People. Innovating. Sanitation.

DEWATS implementation by BORDA

BREMEN 2017

List of Funding Partners & Programs

Free Hanseatic City of Bremen

Additionally, different national and local governmental funding lines exist in each region to support BORDAs work.

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The statistical information provided in this brochure is derived from BORDA's Global DEWATS inventory (status 07. 09. 2017).

For further information,
please contact
Dr. Alexander Wolf (wolf@borda.de)
Elli Rodriguez (rodriguez@borda.de)

Layout – Gegenfeuer, Berlin

Implementing partners & agencies

Africa

Lesotho: TED – Technologies for Economic Development
South Africa: eThekwini Water and Sanitation (EWS)
Tanzania: ABContractors, APC/MECPLAN Ltd, BORDA, BORDA/EEPCO, Estim construction co. Ltd, Hassan Swedi, Pioneer Builders Limited, Send Star Company, Shokony, TBA – Construction Brigade
Zambia: WASAZA, Southern Biopower

West and Central Asia

Afghanistan: Ministry of Urban Development and Housing (MUDH), Afghanistan Urban Water Supply and Sewerage Corporation (AUWSSC), Smart World Sanitation Solutions (SW), Ariana Safa Wastewater Engineering Services (ASWES), Agency for Consulting and Training (ACT)
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South Asia

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Southeast Asia

Cambodia: ESC BORDA Cambodia
Indonesia: BaliFokus, BEST, LPTP
Laos: BORDA Laos, LIRE, DHUP
Myanmar: BORDA Myanmar, YCDC, MES, WEG
Philipinnes: BNS Philippines Inc.
Vietnam: BORDA Vietnam, CTIC, VAWR

Past and/or present implementing partners are listed

Wastewater treatment in an urbanizing world

Conventional wastewater treatment has evolved over time and successfully improved public and environmental health. However, technologies are expensive, resource intensive and often require high technical capacities with regards to urban planning, construction and operation & maintenance (O&M).
With the adoption of the Sustainable Development Goals (SDGs) the world's nations have committed to the urgency for alternative wastewater treatment solutions* that better fit with local needs and currently existing capacities. It is not simply about replacing existing with alternative technologies but to stimulate and rethink the water & sanitation sector by considering the entire sanitation service chain including its governance. Future wastewater treatment solutions need to be more resource efficient; mainly by reducing water use (qualitative as well as quantitative), recycling of nutrients and the production of renewable energy. Cross-sectoral embedment, specifically into urban planning process and the water-energy-food nexus, is required.
BORDA's motivation is not to promote any particular kind of technology but to bring forward a new philosophy of dealing with wastewater, taking into account the rapid urbanization in many cities around the world.
Large, conventional wastewater treatment systems – although in need of improved effectiveness and efficiency – will remain indispensable. Likewise, decentralised, semi-centralised and non-sewered sanitation approaches have proven highly flexible and easily adaptable to local conditions. Decentralized sanitation solutions can help minimize water pollution and allow water reuse to the maximum possible extent (irrigation, groundwater recharge, direct reuse). Without recognizing and making use of this complementarity, neither the SDGs nor the chartered human right to sanitation will be achieved.

DEWATS Principles**
Decentralised Wastewater Treatment Solutions (DEWATS) are based on the principles of decentralization, simplicity and reuse of the treatment products. Simplicity is achieved through on-site treatment without chemicals or electro-chemical equipment/energy input, and by low maintenance requirements. Necessary maintenance activities can be carried out by service providers or by supervised and trained maintenance personnel on-site. There are three main treatment steps & modules, which are combined and customised according to specific local conditions:

- **Primary treatment**
  (Sedimentation)
  Settler and/or Biogas digester

- **Secondary treatment**
  (Biological processes)
  Anaerobic Baffled Reactor – ABR,
  Anaerobic Filter – AF,
  Horizontal/Vertical Gravel Filter – HGF/VGF

- **Advanced secondary treatment options**

DEWATS can treat both domestic and organic industrial wastewater and are reliable, long lasting and tolerant towards inflow fluctuations. DEWATS can be tailored to treat wastewater flows from 1 to 1500 m^3 per day and are designed to meet the requirements stipulated by country-specific environmental laws and regulations.

* SDG target 6.3: "By 2030, [...] halving the proportion of untreated wastewater [...]". Suggested indicator listed as per IAEG-SDGs: "Percentage of wastewater safely treated"

** In this publication, the term DEWATS is used to refer to decentralized wastewater treatment systems following the principles as layed out above.

Treatment modules fulfilling the DEWATS principles

Primary treatment

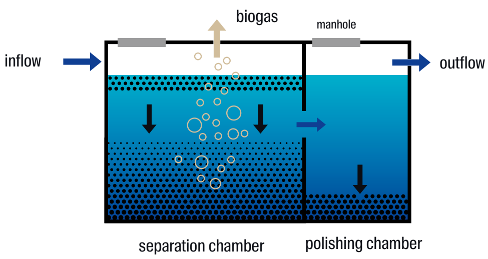
Sedimentation

Secondary treatment

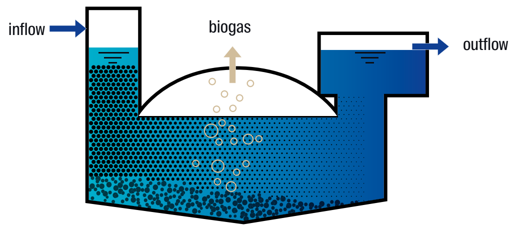
Anaerobic digestion

Aerobic and facultative decomposition

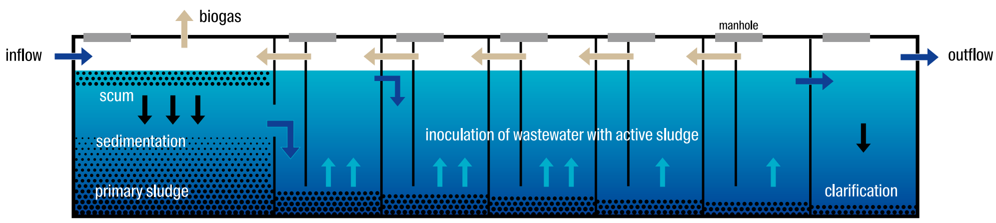
Advanced Secondary treatment



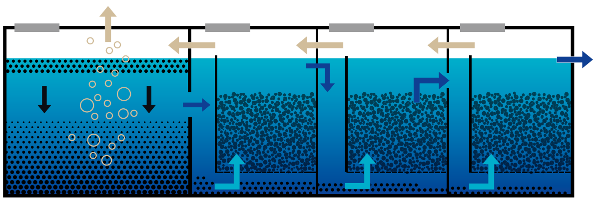
Settler



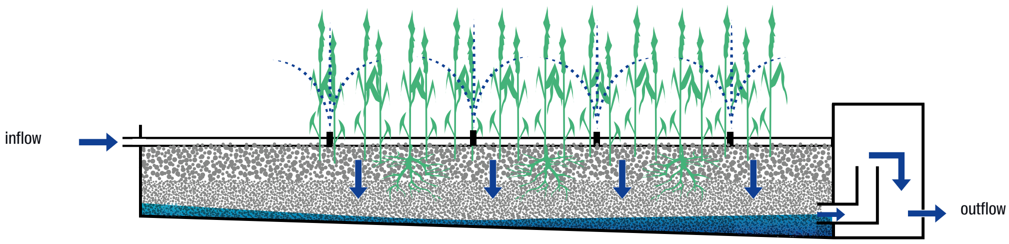
Biogas digester (BGD)



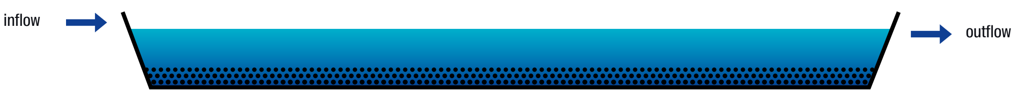
Anaerobic Baffled Reactor (ABR)



Anaerobic Filter (AF)

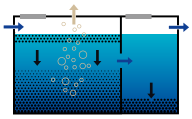


Horizontal (or vertical) Gravel Filter (HGF/VGF)



Polishing Pond (exemplary)

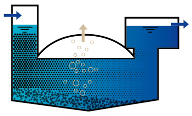
Various combinations of above mentioned treatment modules are possible and widely used.
Details on BORDA's most commonly implemented modules are displayed on pages 13–14



Settler

A settler, or septic tank, consists of a minimum of two, sometimes three compartments. Most scum and sludge is retained in the first chamber, where the settled sludge is stabilised by anaerobic sludge digestion. The second chamber contains only little sludge which allows the water to flow without disturbance from rising gas bubbles.

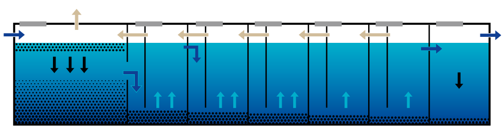
Two treatment principles, namely the mechanical treatment by sedimentation and the biological treatment (sludge digestion) by contact between fresh wastewater and active sludge, are taking place. Optimal sedimentation takes place when the flow is smooth and undisturbed. Biological treatment is optimised by quick and intensive contact between new inflow and old sludge. How the influent enters and flows through the settler decides which treatment principle predominates.



Biogas digester (BGD)

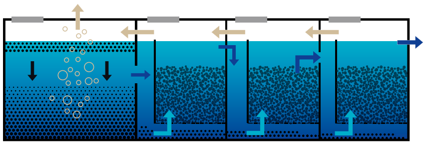
DEWATS allow the valuation and utilization of biogas, especially in combination with concentrated wastewaters streams. To become economically viable, biogas should be used regularly and purposefully directly at site. By using BGDs, approximately 200 l of biogas can be recovered from 1 kg of COD removed. On household level, this requires 2 to 3 m^3 of biogas per day for cooking, meaning 20 m^3 wastewater with BOD of not less than 1000 mg/l is required to serve one kitchen. In order to get strong substrate from domestic wastewater, flow stream separation from toilets and less concentrated greywater are recommended.

Biogas plants are designed as half-ball shape, made by bricks and integrated into the ground. Incoming wastewater is separated into liquid and solid phases and organic solids biologically digested. Processes take place without oxygen input under anaerobic condition, generating biogas useful for cooking, light and heating.



Anaerobic Baffled Reactor (ABR)

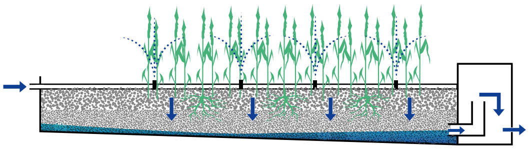
The baffled reactor consists of a series of chambers in which the wastewater flows up-stream. Suspended and dissolved solids in the pre-settled wastewater undergo anaerobic degradation. The activated sludge settles down at the bottom of each chamber and the influent wastewater is forced to flow through this sludge blanket where anaerobic bacteria make use of the pollutants for their metabolism. Progressive decomposition occurs in the successive chambers. A part of the last chambers can optionally be filled up with coarse filter material like stones, cinder or plastic rings. The filter material acts as carrier material for an attached bio-film consuming the organic water pollutants. That kind of reactor is called combined ABR. In ABR plants the BOD reduction rate is up to 90% and the pathogen reduction ranges between 40–75%. The baffled reactor is resistant to shock load and variable inflow. It operates by gravity and maintenance is reduced to desludging of the chambers at intervals of 1–2 years. Sub-soil construction of the module saves space.



Anaerobic Filter (AF)

The anaerobic filter, also known as fixed-bed or fixed-film reactor, includes the treatment of non-settleable and dissolved solids by bringing them into close contact with a surplus of active microbial mass. “Hungy” micro-organisms digest the dispersed or dissolved organic matter within a short retention time.

Most of the micro-organisms are immobile; they attach themselves to solid particles or, for example, the reactor walls. Filter material, such as gravel, rocks, cinder or specially formed plastic shapes, provide additional surface area for them to settle. By forcing the fresh wastewater to flow through this material, intensive contact with active micro-organisms is established; the larger the surface for microbial growth, the quicker the digestion.



Horizontal Gravel Filter (HGF)

Horizontal Gravel Filters are suitable for wastewater with a low percentage of suspended solids that have already been removed by pre-treatment. The main removal or treatment mechanisms are biological conversion, physical filtration and chemical adsorption. In case of HGFs, the bottom slope is 1% and the flow direction is mainly horizontal.

The horizontal filter is permanently soaked with water and operates partly aerobic, partly anoxic and partly anaerobic. HGF combine physical-filtration processes and the influence of plantation (Planted Horizontal Gravel Filter) on the biological-treatment process and oxygen intake. BOD reduction rate is between 75–90% and pathogen removal is over 95%. The operation and maintenance requirements are considered simple.

* **Preliminary treatment** of wastewater by means of grease traps or screens do require additional maintenance but have proven valuable for specific conditions. Detailed information can be found here: Decentralised Wastewater Treatment Systems (DEWATS) and Sanitation in Developing Countries. A Practical Guide (2009). Ulrich, A. (Ed.), Reuter, S. (Ed.), Gutterer, B. (Ed.), Sasse, L., Panzerbieter, T. and Reckerzügel, T. (2009). WEDC, Loughborough University, Leicestershire, UK.

** **Advanced secondary treatment** modules are not described in further detail here, as their selection and integration varies greatly according to context-specific space and cost requirements as well as local effluent discharge standards.

Statistics on BORDA's DEWATS implementation 1989 – 2017

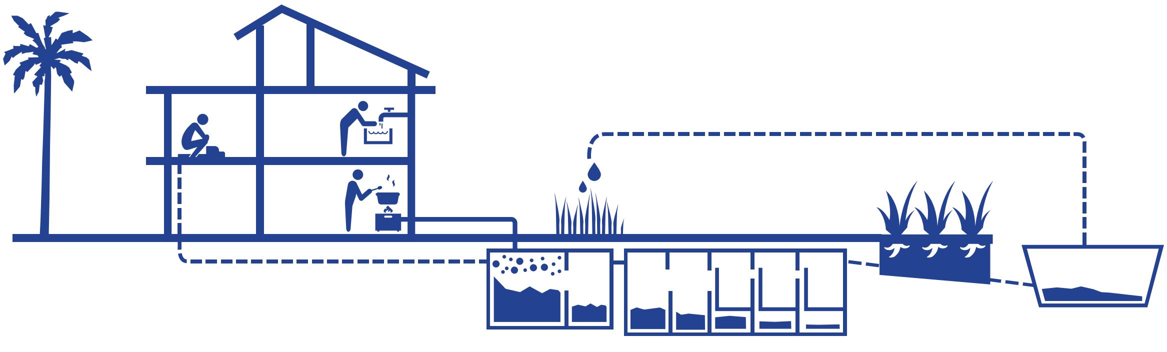
BORDA started designing and implementing DEWATS in 1989 with partners from France, India and China. Since then, BORDA, together with its international "Basic Needs Services" network have implemented more than 3,000 systems worldwide.

The vast majority of them are documented in BORDA's Global DEWATS Inventory. All systems included are designed, constructed and/or supervised – i. e. their implementation facilitated – by BORDA in cooperation with its partners since 1989.
While system hardware (brick, mortar, concrete, etc.) has – and still is – generally financed by local project owners (governmental and private institutions as well as end users), design and implementation of the systems' approach would not have been possible without the financial support of numerous international /ODA financing partners.
The statistics introduced with this publication relate to 2756 DEWATS. Those for which implementation or commissioning is in progress, or, where partners or system owners do not allow public access, have been excluded.

All data, including key design values and parameters, are derived from regional project documentation (DEDs – Detailed Engineering Designs, Feasibility Studies, Community Action Plans, etc.).
A geographical visualization of BORDA's DEWATS is made available via a 'mWater', the IT platform for BORDA's internal M&E Program on DEWATS. mWater is a global and sector-oriented knowledge sharing platform, used by key stakeholders within the water & sanitation sector and beyond.

A map for public display is available here:
https://tinyurl.com/borda-dewats-map

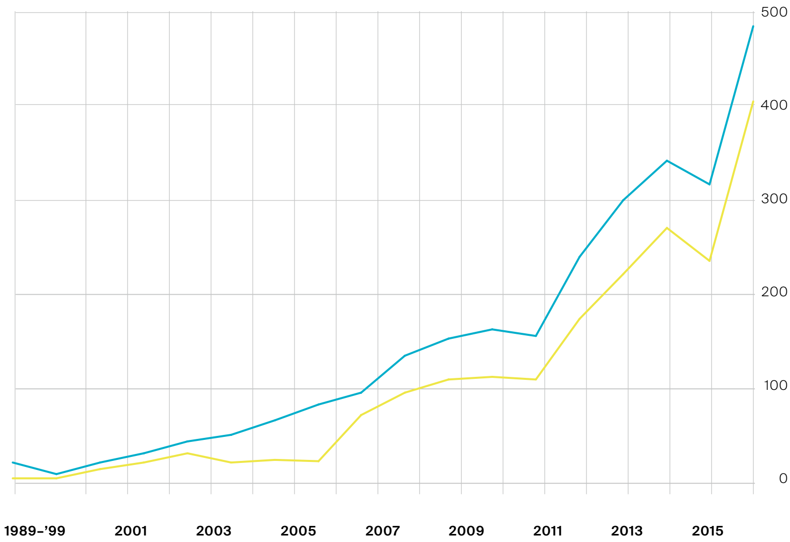
Individual site information (key project information and design parameters) can be extracted for each displayed system. Exact geographic locations and GPS coordinates are not displayed in order to adhere to BORDA's privacy standards in an effort to protect local stakeholder from "science tourism".



Implemented DEWATS per year

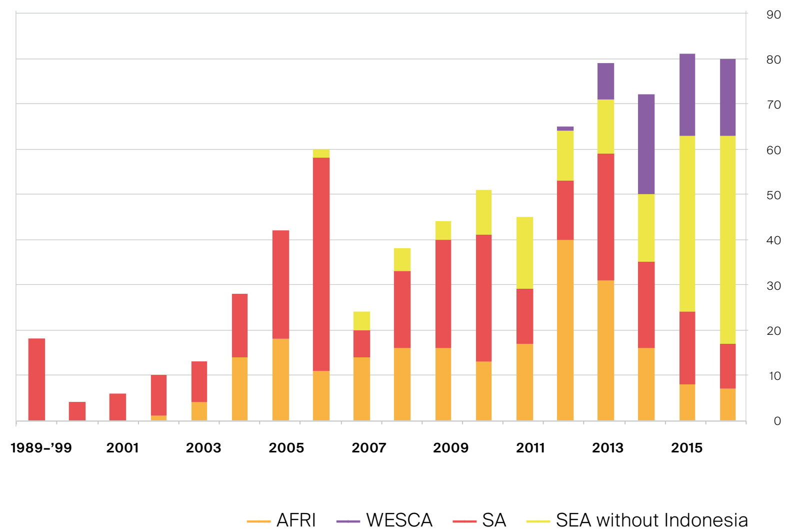
The total number of implementations by BORDA and partners steadily increased over the last decades. With regard to Indonesia, scaling-up DEWATS on national level has been proven achievable. Here, our CBS approach (Community Based Sanitation) became a major success and is firmly embedded in the national SANIMAS ("Sanitation by Communities") program. SANIMAS was jointly initiated by the inter-ministerial Water and Environmental Sanitation Working Group, chaired by the Ministry of National Development Planning (Bappenas), the World Bank's Water & Sanitation Program (WSP), BORDA and its Indonesian partner organizations.

DEWATS per year globally and in Indonesia



Importantly, BORDA's primary role is that of a technical facilitator & process consultant rather than an implementing agency only. BORDA is also active on multiple political levels; engaged in advocacy on the national level as well as in hands-on cooperation on municipal level. In this context, BORDA's work on the ground is to develop innovative strategies and to facilitate the management of urban waters, waste, livable spaces and local development – work that starts off in municipalities. Therefore, DEWATS implementations are the means to showcase and mainstream sustainable alternatives for the development of the water and sanitation sector.
By the adoption of the SDGs, the Paris Declaration and the formulation of the New Urban Agenda, BORDA's longstanding vision of close cooperation with municipalities to foster city-wide and inclusive urban planning processes, to accelerate global scaling up, is finally embedded in the global agenda.

DEWATS per year per region (without Indonesia)*



* Excluded from regional comparison is the region Las Américas in which BORDA has started working only recently. Currently one DEWATS is operational in Nicaragua, treating the wastewater from a slaughterhouse.

Impact

One million people served

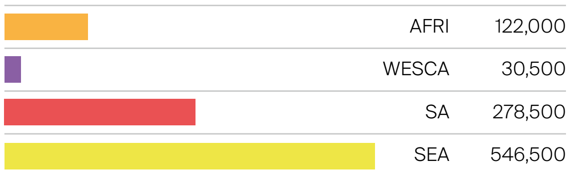
By providing access to clean water and sanitation services, BORDA's mission is to improve the living conditions of communities while maintaining or improving environmental health.

DEWATS implementation has had a great impact on the lives of many people. Over the last three decades one million people have gained access to sanitation services.

Categories* per country

At BORDA, DEWATS are designed for and can be categorized according to different project types and therefore, user categories (e.g. for people and/or animals, students, hospital beds, market stalls, etc).

People served*



* This graph includes the user categries people and students. At the time of publication, 6% of global and 25% of SA data on user type and units served was unavailable.

	People	Students	Hospital beds	Hotel beds	Animals	Market stalls
Lesotho	2,487	1,211	115	0	170	0
South Africa	462	0	0	0	0	0
Tanzania	33,172	2,865	1,571	164	0	0
Zambia	80,543	1,380	214	0	1,735	0
Afghanistan	22,120	5,554	260	0	155	0
Iraq	652	2,020	0	0	724	0
India	176,394	14,380	650	287	0	0
Cambodia	1,054	24,706	0	0	6,660	250
Indonesia	487,395	200	6,003	58	1,753	20
Laos	5,590	213	50	0	0	0
Myanmar	0	850	0	0	0	0
Philippines	3,559	6,688	490	0	2,458	1,288
Vietnam	15,362	1,052	588	0	2,620	0
Total	915,515	62,112	9,941	509	16,275	1,558

* Additionally in the food industry, 32 DEWATS treat food production wastewater for up to 31,500 kg tofu/per day. At the time of publication, 55% of data from Nepal, 80% of data from Pakistan and 100% of data from Bangladesh on user type was unavailable. Therefore, values for Nepal, Pakistan and Bangladesh are not included in the table.

57,000 m³ wastewater treated daily

Wastewater treated by DEWATS is domestic wastewater from private homes, community sanitation centres, schools, hotels and hospitals as well as organic wastewater from SME, such as slaughterhouses, animal husbandry, market stalls, food production, and other industries.

Wastewater treatment capacity [m³/day]*

AFRI	1000
WESCA	2,000
SA	18,500
SEA	35,500

* At the time of publication, 4% of global and 19% of SA data on hydraulic load was unavailable.

Wastewater treatment capacity per country [m³/day]*

Lesotho	275
South Africa	42
Tanzania	250
Zambia	374
Afghanistan	1,938
Iraq	96
Bangladesh	149
India	11,178
Cambodia	430
Indonesia	31,919
Laos	468
Myanmar	7
Philippines	1,720
Vietnam	1,136

* At the time of publication, 49% of data from Nepal and 90% from Pakistan on hydraulic load was unavailable. Therefore, wastewater volumes for Nepal and Pakistan are not included in the table.

2,756 DEWATS implemented

A DEWATS project is defined as one independently working treatment system which has been constructed, implemented or supervised during significant parts of project implementation by BORDA and its partners. 45% of all global DEWATS are prefabricated, 55% were built conventionally.

Total implemented DEWATS*

AFRI	229
WESCA	67
SA	342
SEA	2,118

* Only commissioned and operating DEWATS are included.

Total DEWATS per country

	Total	Prefab	Conventional
Lesotho	161	0	161
South Africa	1	0	1
Tanzania	16	1	15
Zambia	51	0	51
Afghanistan	59	20	39
Iraq	8	6	2
Bangladesh	5	0	5
India	253	12	241
Nepal*	74	1	57
Pakistan*	10	0	9
Cambodia	62	6	56
Indonesia	1,950	1,155	795
Laos	21	0	21
Myanmar	1	0	1
Philippines	66	35	31
Vietnam	18	2	16

* At the time of publication, 22% of data (distinction prefab/conventional) from Nepal and 10% from Pakistan was unavailable.

BORDA Project types

Residential DEWATS treats domestic wastewater, e.g. from residential apartments, single houses or settlements. Community Sanitation Centres, including public toiltets, connected to DEWATS are also considered as residential projects.

School and University DEWATS treats the wastewater of schools and universities, including vocational schools, orphanages, child centres and student dormitories.

Hospital DEWATS treats the wastewater of public and private hospitals (no medical wastewater streams).

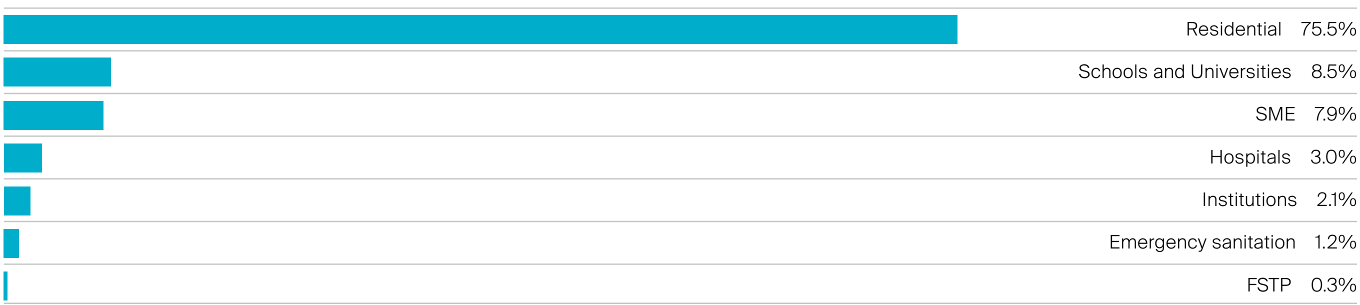
Emergency Sanitation DEWATS treats the grey- and/ or blackwater of emergency sanitation projects, e.g. refugee camps.

Institution DEWATS treats the grey- and/ or blackwater of public and private institutions such as religious centres, prisons, and all institutions which are not considered as small and medium enterprises (SME).

SME DEWATS treats the grey- and/ or blackwater as well as organic industrial effluent of SME, such as slaughterhouses, animal husbandries, food production, markets, offices, hotels, hostels and resorts as well as other industries.

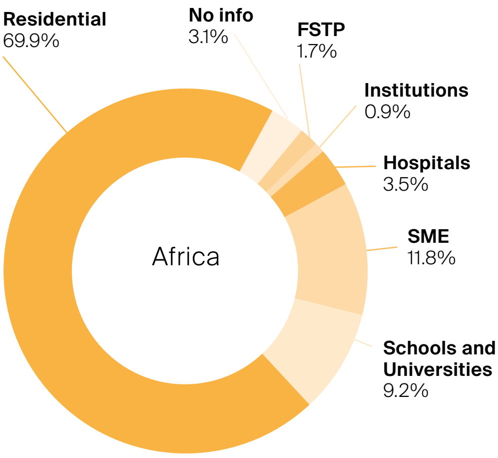
FSTP DEWATS treats faecal sludge transported to the plant by trucks as part of a faecal sludge management system (often municipal).

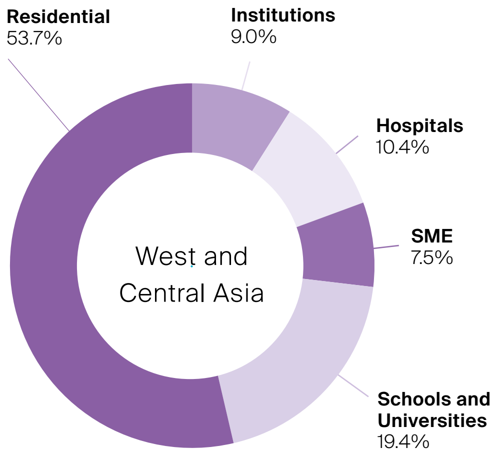
BORDA Project types (global)*

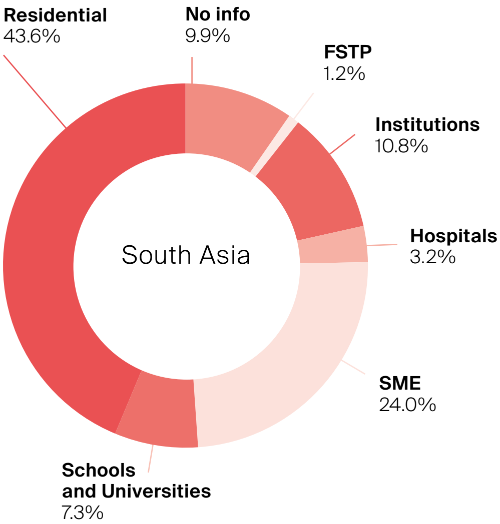


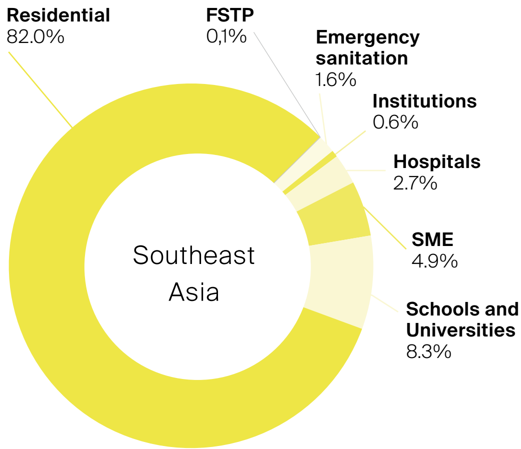
* Project types do not provide information on technical aspects of the DEWATS, e.g. what treatment modules are implemented or whether a small sewer system (SSS) is part of the design. At the time of publication, 1.5% of global data on project types was unavailable.

Project types per region









BORDA Project types per country

	Residential	Schools and Universities	Hospitals	Institutions	SME	Emergency sanitation	FSTP
Lesotho	134	10	1	2	7	0	0
South Africa	1	0	0	0	0	0	0
Tanzania	5	3	5	0	1	0	2
Zambia	20	8	2	0	19	0	2
Afghanistan	33	9	7	6	4	0	0
Iraq	3	4	0	0	1	0	0
Bangladesh	5	0	0	0	0	0	0
India	117	19	5	33	56	0	2
Nepal	21	4	6	4	24	0	2
Pakistan**	6	2	0	0	2	0	0
Cambodia	1	55	3	0	3	0	0
Indonesia	1,719	108	45	9	68	0	1
Laos	9	6	1	1	4	0	0
Myanmar	0	1	0	0	0	0	0
Philippines	4	3	5	1	19	34	0
Vietnam	3	2	3	1	9	0	0
Total	2,081	234	83	57	217	34	9

DEWATS Modules

Primary and secondary treatment modules

Primary, secondary and advanced secondary treatment modules

The existing combinations of primary, secondary and advanced secondary treatment modules vary per country and region.

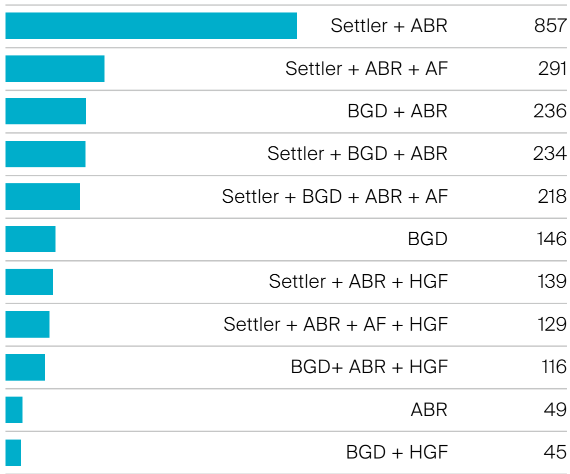
Globally, the most commonly occurring combination of treatment modules is that of Settler + ABR (31.1%), followed by Settler + ABR + AF (10.6%) and BGD + ABR (8.6%).

7.4% of all DEWATS include advanced secondary treatment modules. This number is strongly influenced by the large amount of DEWATS in Indonesia which do not comprise advanced secondary treatment modules. Without Indonesia's DEWATS, 18.1% of all remaining DEWATS are built including advanced secondary treatment modules.
Overall, the percentages of advanced secondary treatment modules implemented in the regions vary from 3.9% (AFRI), 13.4% (WESCA), 26.6% (SA) to 4.4% (SEA).
In total, polishing ponds represent the most common advanced secondary treatment module present in 4.8% of all DEWATS.

Storage & Discharge

DEWATS can also include additional modules such as collection tanks which are used to store treated wastewater before re-using it. Globally, 3.8% of DEWATS include such collection tanks. In WESCA, about 40% of all DEWATS comprise collection tanks.
Regarding wastewater discharge, 2.6% of all DEWATS include French drains which help infiltrate the treated wastewater into the soil. Both the Africa and WESCA region implemented French drains in about 10% of DEWATS.

Most common combinations of primary and secondary treatment modules*

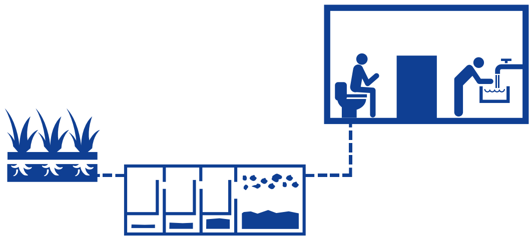


* At the time of publication, 6% of global data on primary and secondary treatment modules was unavailable.

Regional use of primary and secondary treatment modules*

* At the time of publication, 6% of global data on primary and secondary treatment modules was unavailable

Towards advanced wastewater treatment



DEWATS treatment modules per country

	Primary treatment		Secondary treatment			Advanced secondary treatment					
	Settler	**BGD**	**ABR**	**AF**	**HGF**	**Polishing pond**	**Vortex**	**Activated carbon filter**	**VSF**	**UV-System**	**Chlorination**
Lesotho	1	159	110	1	149	0	0	0	0	0	0
South Africa	1	0	1	1	1	0	0	0	1	0	0
Tanzania	3	13	10	7	10	6	4	0	1	2	0
Zambia	2	51	5	3	7	0	0	0	0	1	0
Afghanistan	40	19	41	22	28	9	1	0	0	0	0
Iraq	7	8	7	0	0	0	0	0	0	0	0
Bangladesh	5	0	5	0	5	5	0	0	0	0	0
India	226	11	226	127	134	25	30	6	1	0	1
Nepal	53	2	27	5	16	1	3	0	4	0	0
Pakistan	5	0	8	0	8	3	0	0	0	0	0
Cambodia	62	0	62	21	42	0	0	0	0	0	0
Indonesia	1,468	780	1,721	440	51	53	5	0	0	0	0
Laos	21	0	21	21	9	4	0	0	0	2	0
Myanmar	1	0	1	1	0	0	0	0	0	0	0
Philippines	24	8	66	30	22	22	0	4	1	0	0
Vietnam	17	3	18	18	14	4	0	0	0	0	1
Total	1,936	1,054	2,329	697	496	132	43	10	8	5	2

Advanced Secondary Treatment Modules

Activated Carbon Filter Activated carbon removes contaminant and impurities from wastewater through adsorption. Its effectiveness is due to its very fine pores and very large surface area per volume of filter-material.

Chlorination Chlorination allows wastewater disinfection and is particularly useful against the potential spread of waterborne diseases such as cholera, dysentery, and typhoid. It has however detrimental effects on any natural water-course, leads to toxic by-products and should only be used in controlled, minimal dosages or in emergencies.

Polishing pond A polishing pond is a shallow pond with large surface area, enabling light penetration and oxygenation of pre-treated wastewater. The effluent is generally free of pathogens but rich in nutrients and can be reused for agriculture or aquaculture.

UV System UV treatment is a possible wastewater disinfection process. It consists of a UV lamp at the centre of a pipe, submerged in flowing, pre-treated wastewater.

Vertical Sand Filter (VSF) Vertical Sand Filters are well researched and widely used batch-fed reactors for pre-treated wastewater. Anaerobic and aerobic processes inside the filter-bed lead to significant reduction of pathogens, COD, nutrients and smell.

Vortex Vortex technology allows the oxygenation of ww due to its continuous swirling motion; its wider applicability is currently under investigation. Further advantages are odour control as well as low energy and space requirements.

Current investigations Further engineering concepts currently under investigation concern DEWATS with distinct storm water design, rota-moulded DEWATS, aerated fixed bed reactors and Vertical Sand/Trickling filters as well as aerated gravel filters

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BORDA

Am Deich 45
28199 Bremen

fon: + 49 (0) 421 40 89 52 0
fax: + 49 (0) 421 40 89 52 50

office@borda.de
www.borda.de
facebook.com/borda.bremen
twitter.com/BORDA_Bremen
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