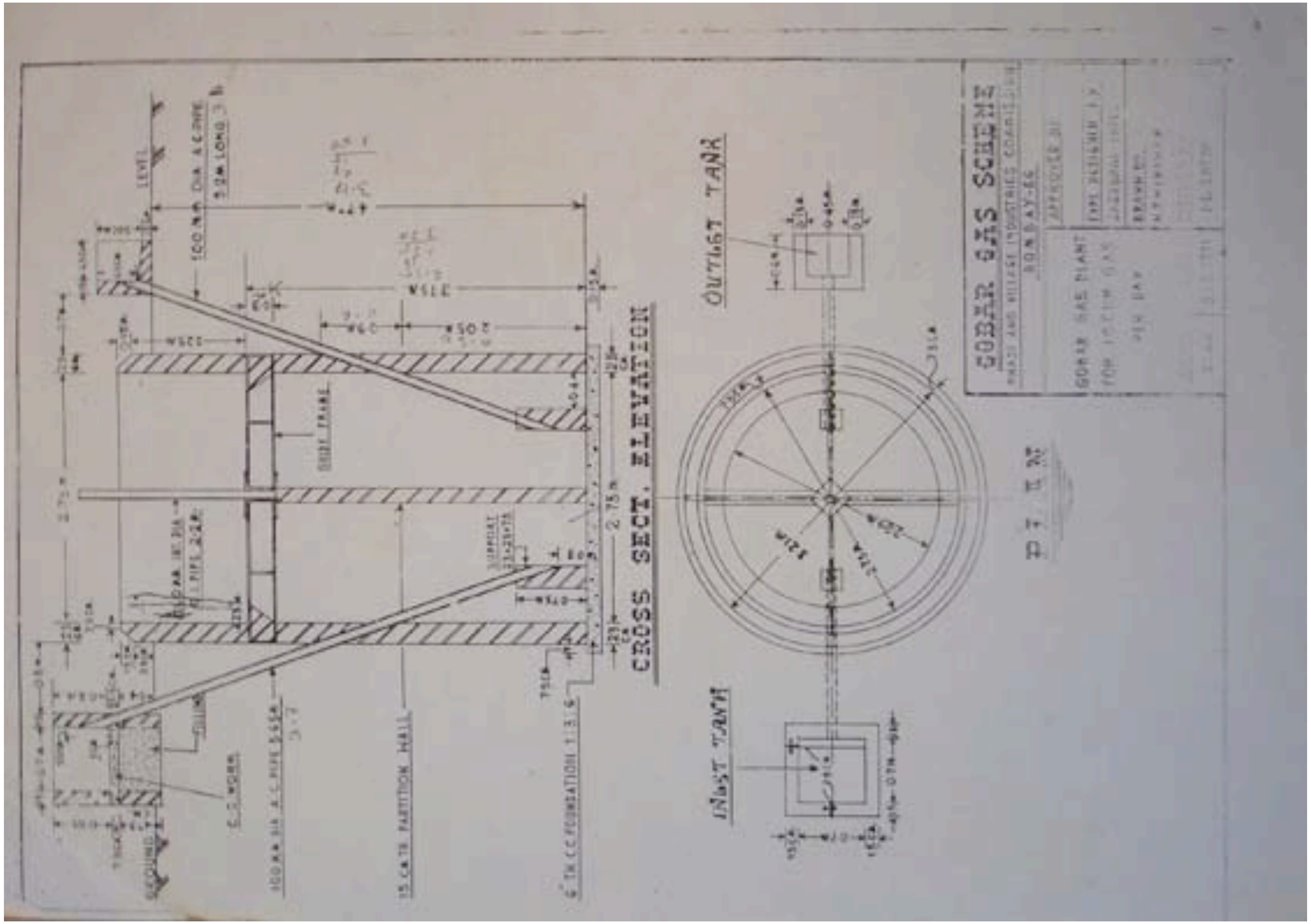


figure 19: Design of floating-drum type biodigester constructed at Dalit Shakti Kendra (part I)

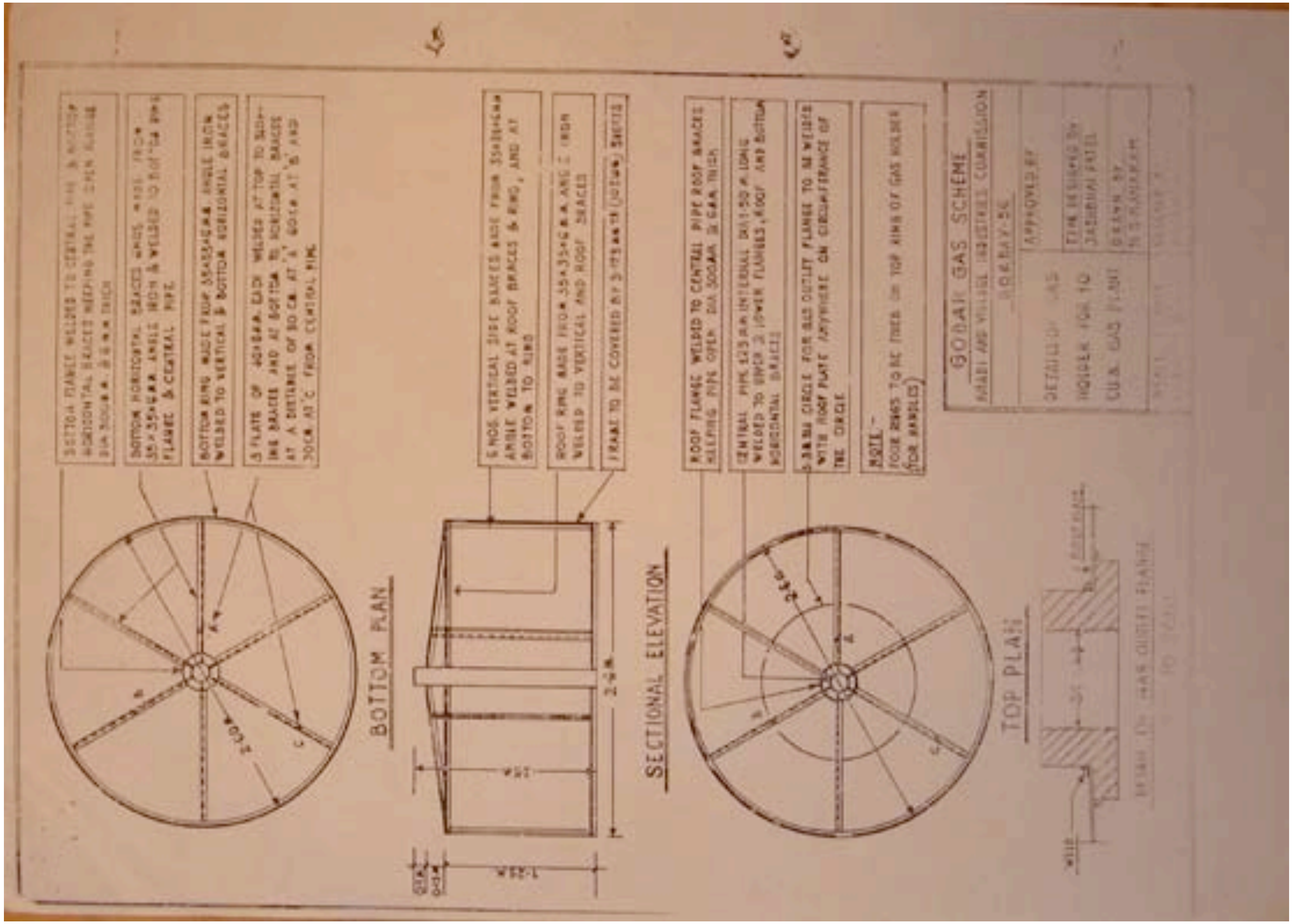


figure 20: Design of floating-drum type biodigester constructed at Dalit Shakti Kendra (part II)

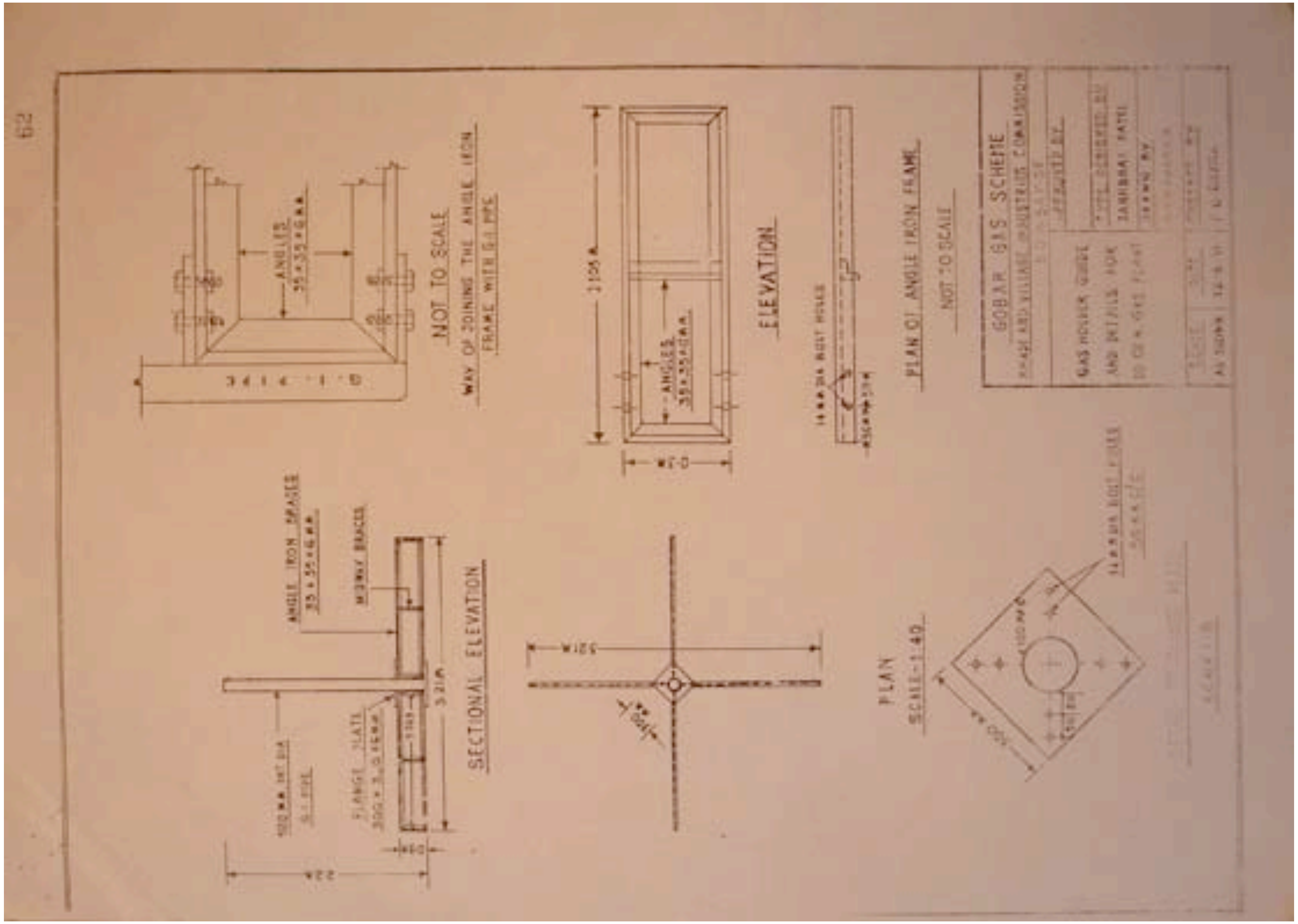


figure 21: Design of floating-drum type biodigester constructed at Dalit Shakti Kendra (part III)

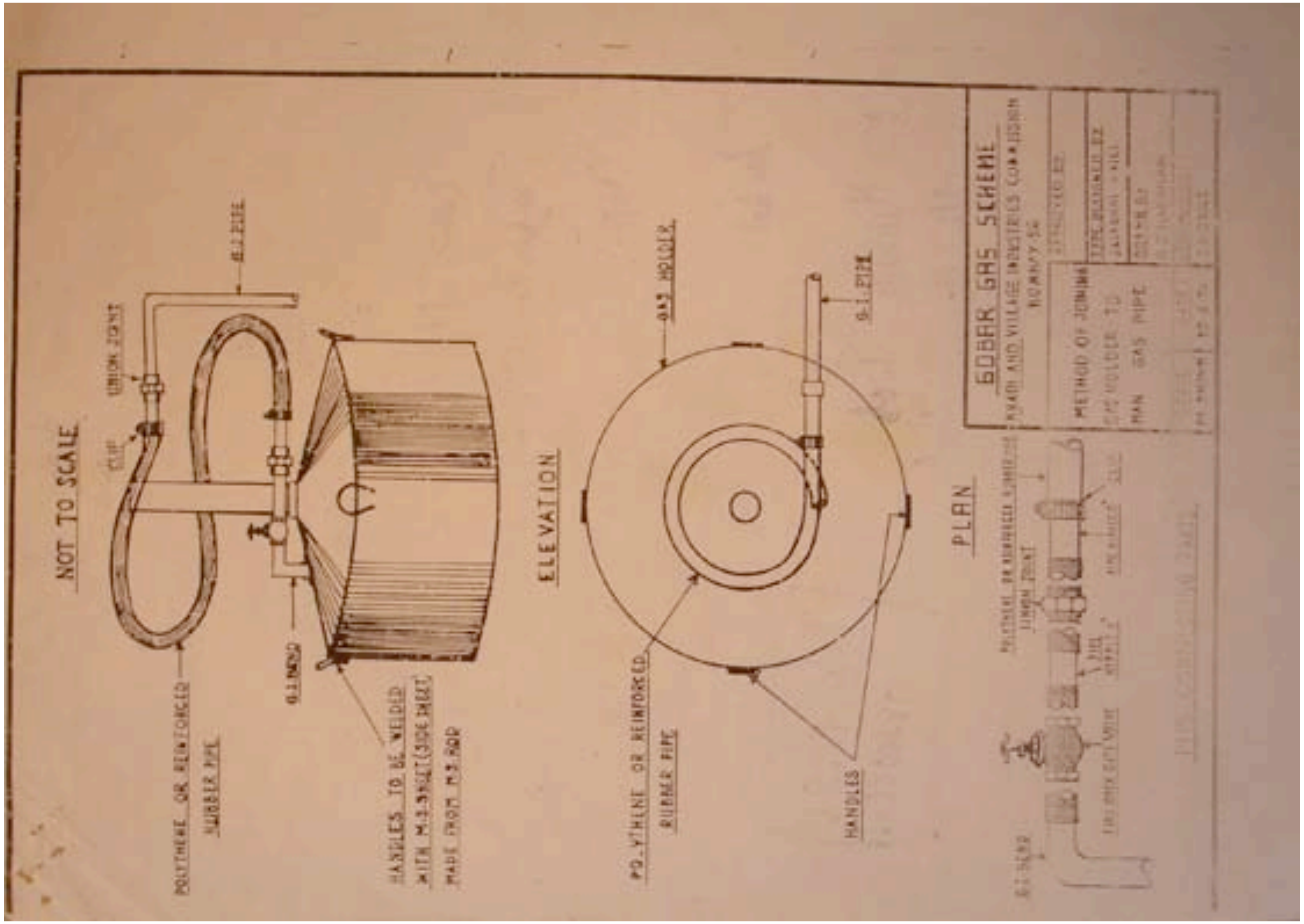


figure 22: Design of floating-drum type biodigester constructed at Dalit Shakti Kendra (part IV)

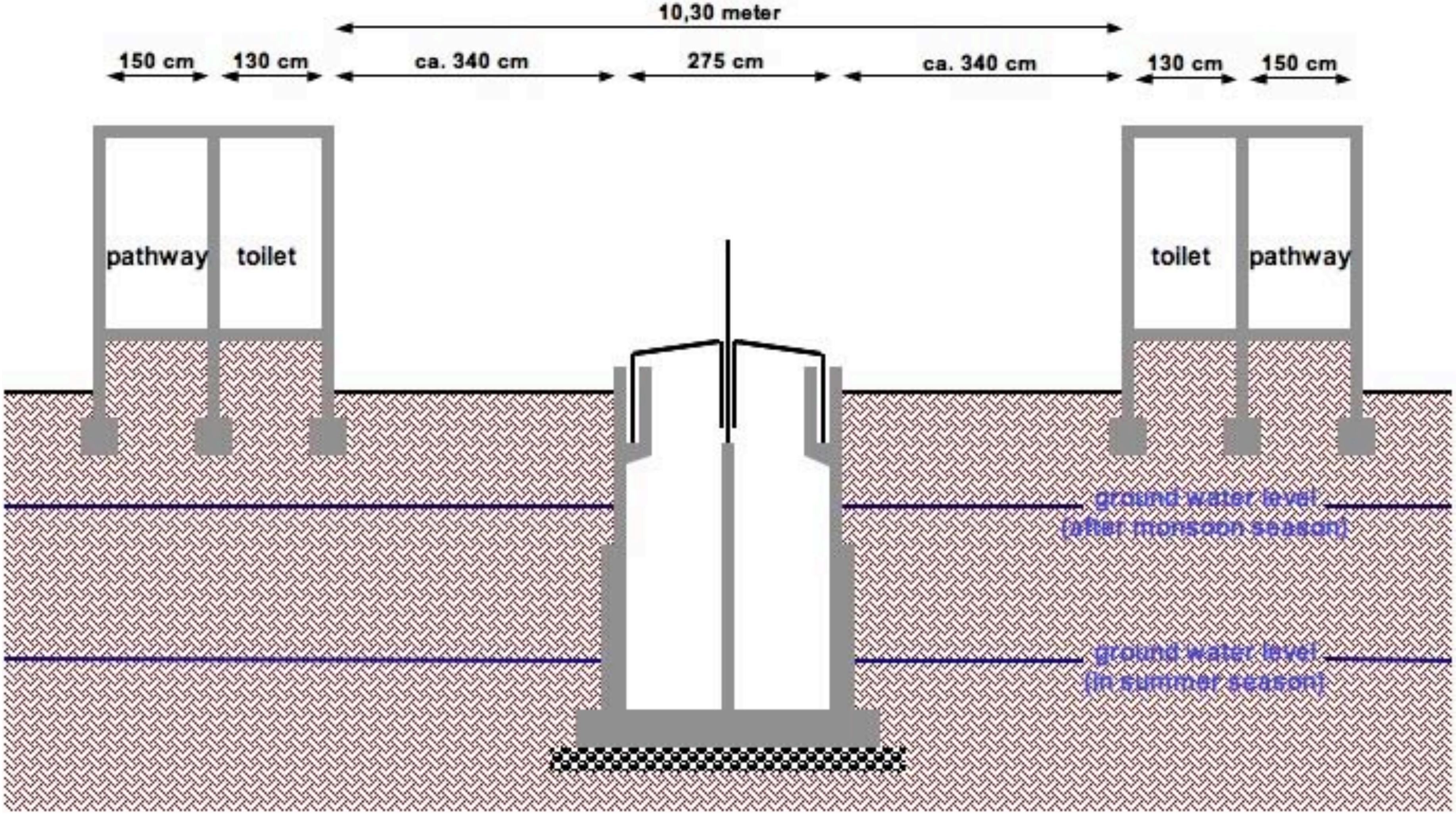


figure 23: Conceptual sketch (cross section) of new toilet centre and biogas plant at Dalit Shakti Kendra

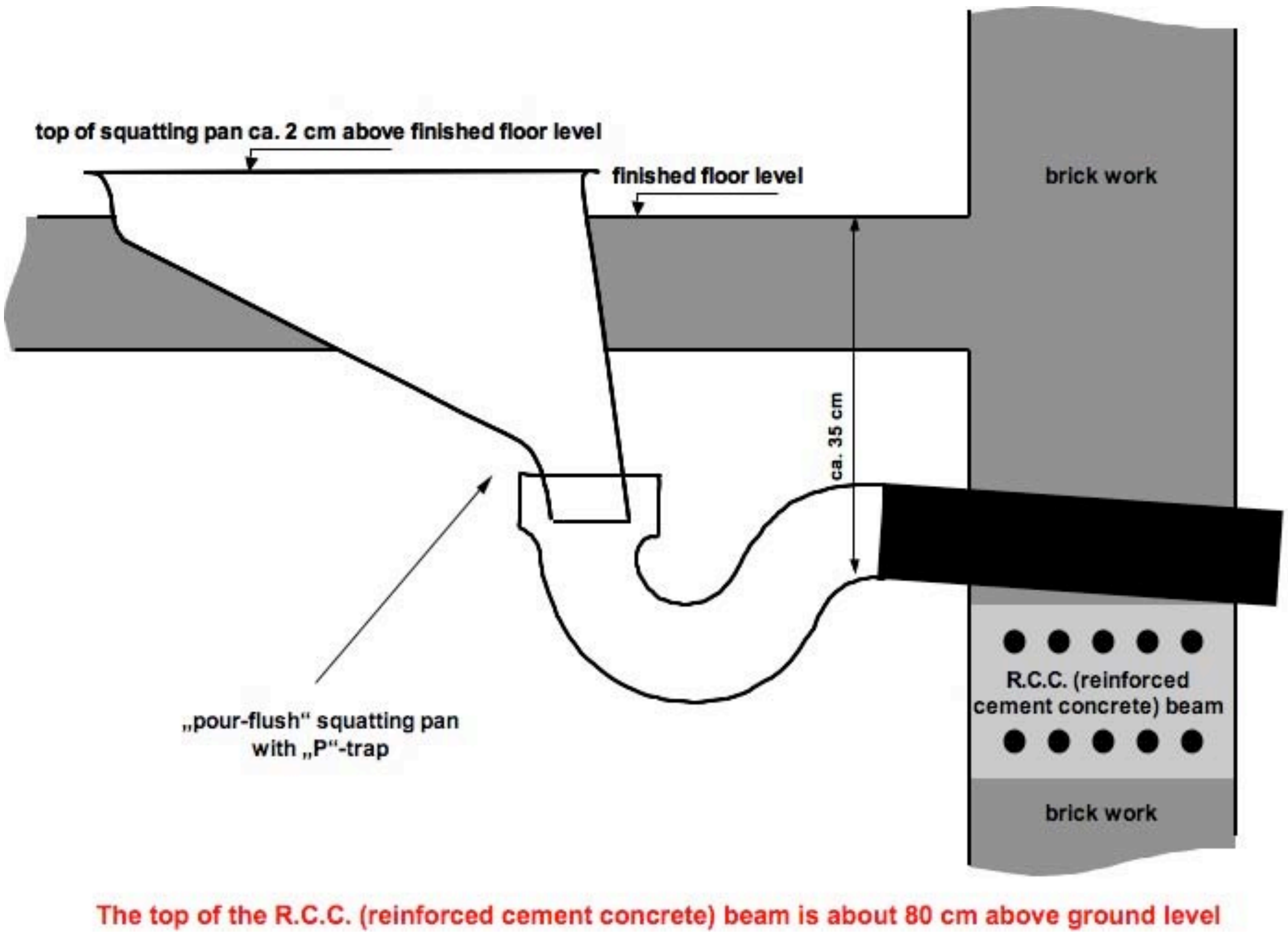


figure 24: Detail of „pour-flush" squatting pan

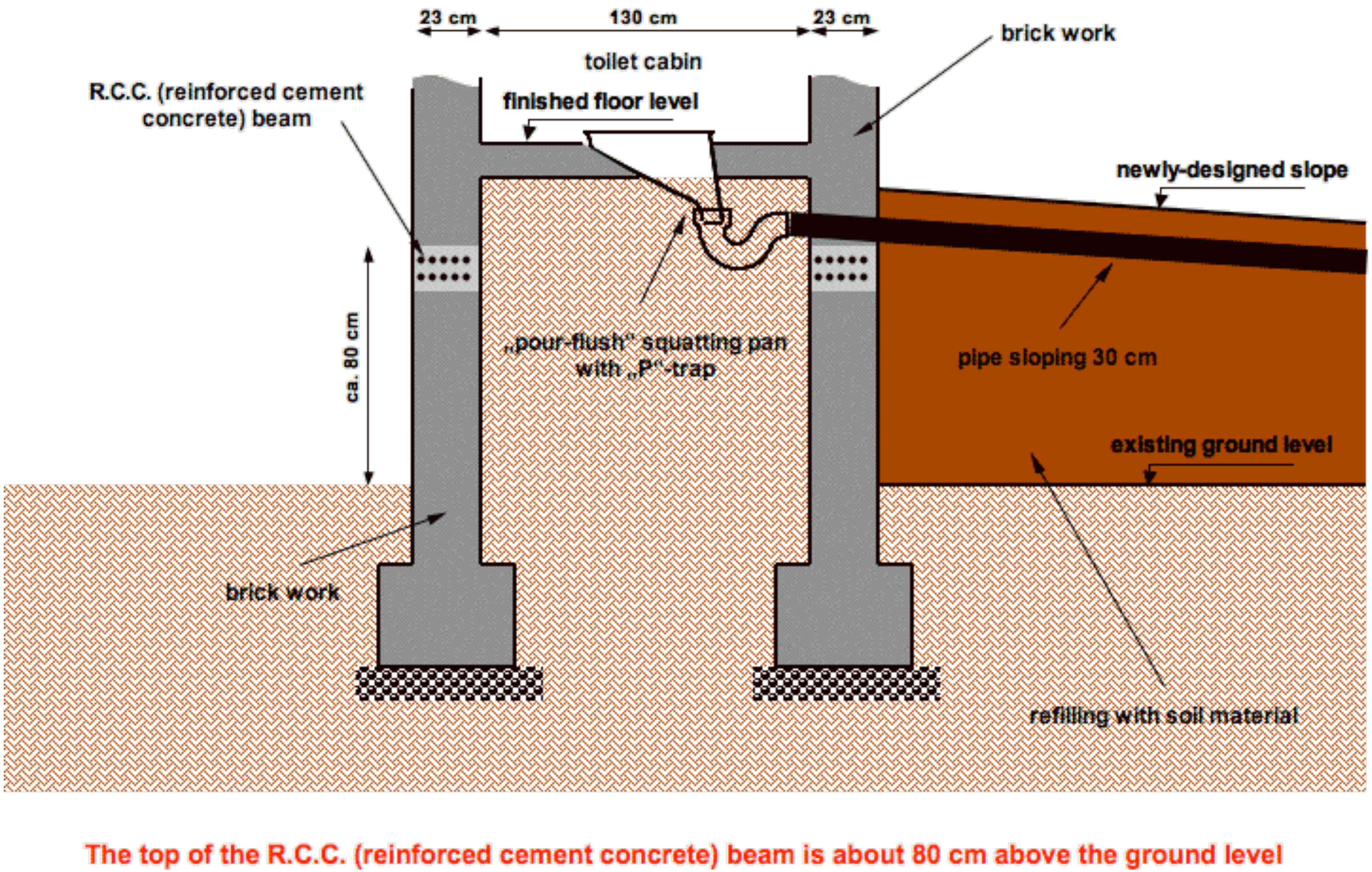
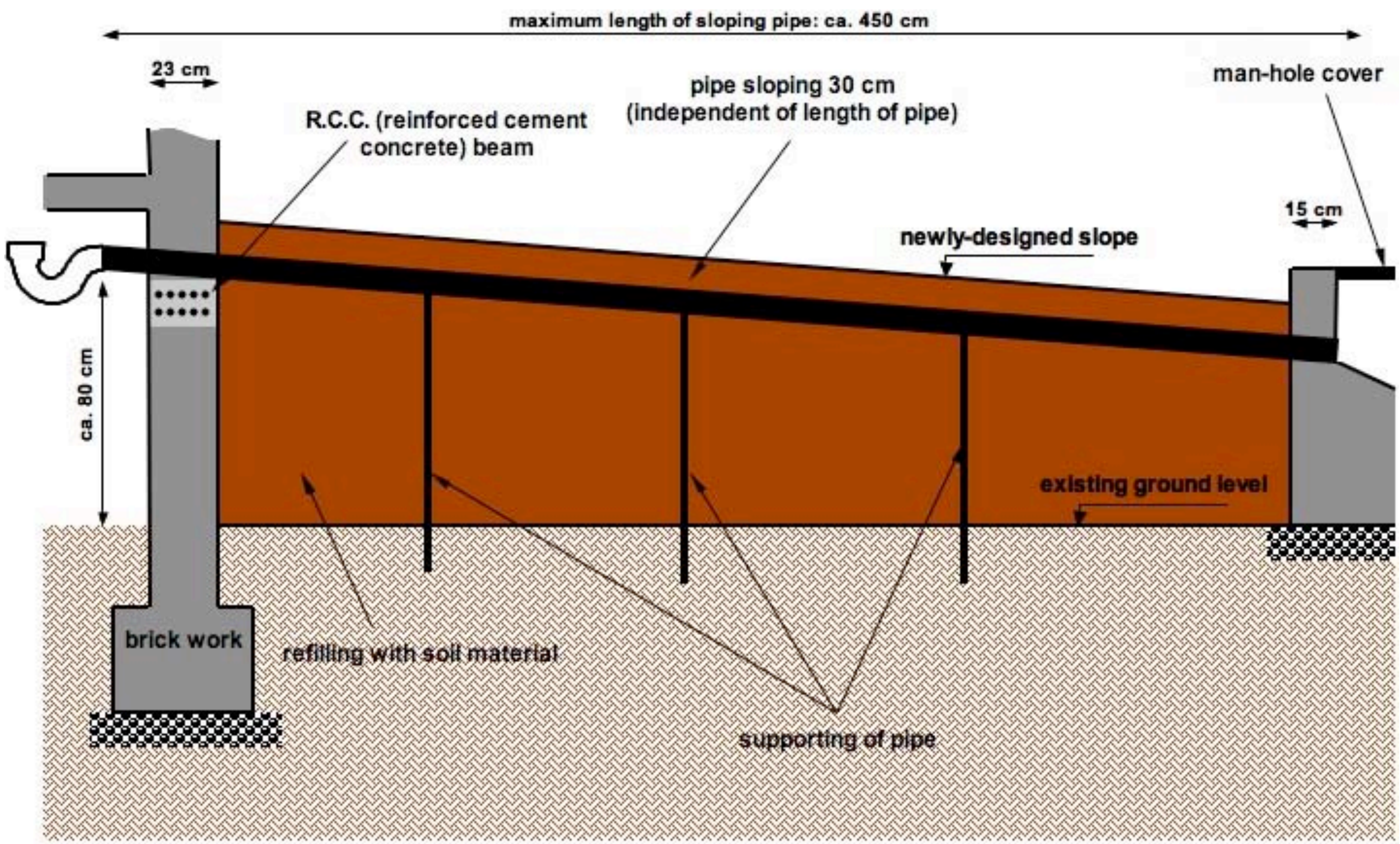


figure 25: Individual connection of „pour-flush" squatting pans to biogas plant (detail: toilet cubicle)



The top of the R.C.C. (reinforced cement concrete) beam is about 80 cm above the ground level

figure 26: Individual connection of „pour-flush“ squatting pans to biogas plant (longest pipe)

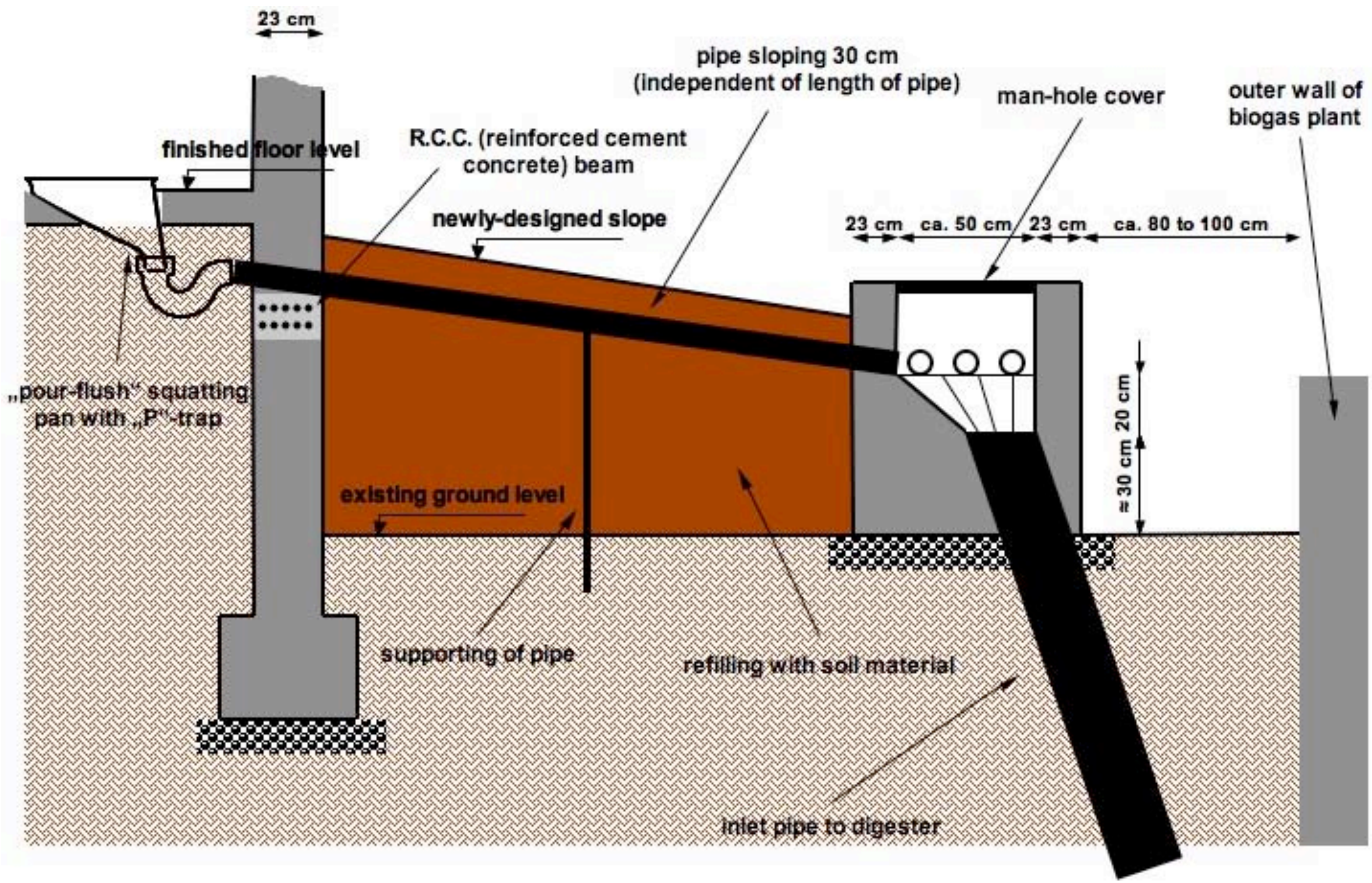


figure 27: Individual connection of „pour-flush" squatting pans to biogas plant (shortest pipe)

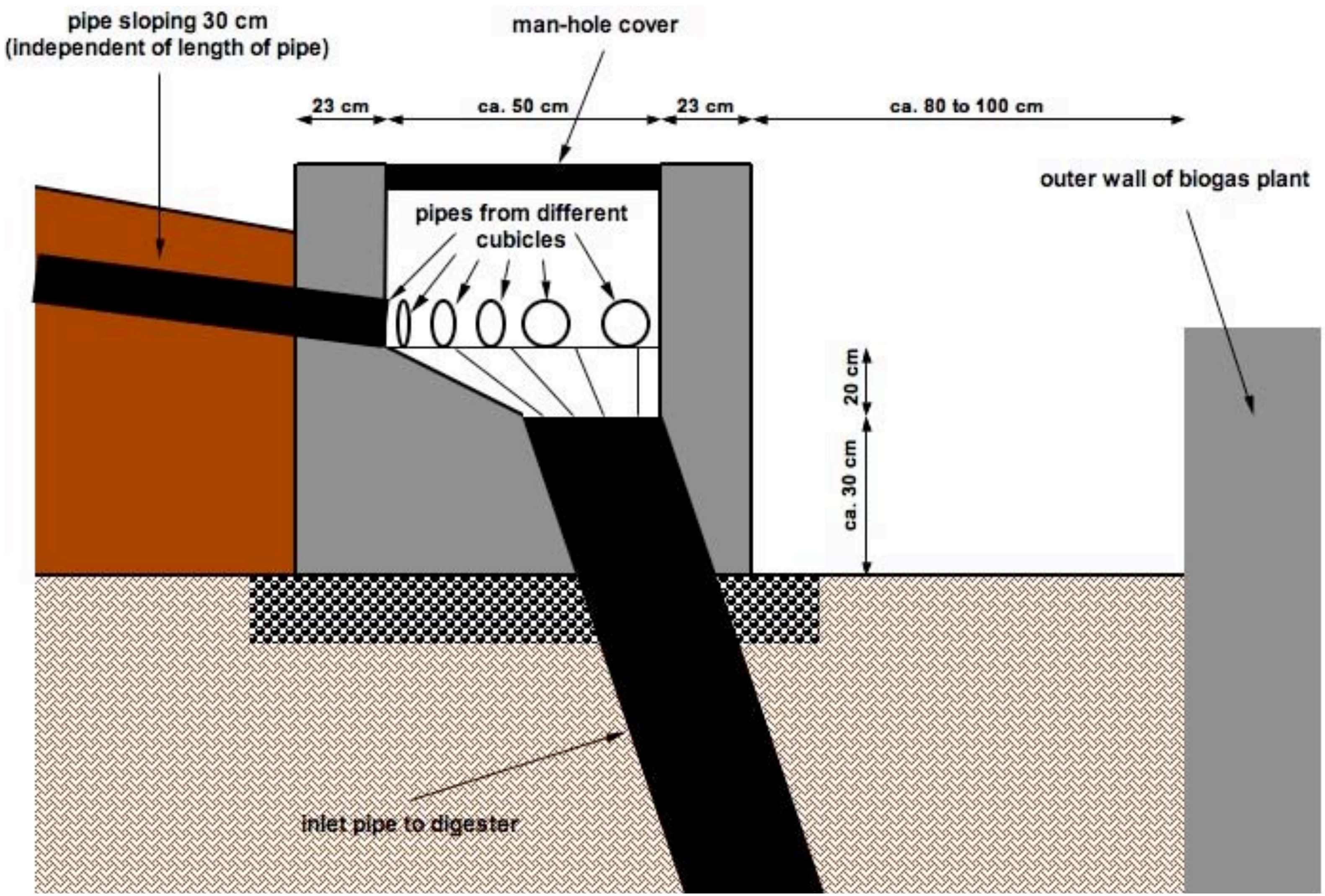


figure 28: Individual connection of „pour-flush" squatting pans to biogas plant (detail: hopper)

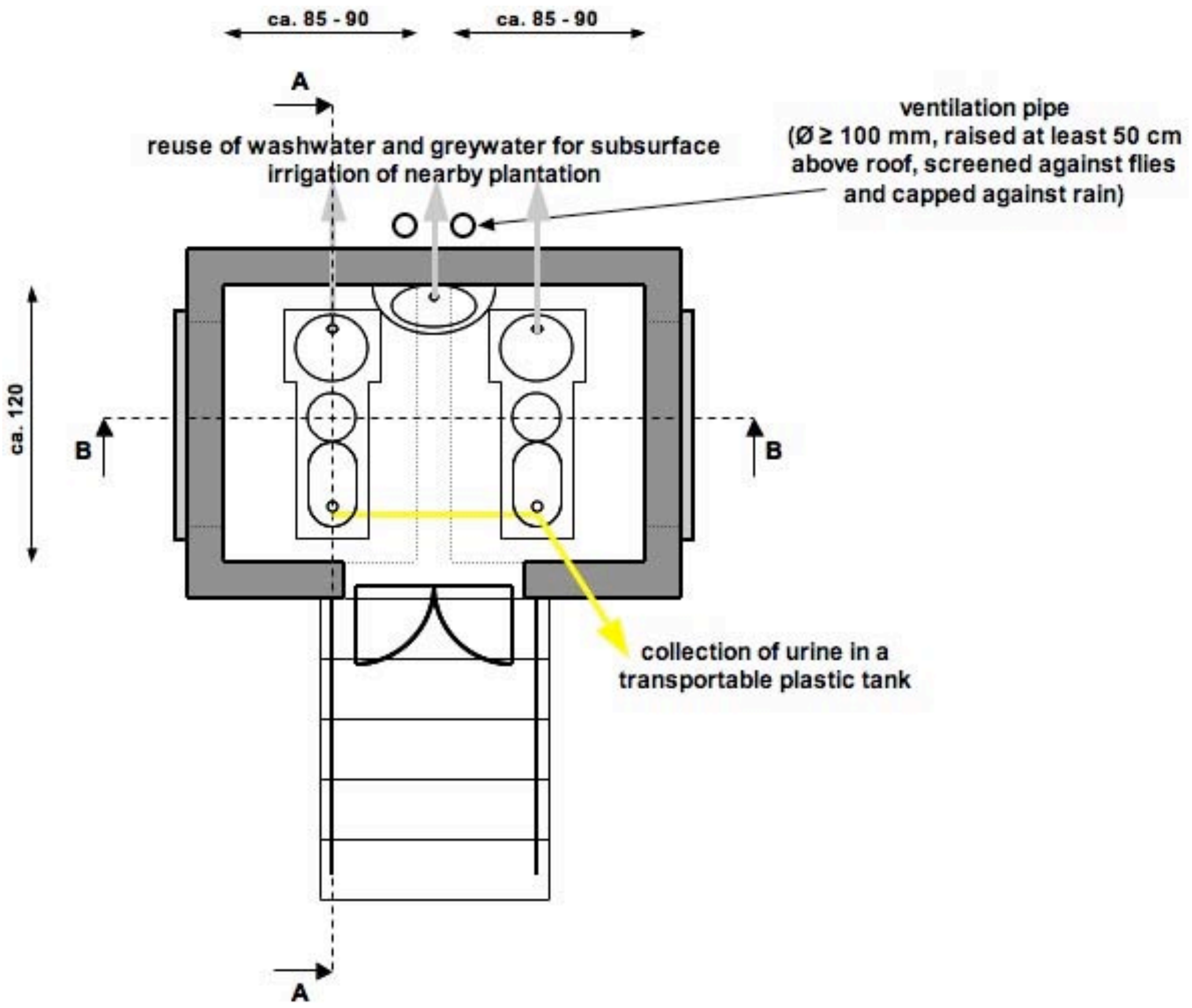


figure 29: Conceptual sketch of Urine-Diversion Dehydration Toilet (ground plan, design A)

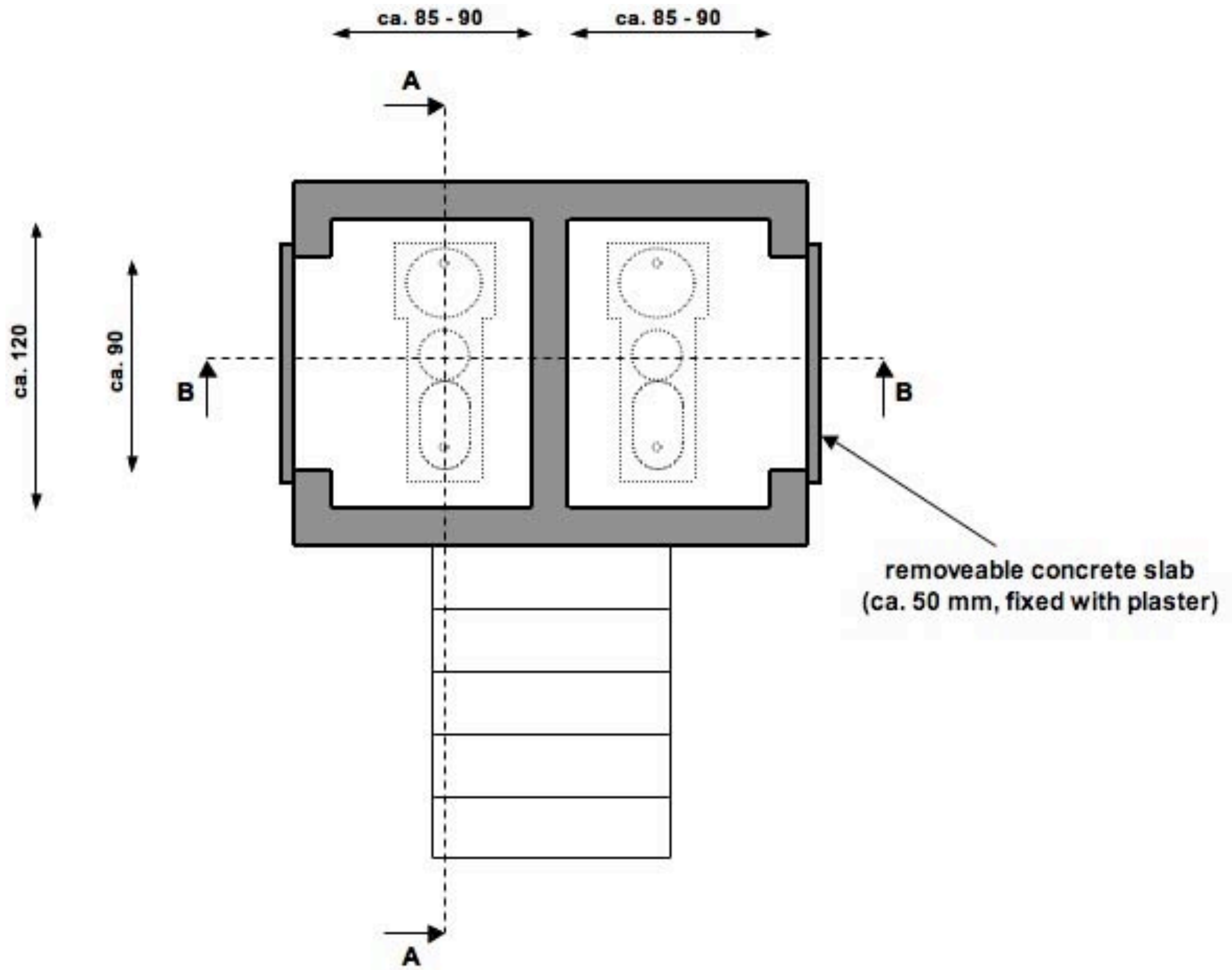


figure 30: Conceptual sketch of Urine-Diversion Dehydration Toilet (horizontal cross section, design A)

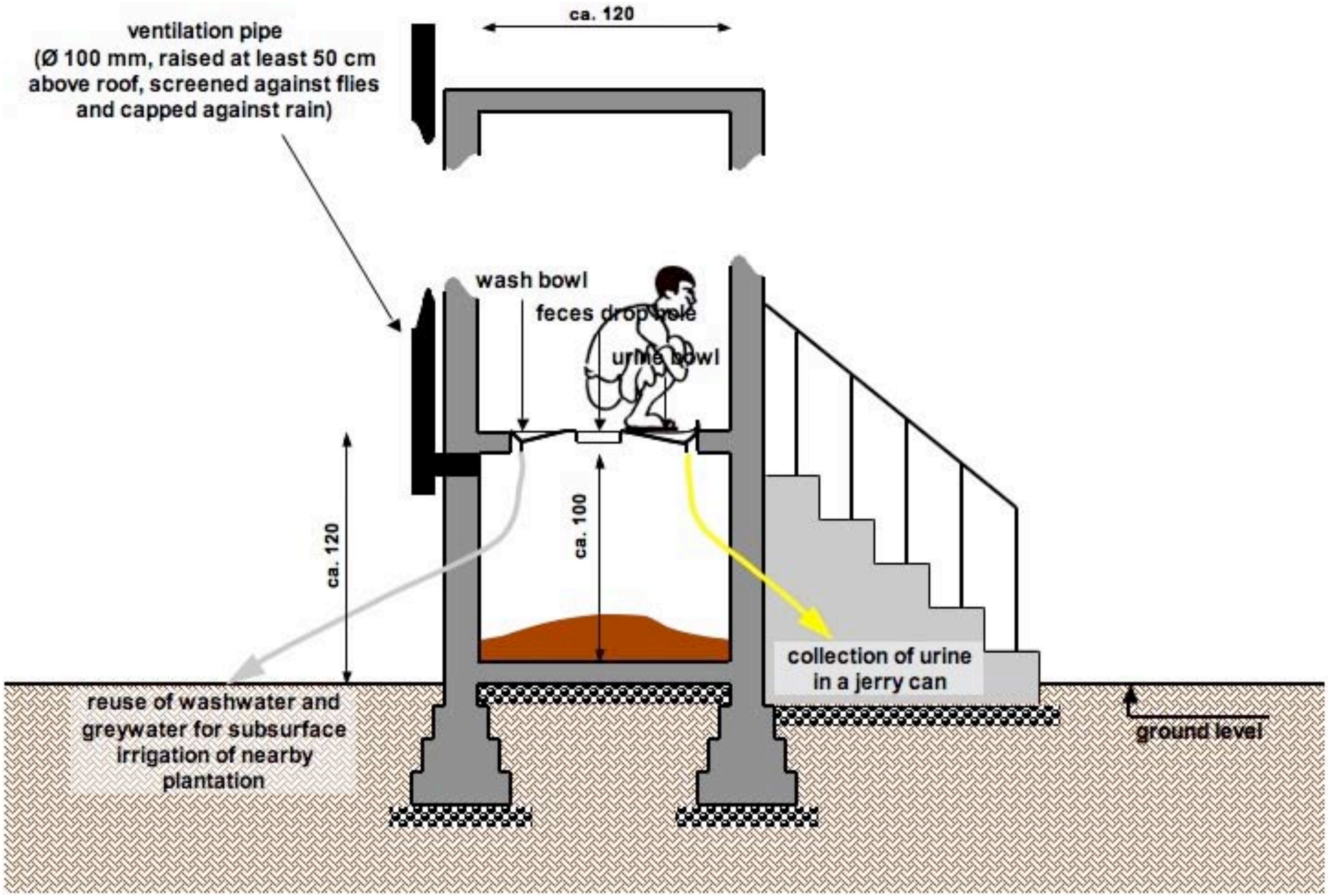


figure 31: Conceptual sketch of Urine-Diversion Dehydration Toilet (cross section A - A, design A)

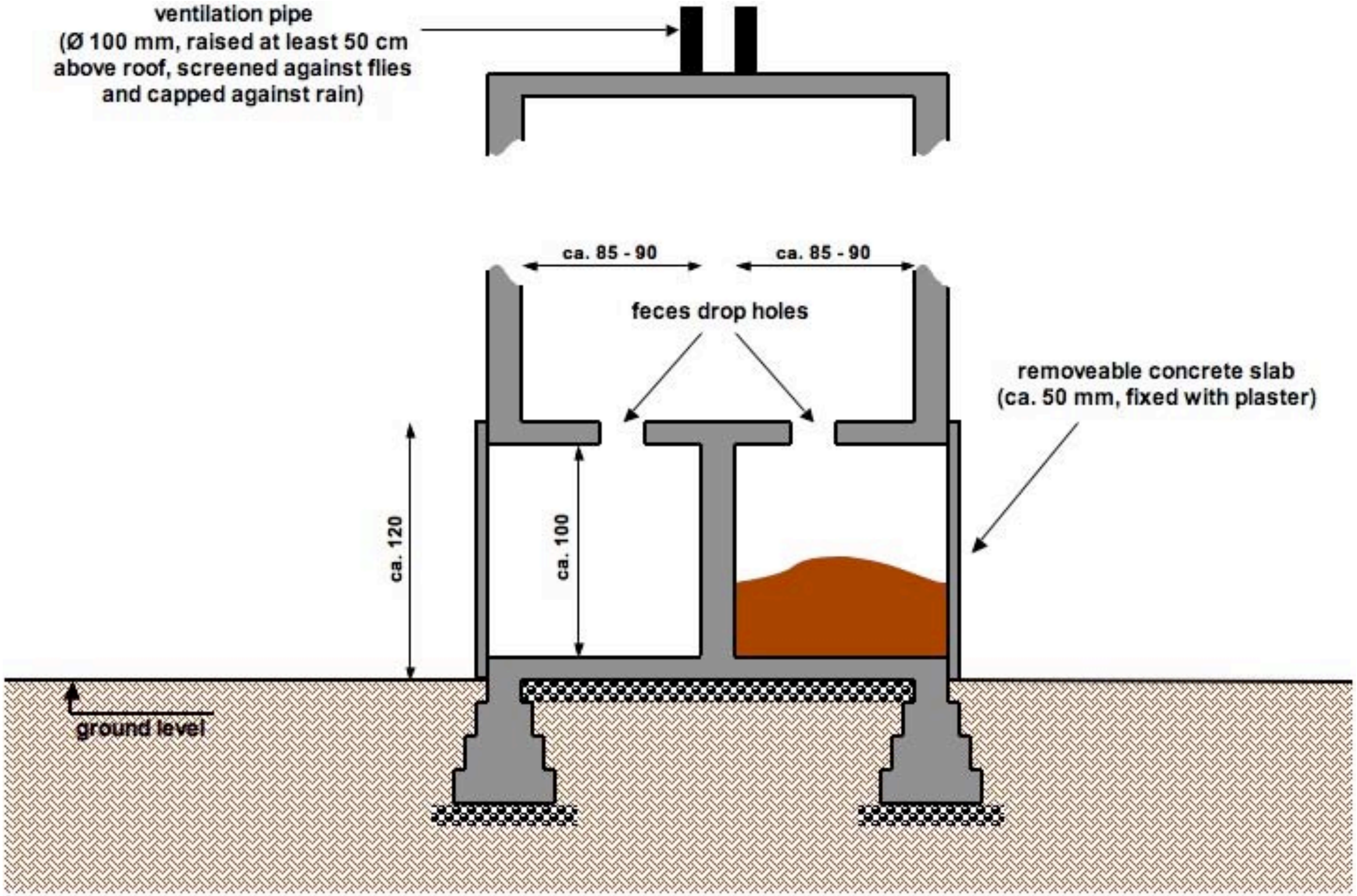


figure 32: Conceptual sketch of Urine-Diversion Dehydration Toilet (cross section B - B, design A)

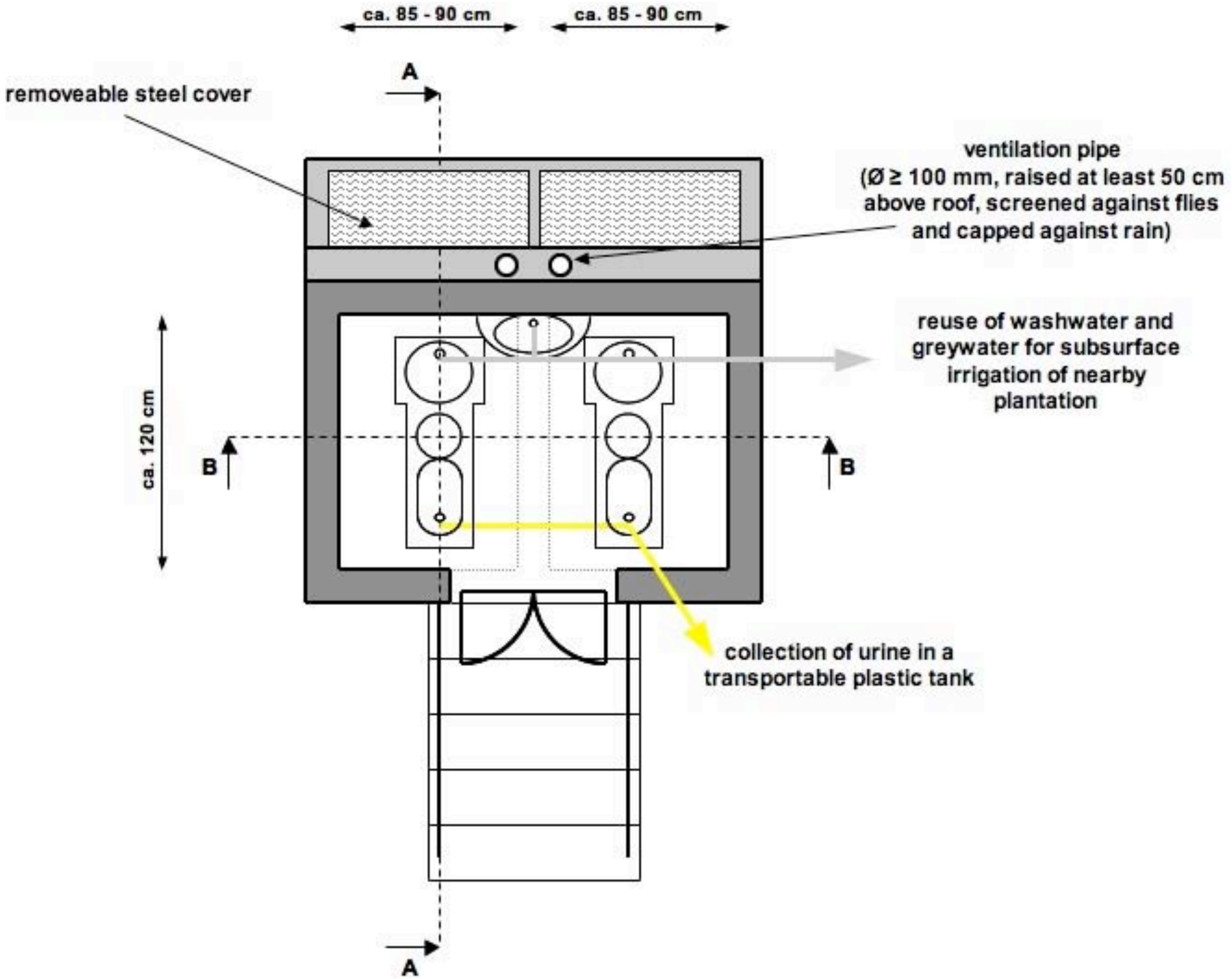


figure 33: Conceptual sketch of Urine-Diversion Dehydration Toilet (ground plan, design B)

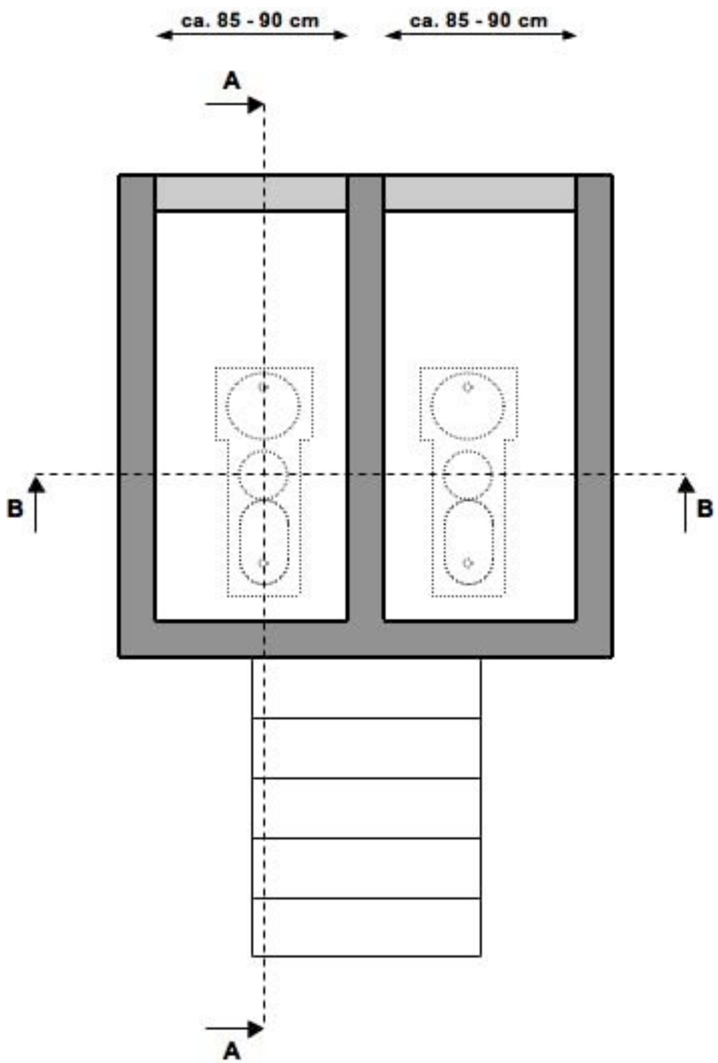


figure 34: Conceptual sketch of Urine-Diversion Dehydration Toilet (horizontal cross section, design B)

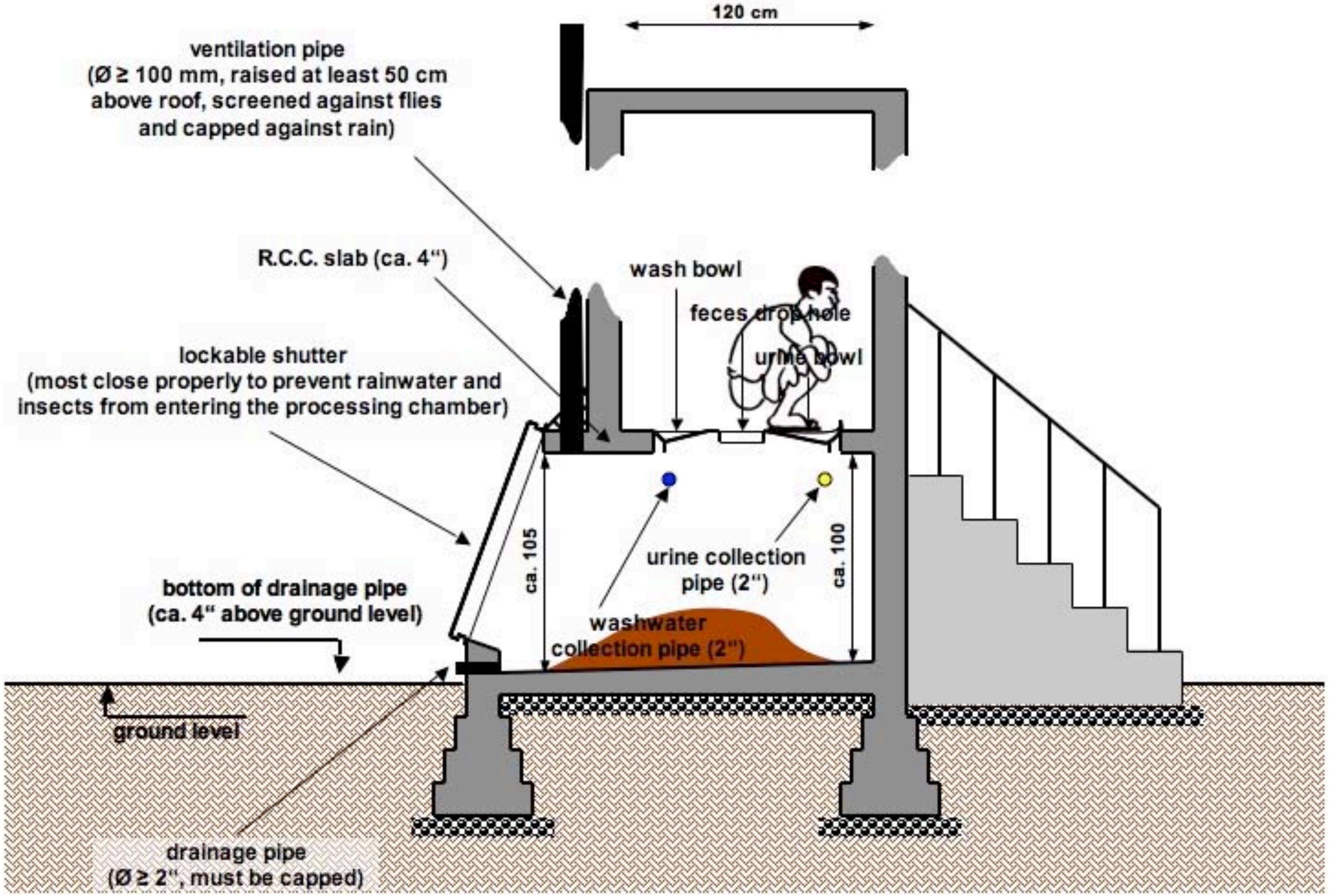


figure 35: Conceptual sketch of Urine-Diversion Dehydration Toilet (cross section A - A, design B)

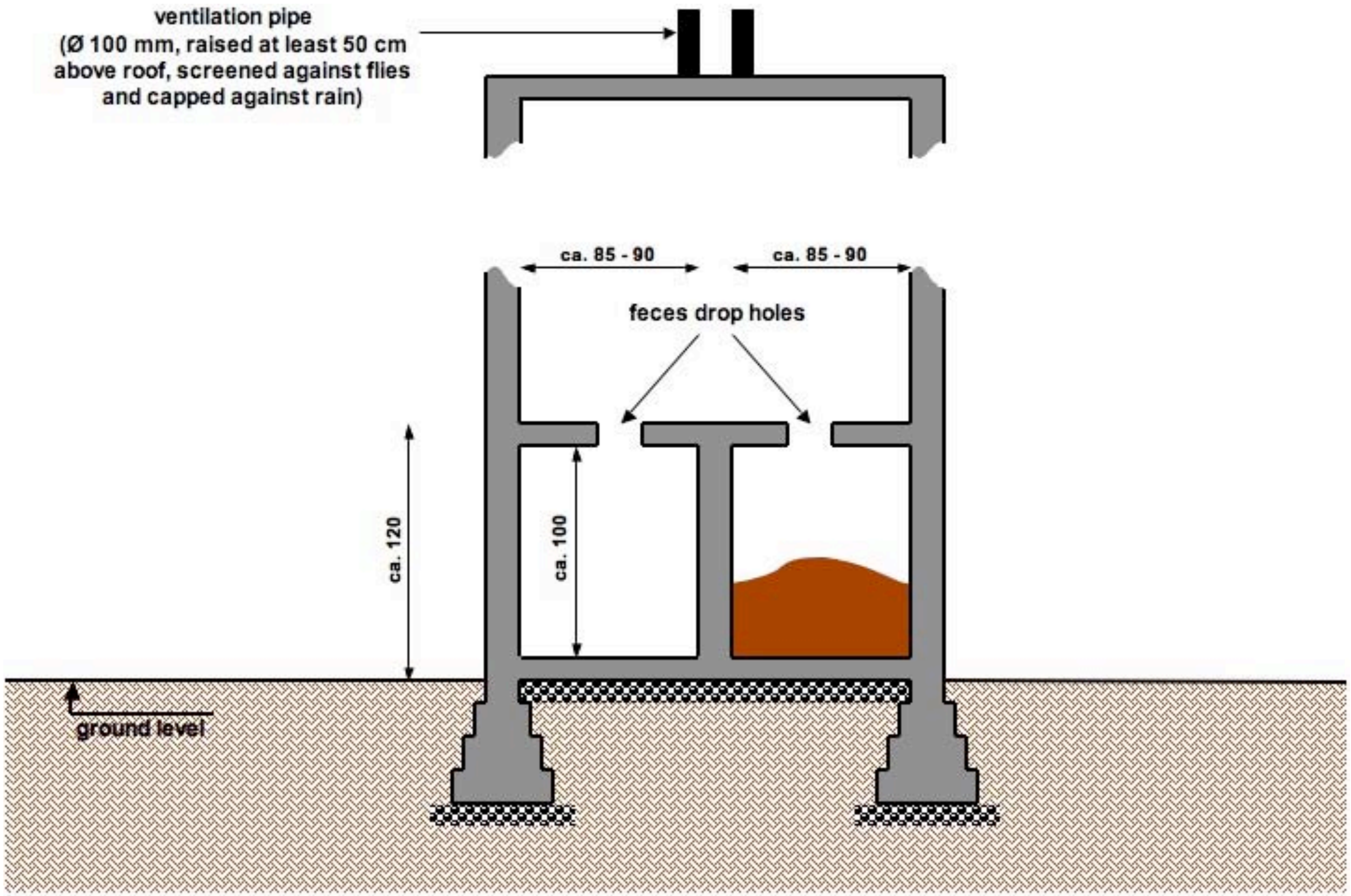


figure 36: Conceptual sketch of Urine-Diversion Dehydration Toilet (cross section B - B, design A)

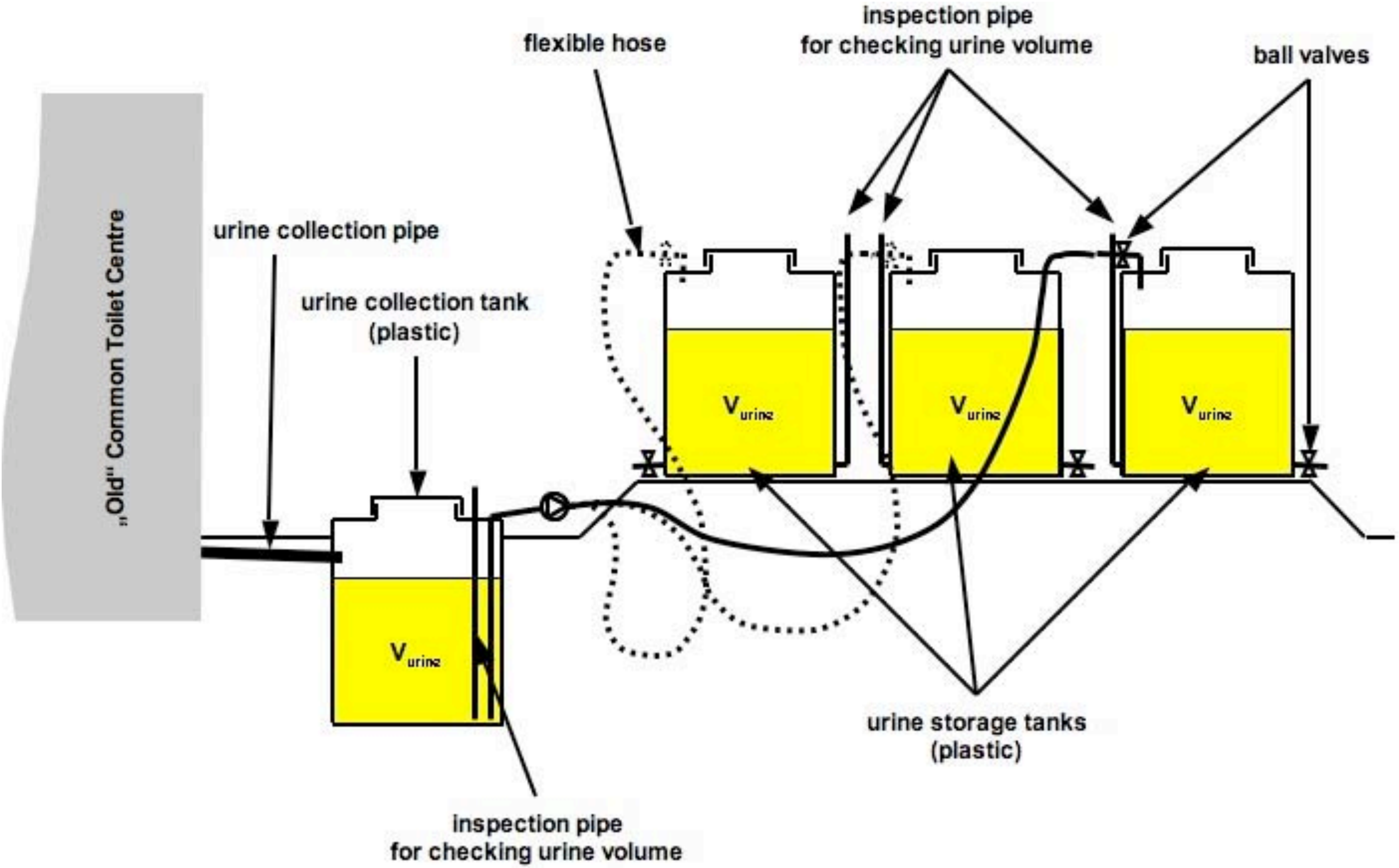


figure 37: Conceptual sketch (cross section) of urine collection and storage scheme at Dalit Shakti Kendra

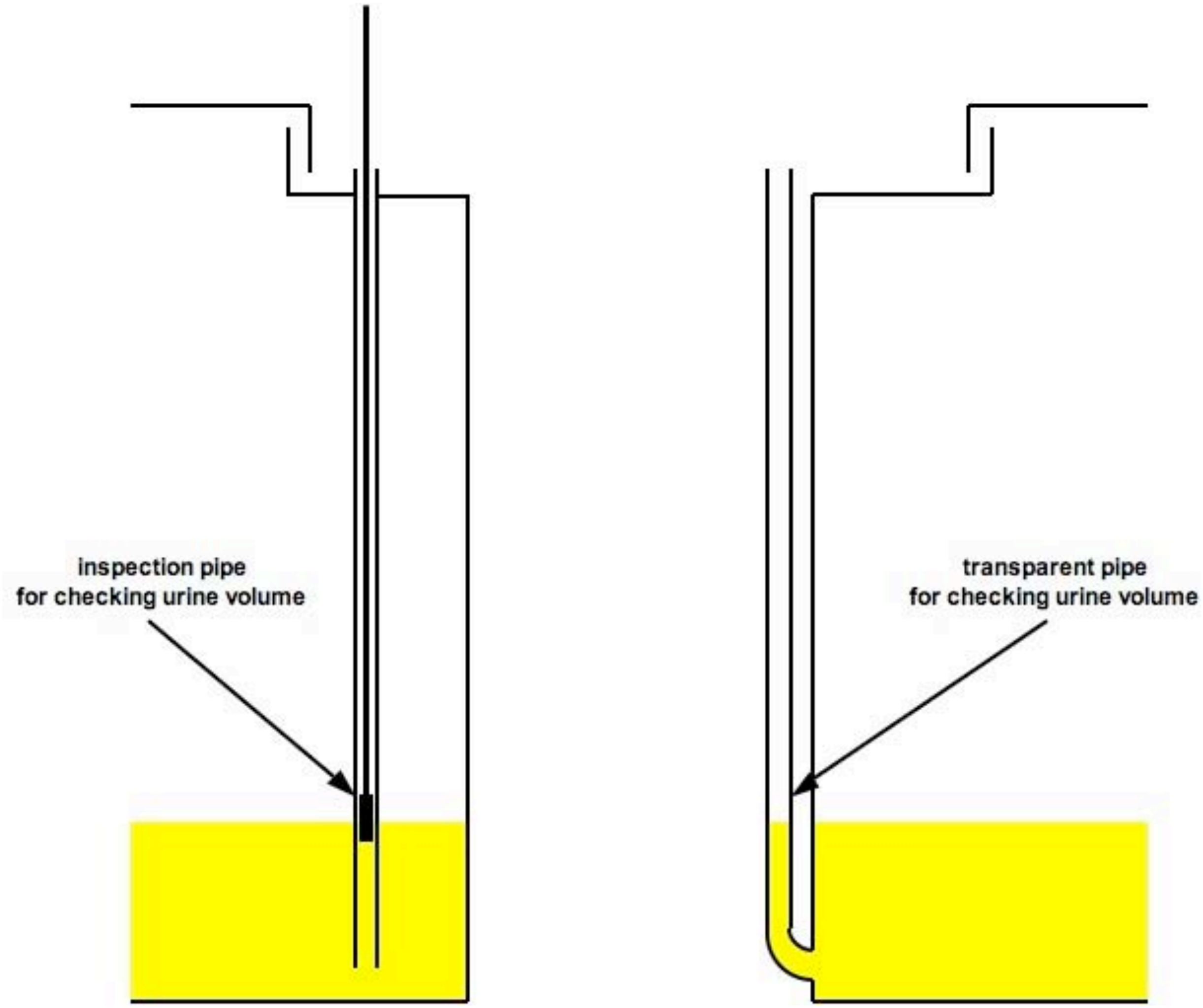


figure 38: Deatils of urine collection and hygienisation/storage tanks

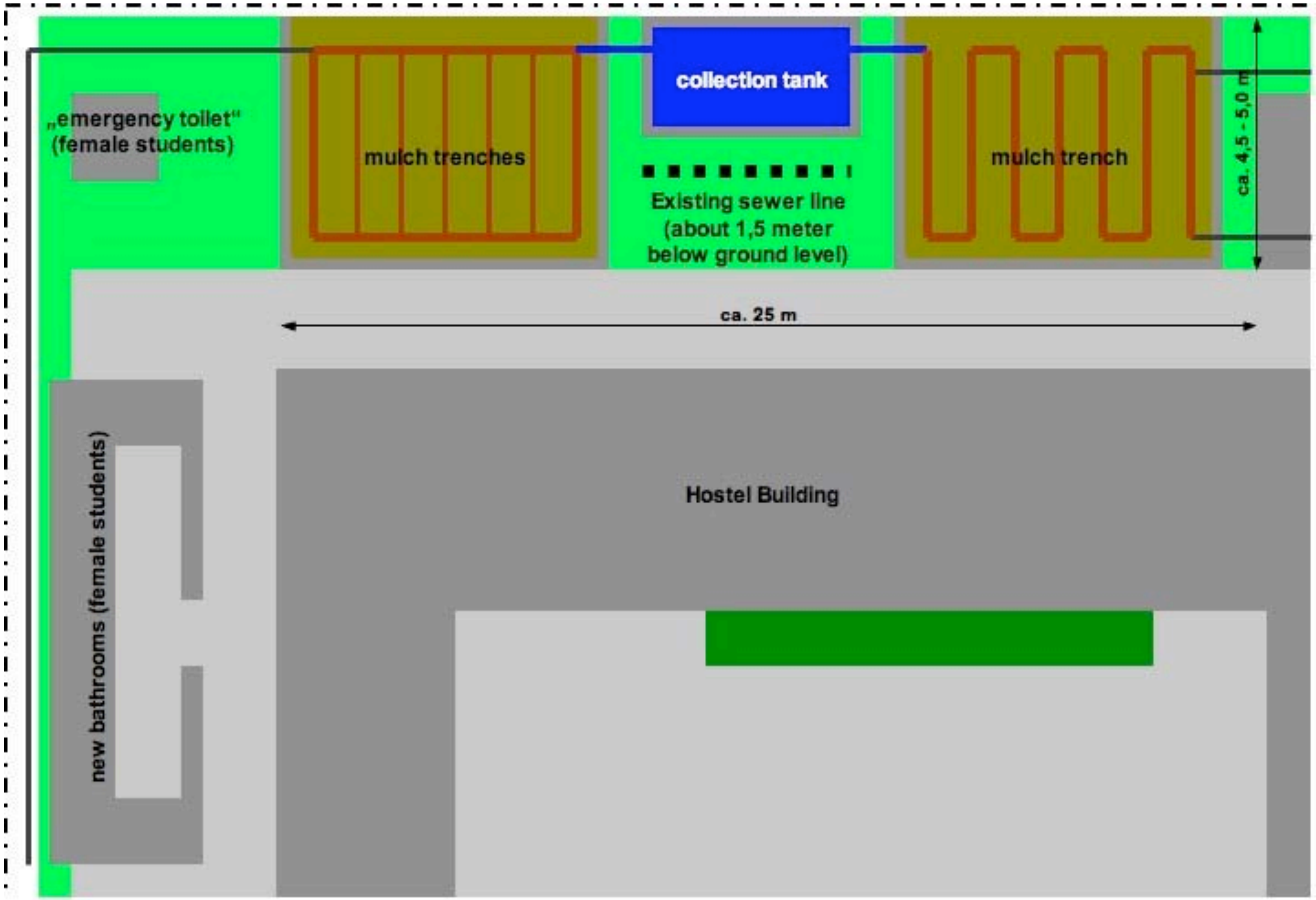


figure 39: Conceptual sketch (top view) of new bathrooms and greywater reuse/treatment facilities at Dalit Shakti Kendra

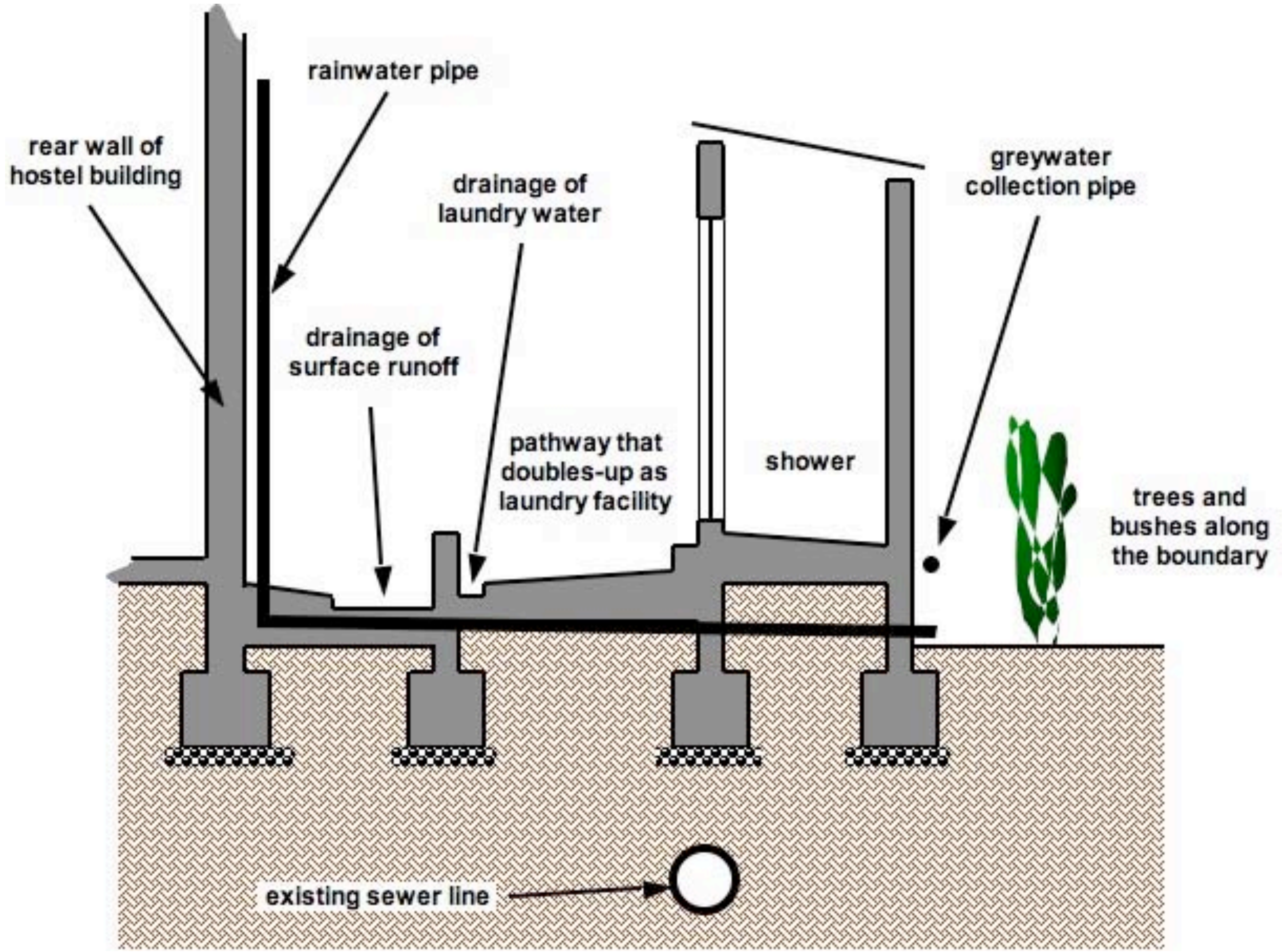


figure 40: Conceptual sketch (cross section) of new bathrooms at Dalit Shakti Kendra

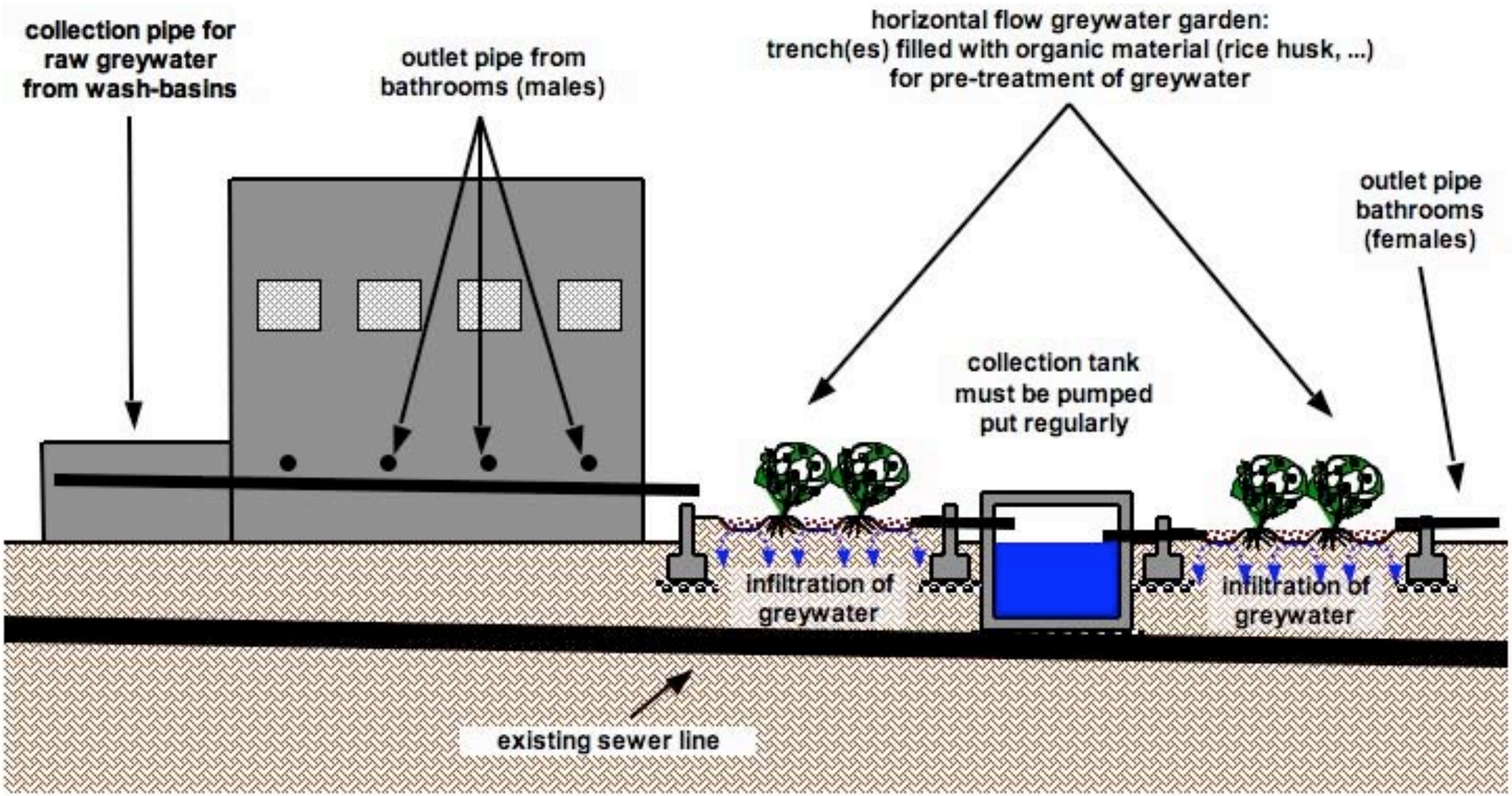


figure 41: Conceptual sketch (longitudinal section) of new bathrooms at Dalit Shakti Kendra

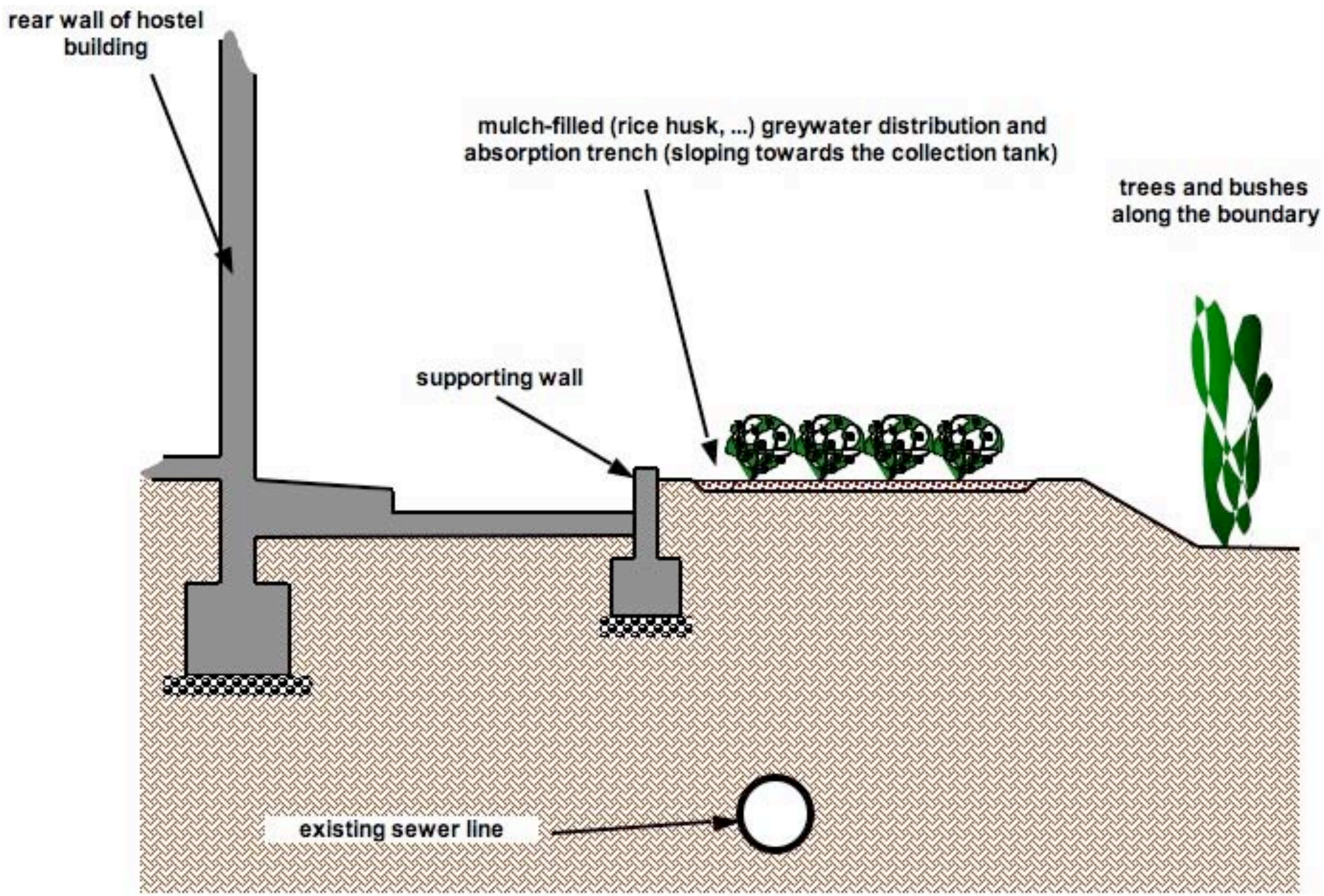


figure 42: Conceptual sketch (cross section) of elevated greywater gardens at Dalit Shakti Kendra

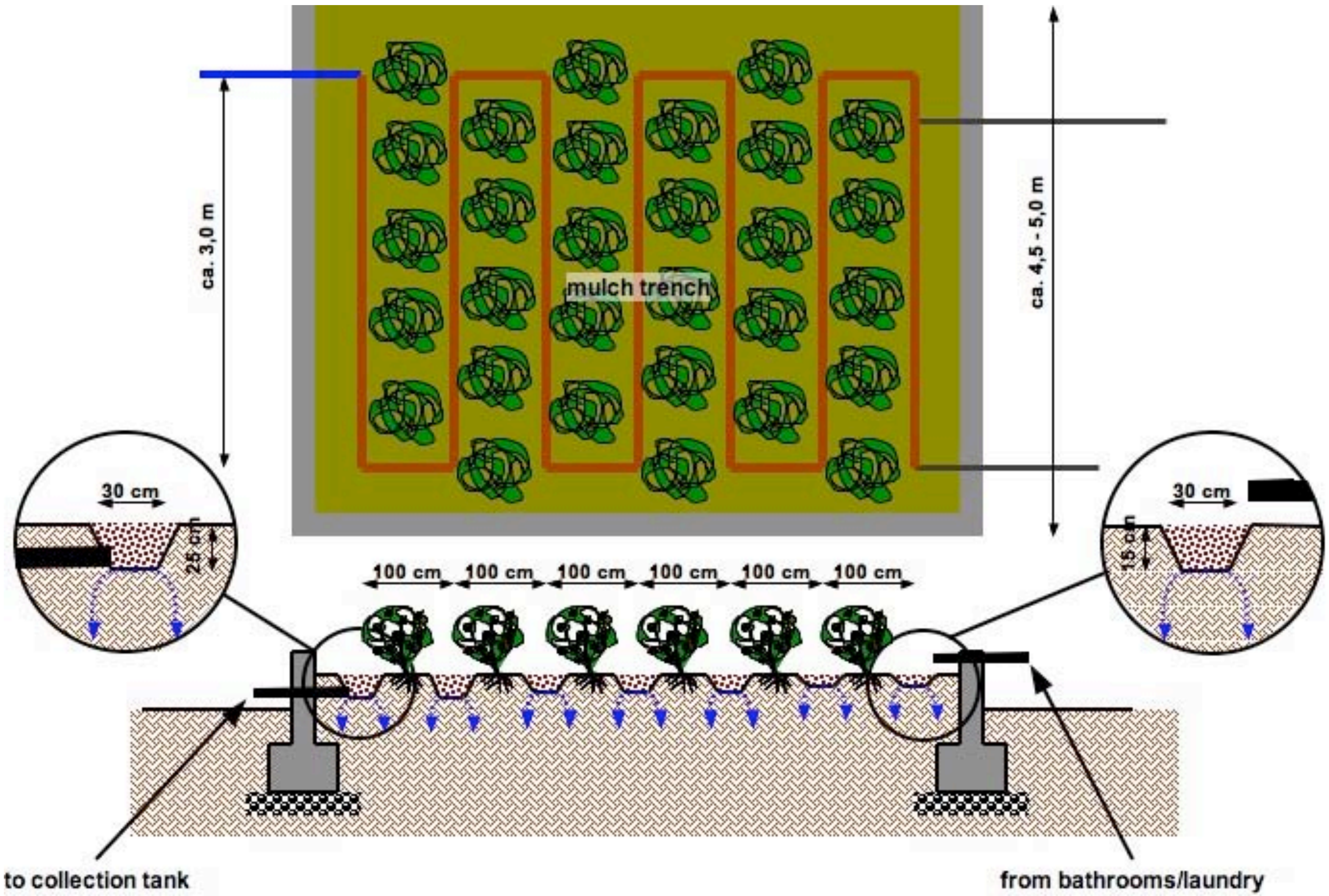


figure 43: Conceptual sketch (top view) of elevated greywater gardens at Dalit Shakti Kendra

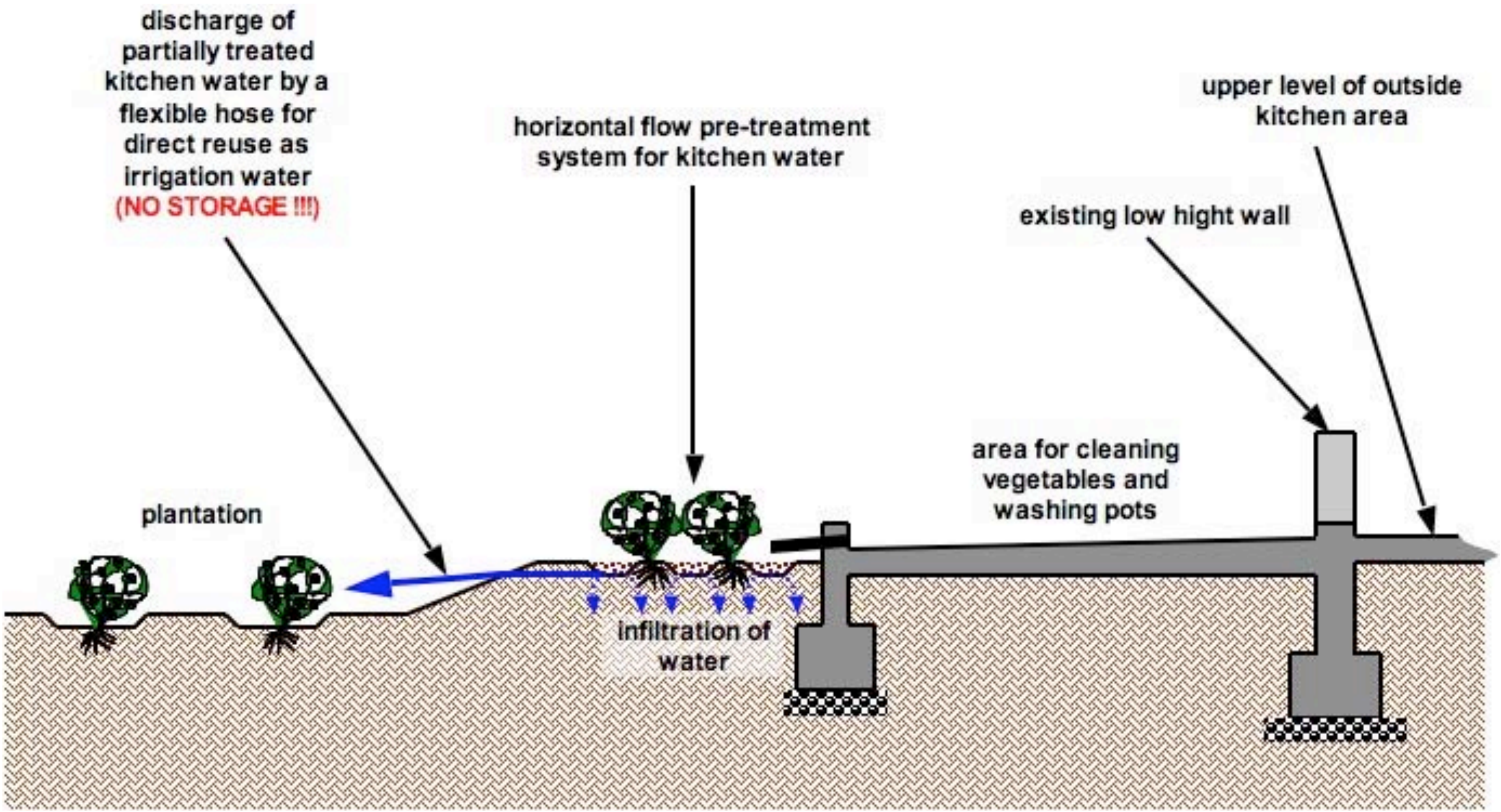


figure 44: Conceptual sketch (cross section) of greywater garden for reuse/tretament of kitchen water at Dalit Shakti Kendra

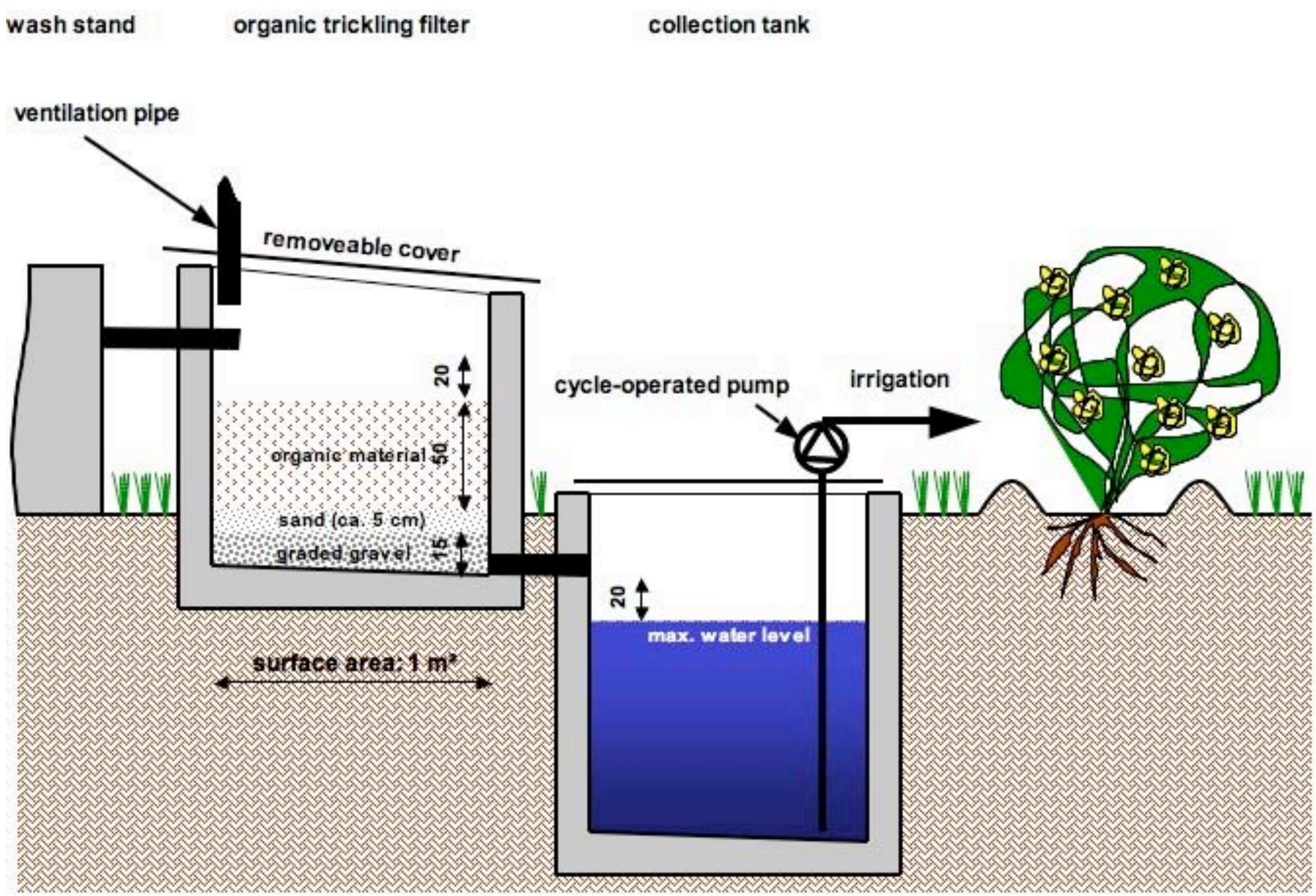


figure 45: Proposed design of vertical flow organic filter for pre-treatment of water spent for washing dishes at Dalit Shakti Kendra

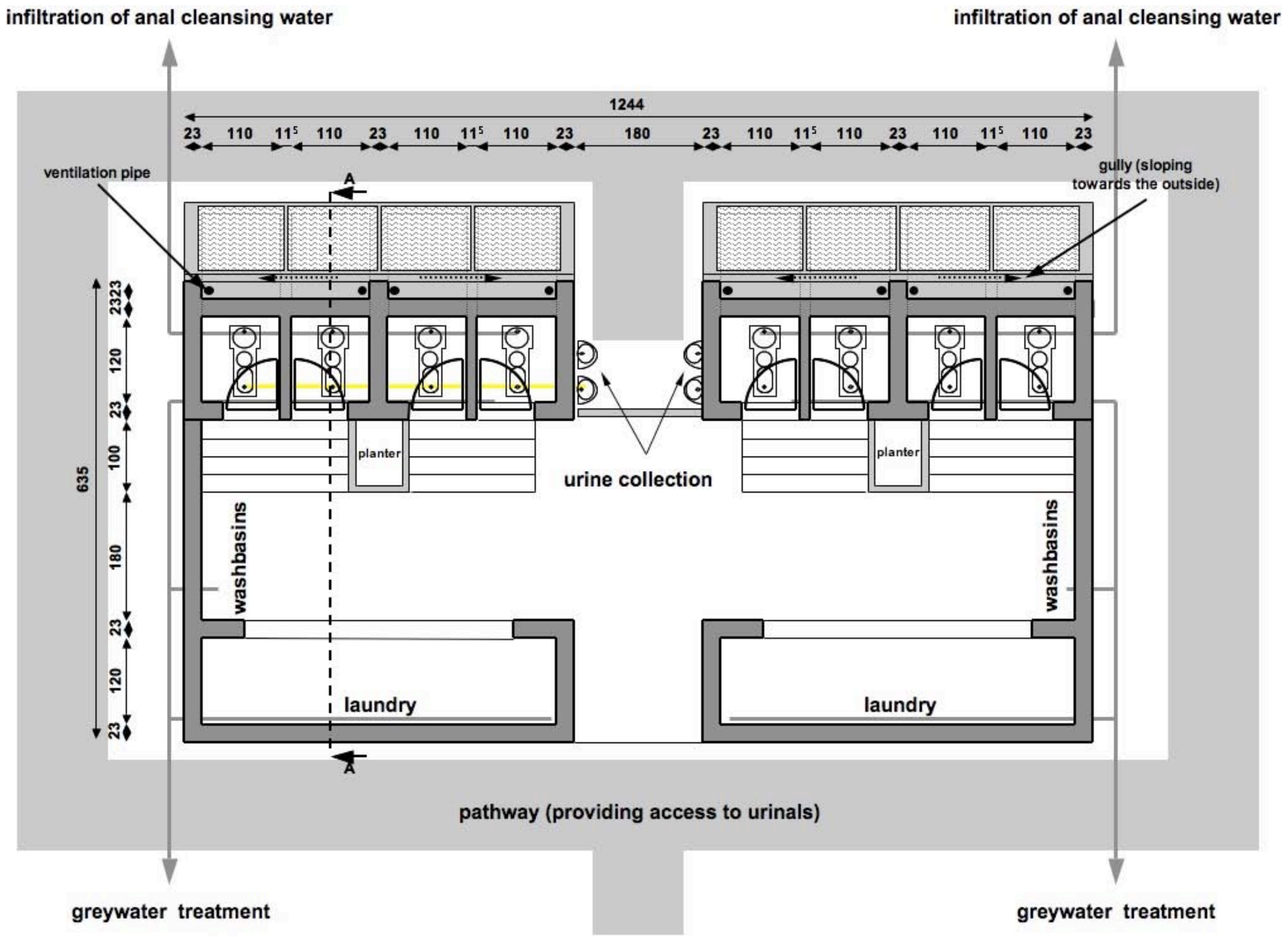


figure 46: Conceptual sketch of Urine-Diversion Dehydration Toilet Centre at Navsarjan Primary Schools (ground plan)

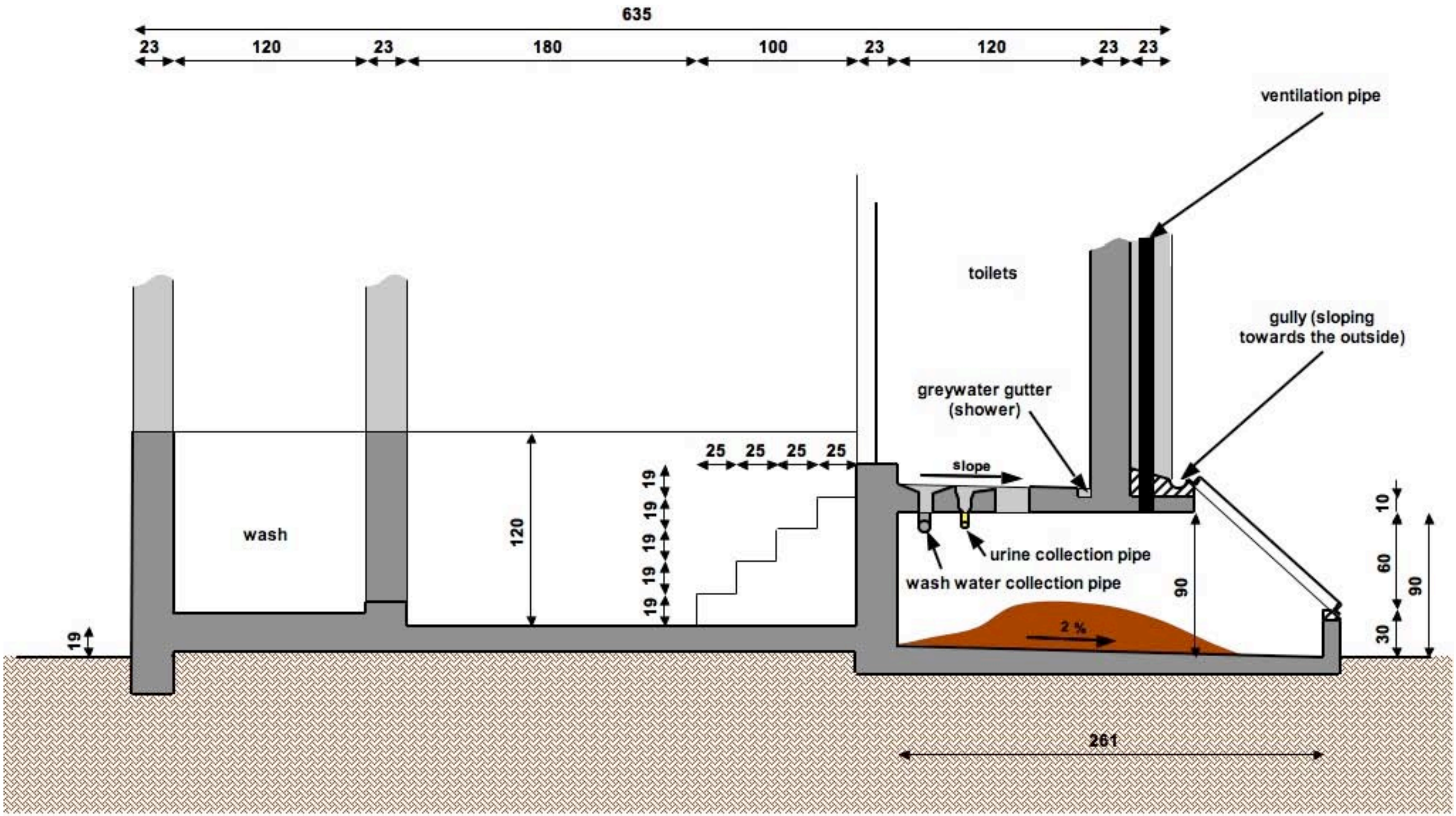


figure 47: Conceptual sketch of Urine-Diversion Dehydration Toilet Centre at Navsarjan Primary Schools (cross section A - A)

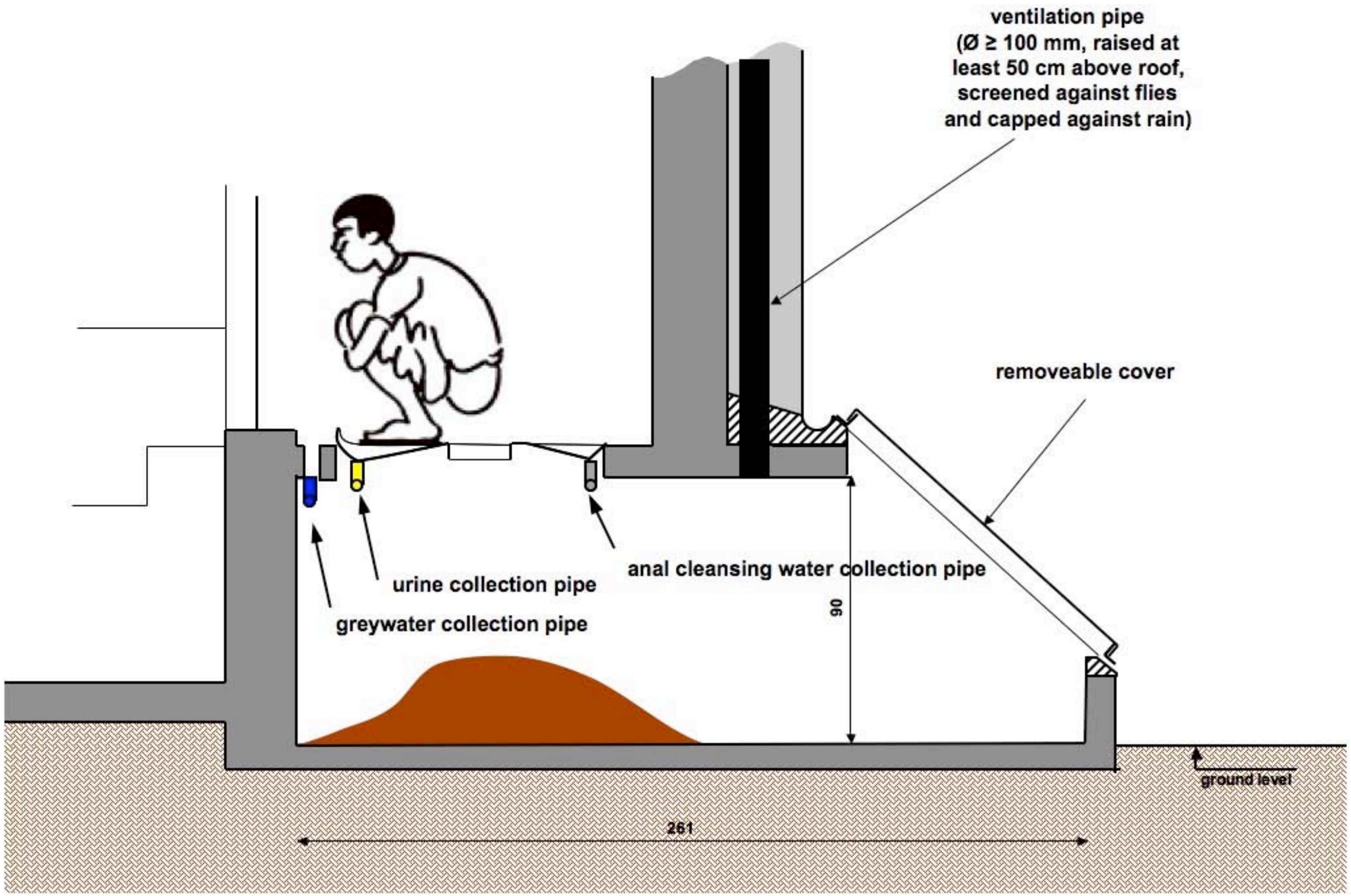


figure 48: Conceptual sketch of Urine-Diversion Dehydration Toilet Centre at Navsarjan Primary Schools (detail processing chamber)

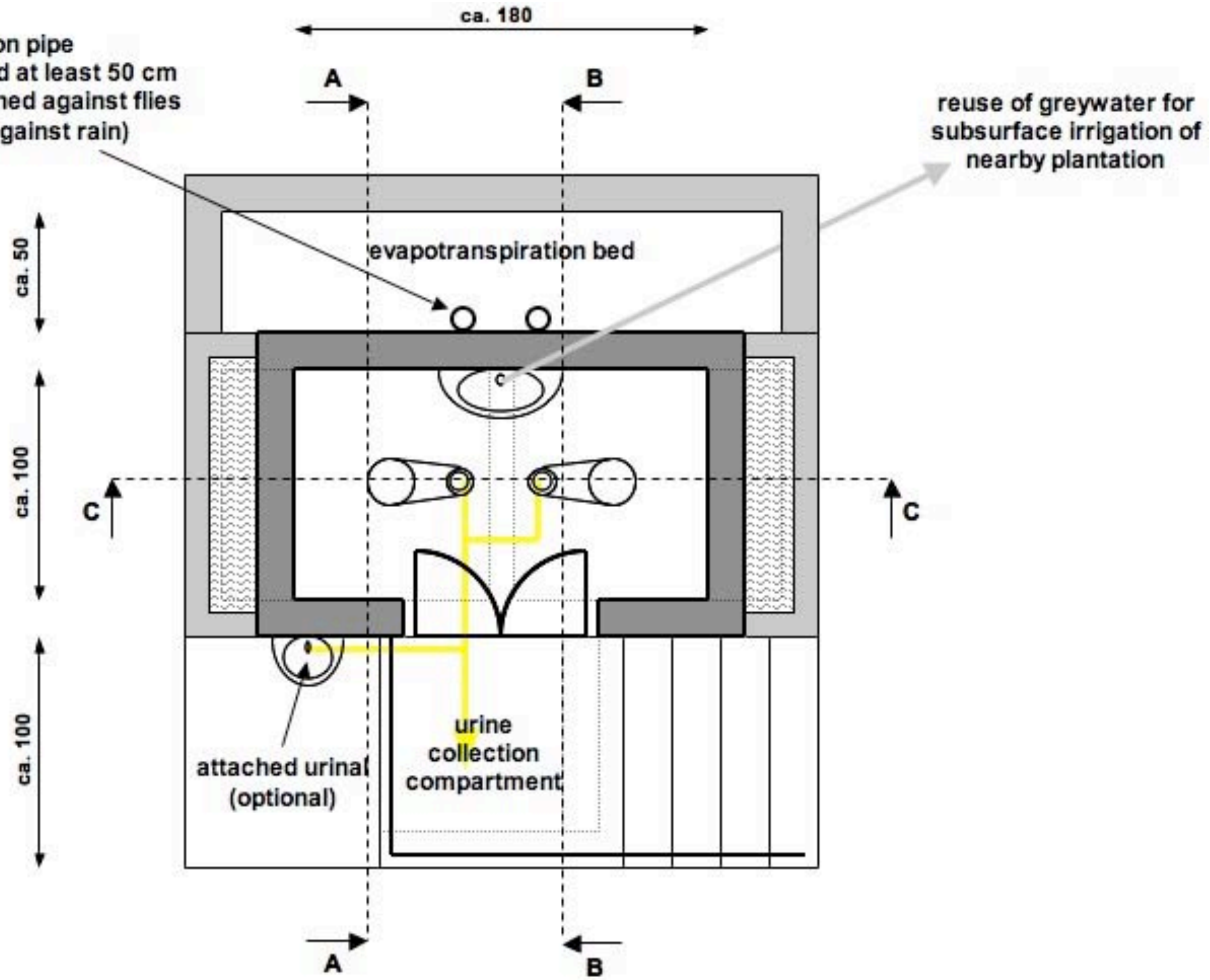


figure 49: Conceptual sketch of Vermicomposting Toilet (ground plan)

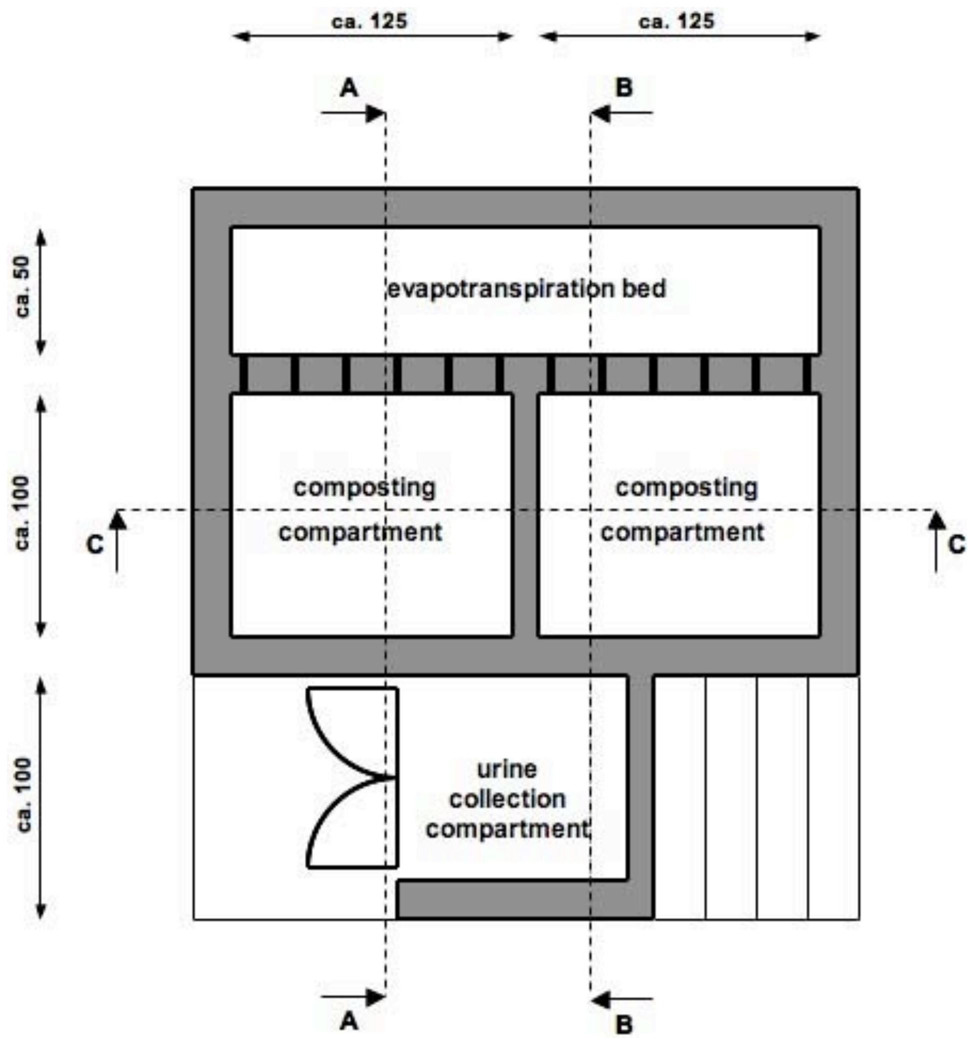


figure 50: Conceptual sketch of Vermicomposting Toilet (horizontal cross section)

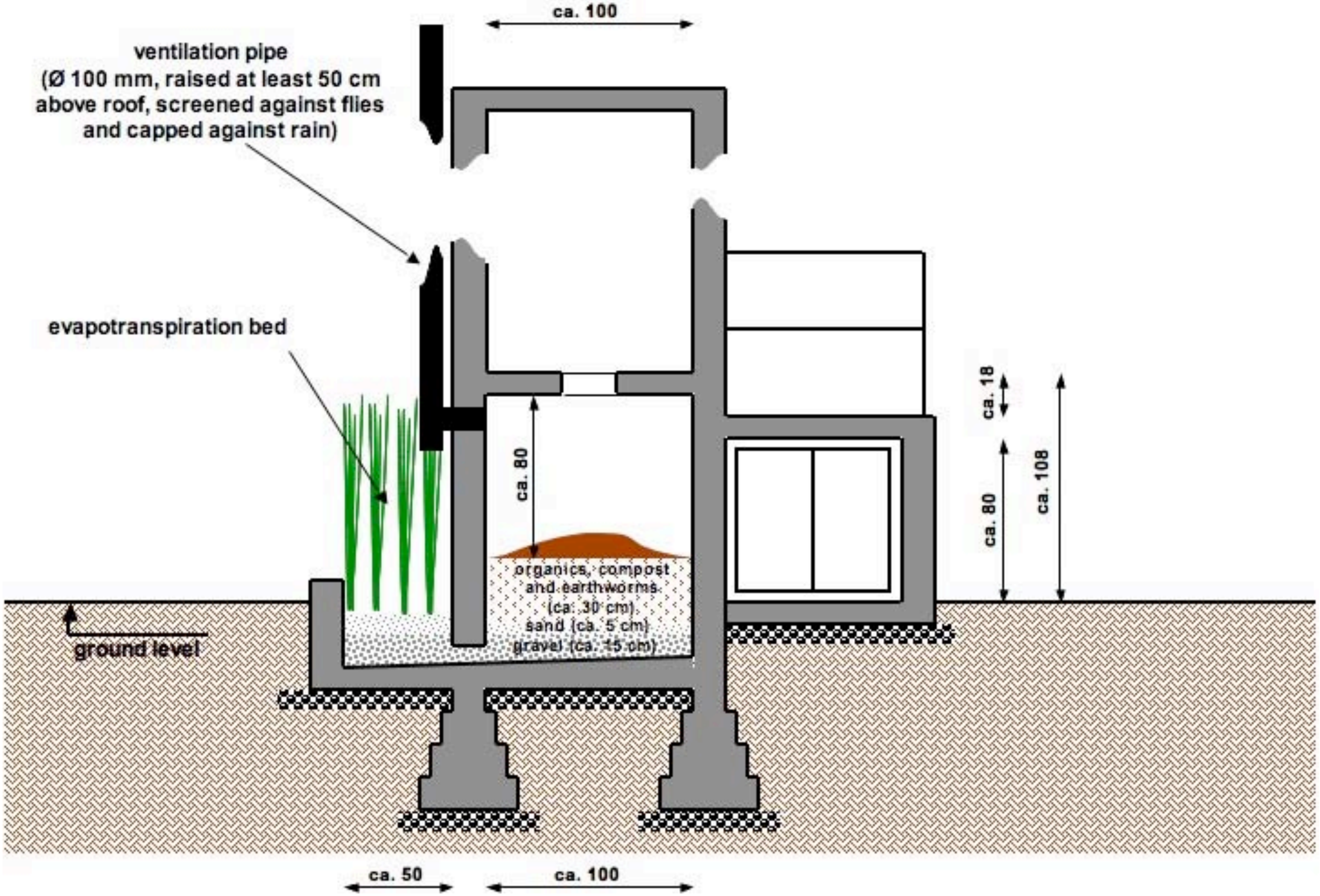


figure 51: Conceptual sketch of Vermicomposting Toilet (cross section A - A)

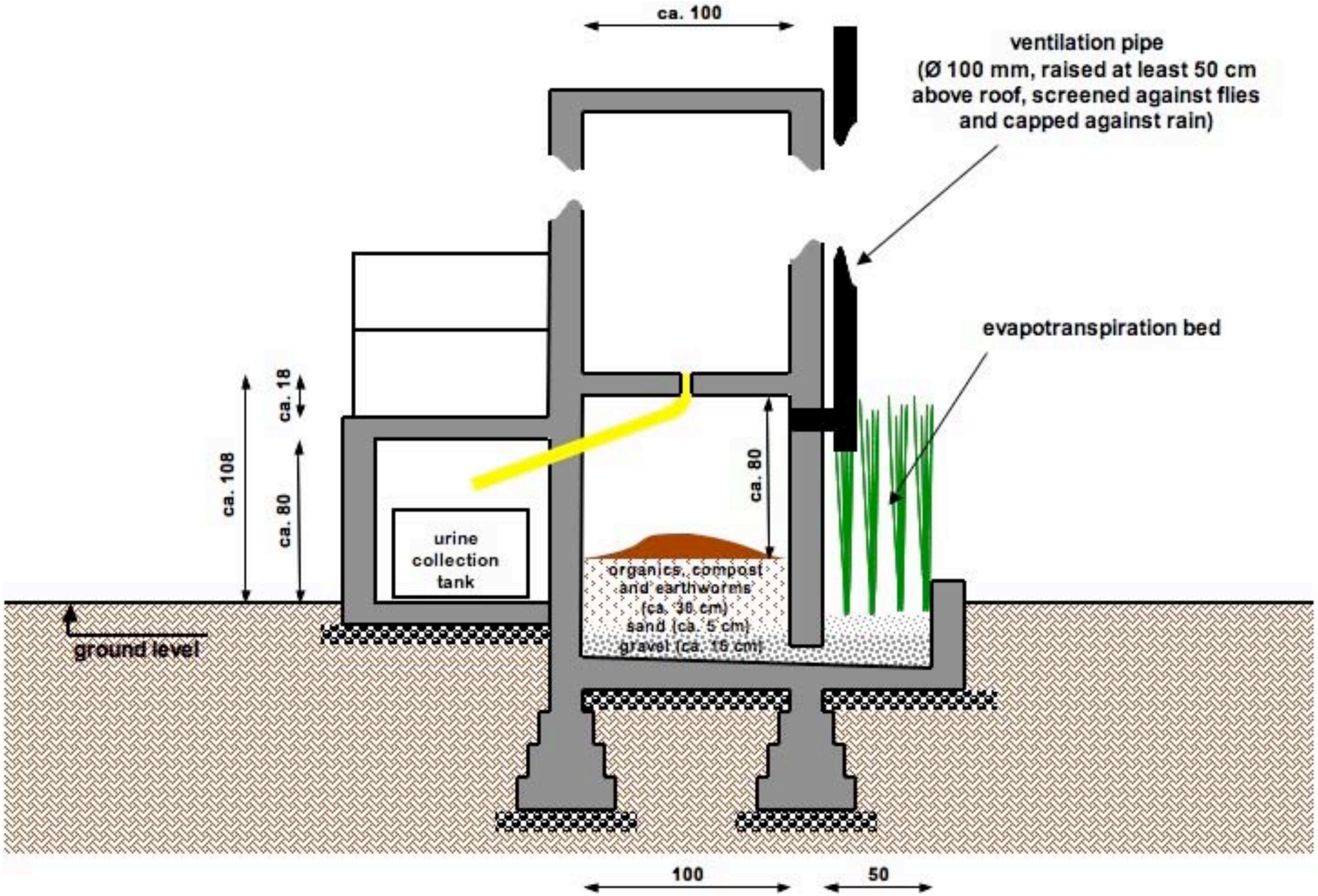


figure 52: Conceptual sketch of Vermicomposting Toilet (cross section B - B)

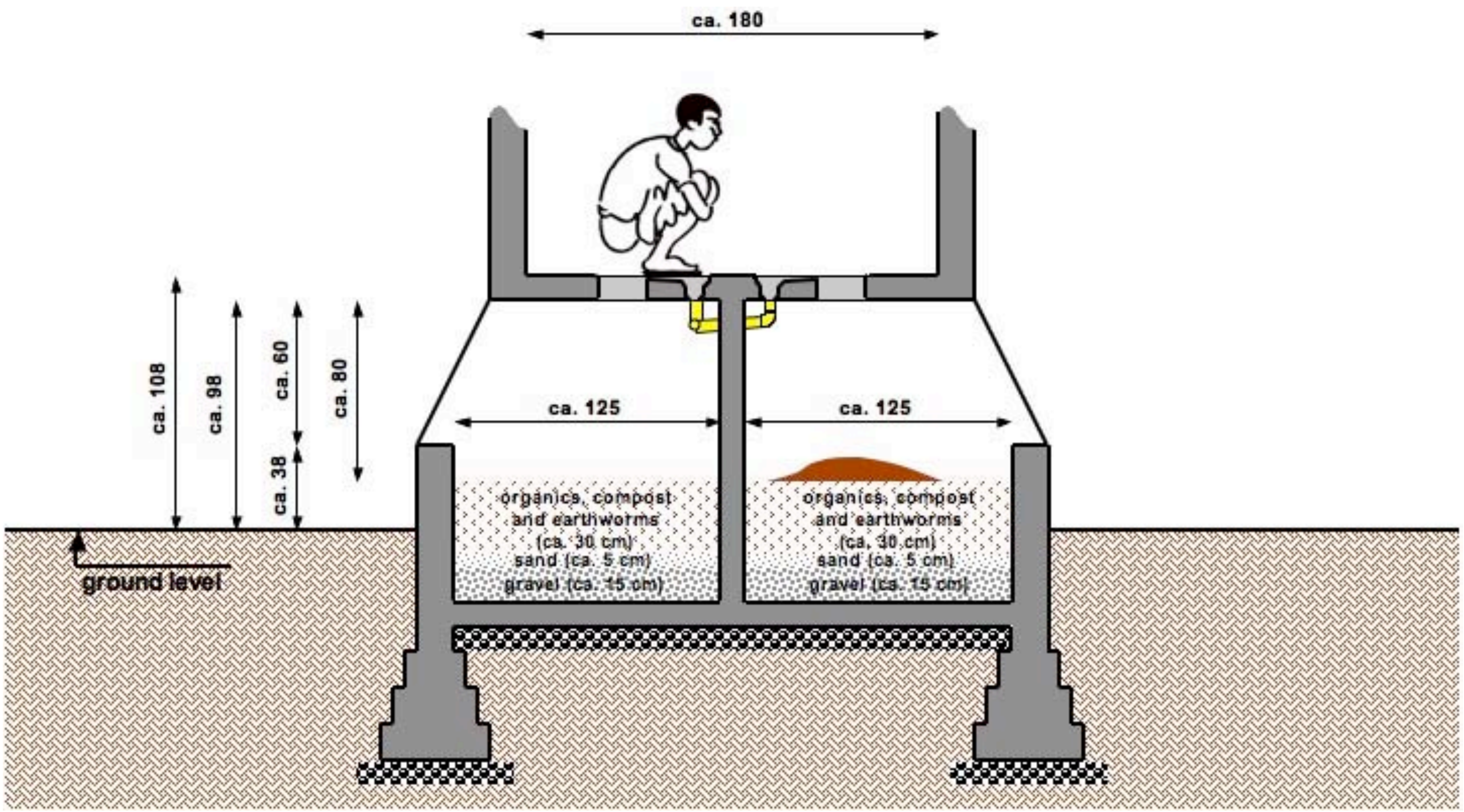


figure 53: Conceptual sketch of Vermicomposting Toilet (cross section C - C)

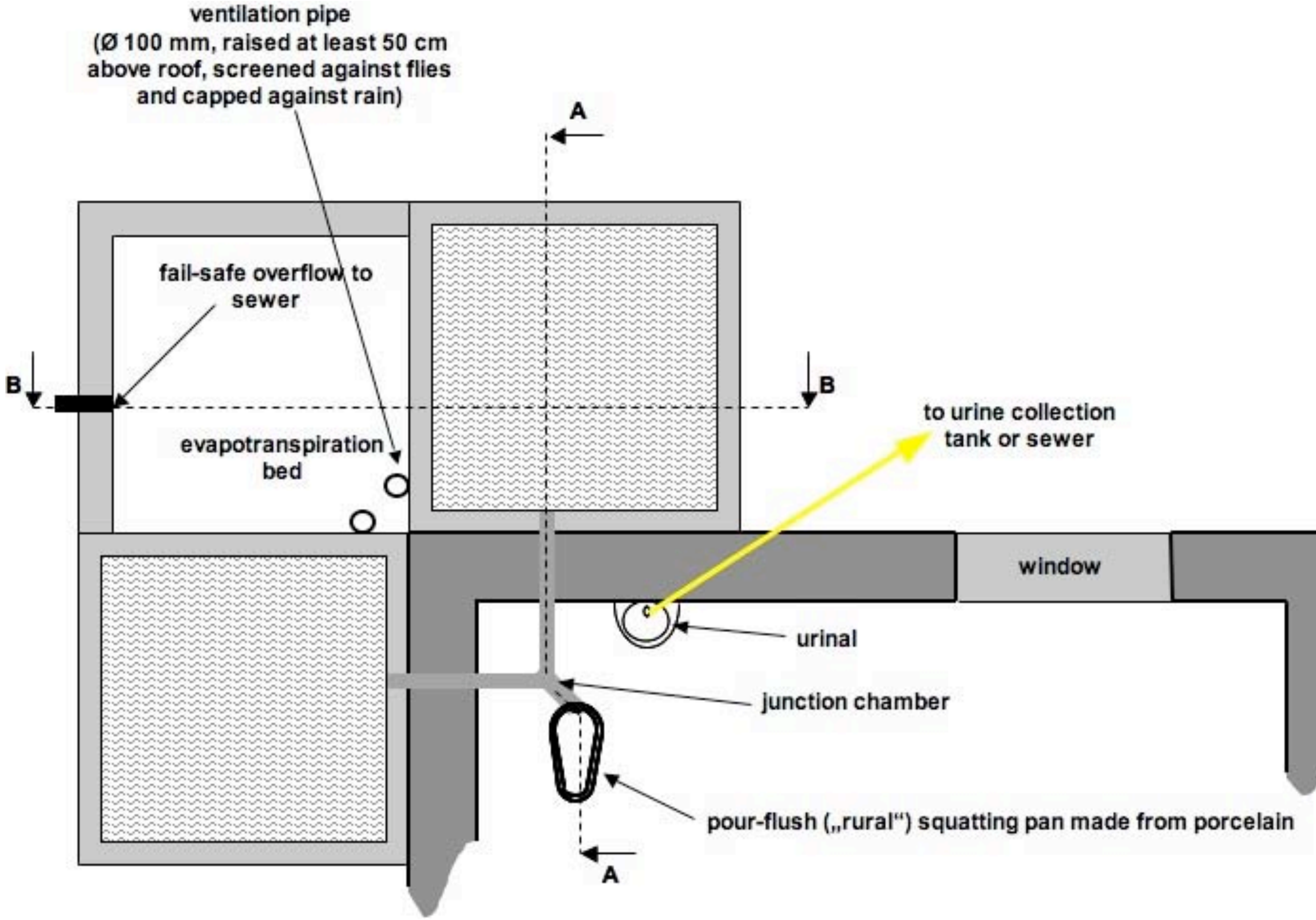


figure 54: Conceptual sketch of Vermicomposting Unit linked to „pour-flush" squatting pan (ground plan)

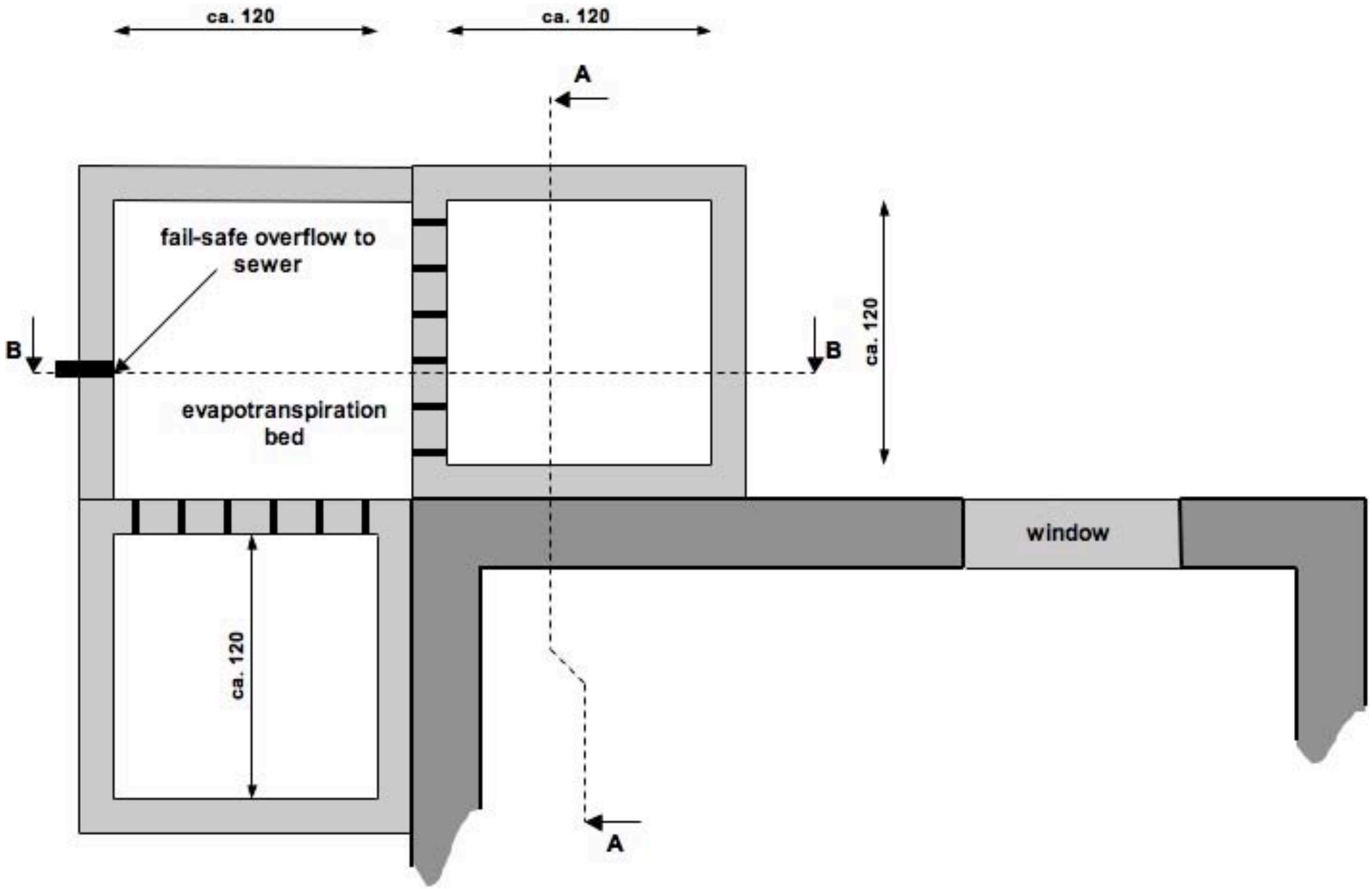


figure 55: Conceptual sketch of Vermicomposting Unit linked to „pour-flush" squatting pan (horizontal cross section)

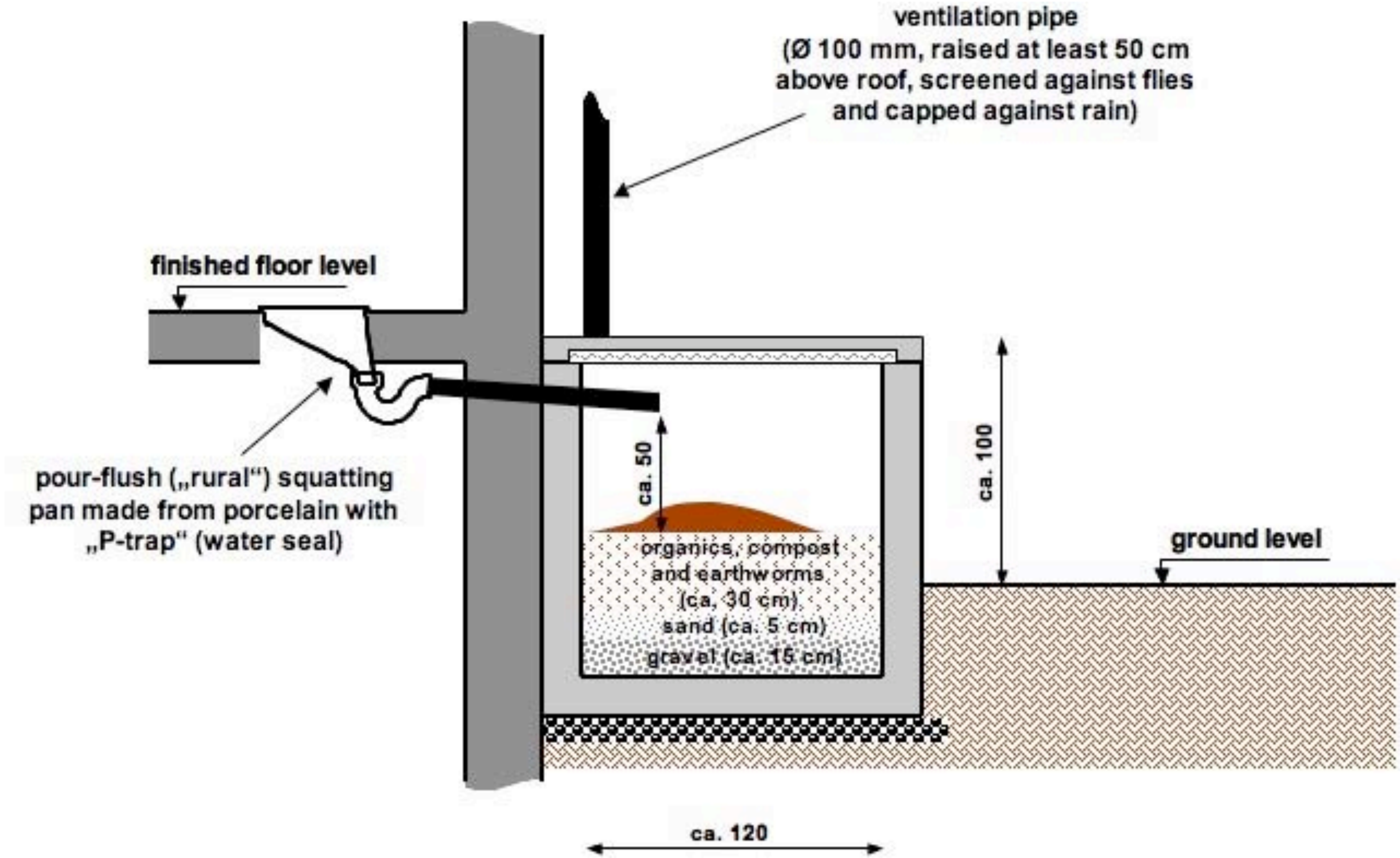


figure 56: Conceptual sketch of Vermicomposting Unit linked to „pour-flush" squatting pan (cross section A - A)

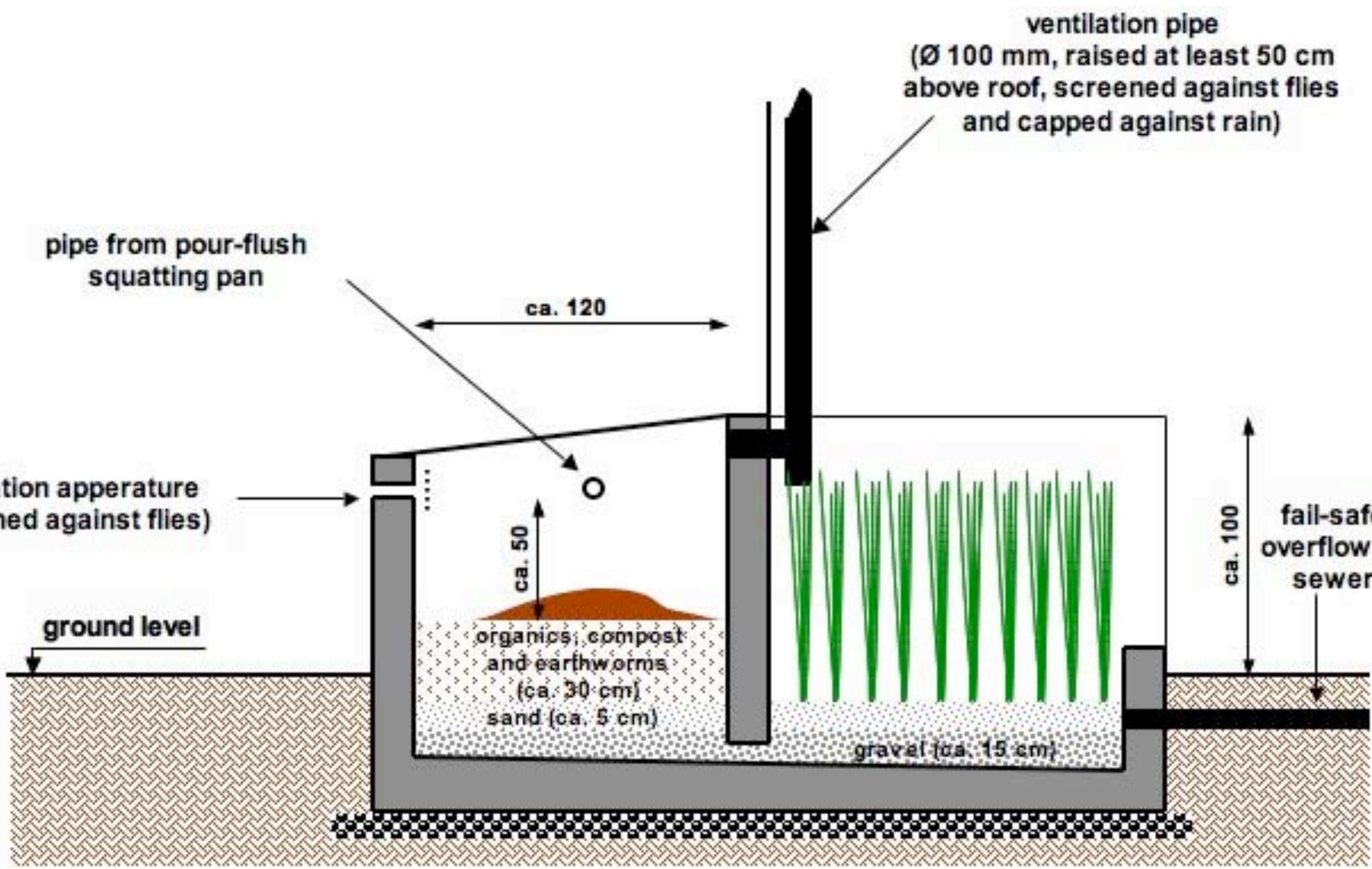


figure 57: Conceptual sketch of Vermicomposting Unit linked to „pour-flush“ squatting pan (cross section B - B)