Tamás Papp

Annex

Examples for Individual Wastewater Treatment Units

Nowadays, the investment in the self-built modern on-site wastewater facilities are common as well as the local community organised, EU founded municipal wastewater management projects. One of the main principles of the law is that there should be adequate regulations for the implementation of advanced individual initiatives until the development of professional, on-site wastewater treatment solutions, developed by the local government, with the assistance of a specialist service provider.

The regulatory principle remains that developments and related environmental authority tasks of household wastewater treatment maximum of 500 m^3/year capacity on a property-by-property basis fall within the competence of local self-government notaries, in particular to relieve the National Inspectorates for Environment, Nature and Water. The involvement of the Inspectorates in case of individual initiatives can be done through professional assistance. In contrast, at municipal-level specialised wastewater treatment development and public services are implemented within the framework of a new legal institution, the Urban Wastewater Management Program, where the participation of the Inspectorate in the opinion of the UWMP can ensure the representation of environmental interests.

Program "B" advises three distinct alternatives for settlements or part of settlements, where the connection to the public sewage system is not economically sound:

- modern individual wastewater treatment (on-site sewage facilities)
- use of small wastewater treatment units
- closed tanks, storage tanks (septage)

These are the legal definitions of these under the Government Decree on Program "B":

Individual wastewater treatment: the use of individual wastewater treatment facilities, which includes the treatment and/or final disposal or temporary collection and storage of municipal wastewater with 1 to 25 population equivalent. Depending on the environmental and water management aspects and the building density, these may include: on-site sewage facilities, individual small wastewater treatment units and closed wastewater storages. Disposal and handling of liquid, sludge and construction waste from individual wastewater treatment facilities must be carried out in accordance with a separate legislation.

On-site sewage facility: A facility that reduces the environmental load of the municipal wastewater non-accessing to the public sewage system and disposal, but able to ensure the same degree of treatment as the large-scale wastewater treatment systems. The on-site sewage treatment facility is able to treat the wastewater without energy input. Elements: septic tank, gravel/sandstone(s), which, on the whole, allow the utilisation of the residual nutrient content of the treated wastewater for the vegetation and soil biota in case of final release into the geological medium or harmless placement in surface waters.

Small wastewater treatment unit: an installation that serves for the non-utility drainage and disposal of municipal wastewater, and provides an environmental solution equivalent to the

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municipal wastewater drainage and treatment. The individual wastewater treatment plant carrying out the treatment of the sewage by means of energy input shall ensure the removal of the pollutants of the wastewater according to a separate legislation; the recipient can be surface water or soil.

Closed wastewater storage: an installation consisting of one or more closed and watertight tanks; for the non-hazardous collection of wastewater and for the temporary storage of municipal liquid waste; the non-hazardous disposal of municipal waste collected in this area is provided after regular disposal and further treatment in accordance with specific waste management legislation.

It is regrettable that the use of on-site sewage facilities, as well as the use of small wastewater treatment units, is still not common even among professionals and manufacturers. It is necessary to pay special attention to the fact that this method, which is very different in the design, operation and last but not least, in the treatment efficiency, as well as the cost of wastewater treatment, i.e. in the public sewage system, should be distinguished in practice.

In the area of settlements with no sewage network, less than 2,000 PE, the operation of the small wastewater treatment unit is justified in the recreation area. In such cases, wastewater can be treated locally.

It is important to know the quality certificate of the small wastewater treatment unit intended for installation, since today in Hungary only the units can be on sale and operated, which is CE certified and was issued according to the standard MSZ EN 12566-3. If the load exceeds 2,000 PE, connection to the public sewage system is required.

Table 1

Effects of waste on small wastewater treatment units (compiled by the author)

Solid or liquid substances not to flush in the toilet	What they cause	Where to place
Ashes	Does not decompose	Bin
Chemicals	Poison the wastewater	Collection site
Disinfectants	Kills bacteria	Collection site
Dyes	Poison the wastewater	Collection site
Frying fat	Dumps in the tubes, causing a plug	Bin
Sticking plaster	Plugging in the tubes	Bin
Medicine	Poison the wastewater	Collection station, pharmacy
Motor oil	Poison the wastewater	Collection station, gas station
Pesticides	Poison the wastewater	Collection site
Razor blade	Can cause injury in the wastewater treatment plant	Bin
Drain cleaner	Smashes pipes and seals, poisoning sewage	Collection site
Powder insecticide	Poison the wastewater	Collection site
Sanitary pads	Cause damage to the environment	Bin
Diluent	Poison the wastewater	Collection site
Cotton bud	Deposited in the units	Bin
Diaper	Plugging	Bin

If the load is even, an anaerobic small wastewater treatment unit is enough, but if the load is uneven, e.g. in the resort area, aeration is inevitable in order to achieve proper treatment efficiency.

Nowadays, many companies design, manufacture, construct, install and commission small sewage treatment units. Manufacturers classify their product in three types of equipment capacity.

- small
- medium
- large

These classifications differ from company to company, because they use different PE limits based on PE: keeping in mind the areas of use that can be:

- single-family buildings
- social houses
- resort areas
- nurseries
- vessels
- motorway rest areas

Polydox treatment unit

In December 1992 Polyduct Zrt., as the first open joint-stock company in Hajdú-Bihar County, it was formed from the plastics plant of KITE (Corn and Industrial Plant Production Cooperation). As a quality supplier of gas and wastewater investments, they have been present in the Hungarian public utilities for about 20 years. Thanks to continuous improvements, Polyduct Zrt. has an extensive product range in water industry now and offers a comprehensive solution for the modern equipment and units required.

Figure 1
Polydox 6 and 12 biological wastewater treatment unit [1]

Recognising its importance, the company is a founding member of the Individual Wastewater Treatment Task Group. The Task Group maintains close contact with the Ministry of Rural Development (formerly the Ministry of Environment and Water) and is involved in shaping the legal background of individual wastewater treatment solutions. As a domestic producer of individual wastewater treatment equipment, the company is committed to spreading their products as widely as possible.

Specifications for the Polydox 6 and 12 wastewater treatment plants (for CE marking, according to EN 12566-3).

Table 2
Technical data of the Polydox 6 and 12 wastewater treatment unit

	Polydox 6	**Polydox 12**
Capacity	1–8 PE (population equivalent)	8–12 PE (population equivalent)
Hydraulic daily load	0.9 m^3/day	1.8 m^3/day
Material	Polyethylene	Polyethylene
Size	Ø1500 × 2300 mm	Ø1700 × 1920 mm
Weight	150 kg	180 kg
Height	2,300 mm	1,920 mm
Volume	2.4 m^3	3 m^3
Electric connection	230 V	230 V
Effective connector size	DN110 PVC pipe	DN110 PVC pipe
Effluent connection size	DN110 PVC pipe	DN110 PVC pipe
Energy use	1 kWh/day	1 kWh/day
Field of application	retail	retail
Treatment efficiency	COD: 90% BOD_5: 90% Total suspended solid: 90%	COD: 90% BOD_5: 90% Total suspended solid: 90%
Disposal of treated wastewater	infiltration release into surface water	infiltration release into surface water

The structure of the Polydox 6 and 12 wastewater treatment unit

Primary clarifier: Coarse mechanical treatment part. Its function is to mechanically remove large size pollutants from municipal wastewater and to store excess sludge from biological processes.

Aerobic tank: Here, complete biodegradation and complete nitrification take place.

Secondary clarifier: It filters out settable materials and sludge. The settled sewage sludge is returned to the aerobic space by the mammoth pump placed here, where it is reintroduced into the treatment process.

Operation of the Polydox 6 and 12 wastewater treatment unit

The wastewater flows among the separate volumes by gravity. This process includes the installation of a mammoth pump controlled by electronics. Finally, the treated wastewater flows out of the unit by gravity. Dissolved oxygen is provided by compressed air required for oxidation. This is produced by a membrane compressor located in the control cabinet with the control unit. The compressed air passes through the air diffuser into the aerobic volume.

The air supply of the wastewater treatment plant and the operation of the mammoth pumps at appropriate intervals are provided by the control system. This system can be operated manually or automatically. In automatic operation, pumps and aeration units operate according to a predetermined program in the control unit as follows:

– the mammoth pump delivers wastewater from the primary clarifier to the aerobic volume
– the aeration unit has an on/off control in automatic mode
– the mammoth pump is switched on by the sludge recirculation at every second hour

Stabilisation of sludge takes place under anaerobic conditions in the sludge storage. Depending on the PE, the sludge zone provides a residence time of 10–14 months. This stabilises the sludge. The approximately 500 l of stabilised sludge thus formed must be removed from the pre-settling zone by suction, and the pre-settling room must be filled with clean water.

Treated wastewater flows to an infiltration zone or may be discharged into surface water. The sizing of the infiltration zone is the task of the designer.

The installation of the equipment is underground, for inspection and maintenance of the Polydox 6 type 1, and for the Polydox 12 type there are two trap doors.

Regulation (EC) No 28/2004 of the European Parliament and of the Council on limit values for pollutants and certain rules for their application (XII.25.) and according to the Hungarian KvVM Decree, the quality of the effluent discharged from the equipment complies with the limit values defined in Area Categories 2, 3 and 4 for direct introduction into the recipient. If phosphorus removal is also required in case of introduction into the recipient, an additional chemical dosage should be installed.

Sludge stabilisation in the sludge storage tank occurs under anaerobic conditions. Depending on the PE, the sludge residence time is about 1–1.5 years. The stability of the sludge is then the most favourable. Finally, the stabilised sludge can be removed by septage truck. Treated wastewater during the process can be drained through an infiltration zone.

Selecting the location of the small wastewater treatment unit

The unit can receive max. 60 cm deep sewage without lifting:

– A free space of at least 3 m in diameter should be provided to accommodate the reservoir so that the pit can be made free of obstructions.
– Keep a minimum distance of 1 m between the tank and the nearest building. If the depth of the pit exceeds the depth of the foundation, this distance should be increased to 3 metres. Do not build above the tank!
– Avoid installing the tank in the groundwater area. If this is unavoidable, the tank may need to be anchored and ask for assistance from a specialist.
– The tank can be placed under a traffic route exposed to pedestrians, but can only be built on a separate technical design for the area exposed to motor traffic!
– In the vicinity of trees and plants, the tank should not be closer than 2 m to the tree trunk. Plants can be planted above and below the tank only in case their roots will not be in the way of the tank or the root of the container will not push the container wall.

In case of slopes, a specialist should be inspected to determine if a support wall is needed within the 5 m range of the tank.

Placement of a sewage treatment tank

To create a foundation pit

Create a foundation pit with a flat base with a diameter of 0.3 metres in all directions for the maximum diameter of the tank (ø 1.6 m) due to the need for work and the space needed for filling/re-filling and compacting the bedding material.

To avoid the risk of collapse, the wall around the excavation should be expanded at an angle of 35 to 80 degrees.

When determining the depth of the pit, you must take into account the need for a minimum depth of 20 cm, and the tank can receive max. 60 cm deep water.

After lifting the ground, at the bottom of the foundation pit – preferably from gravel – form the bottom bed, which must be sufficiently compacted (3-fold machine ramming or equivalent manual compaction) and then levelled. There can be no sharp stones or protrusions in the bedding.

Placing the tank

Carefully lower the tank (using straps) into the pit and check the level. The lifting tabs on the tank can only be used when the tank is empty (weight is approximately 150 kg).

Fill the tank with water half.

Put the manhole cover so that no gravel or sand gets into the tank during the top recharge.

Fill the tank around the filler – sand and sand-aggregate mixture (grain size is in the range of 0.8–0.32) evenly over the tank at –0.2 metres. Tighten all layers with a manual machine compression tool evenly. Machine compaction near the tank wall is forbidden. It is forbidden to return the soil to the immediate vicinity of the tank.

If filling the side bed has reached the height of the water in the tank, the tank must be filled with water up to the level of the spaces.

You can then continue – as described above – to develop the side bed.

Connect the inlet and outlet pipelines without voltage, observing the correct slopes.

You can use the soil out of the pit to fill the last 20 cm layer, but it cannot contain sharp stones.

Installation of the electrical control cabinet of the unit

Following the above, a pre-assembled cabinet with the support stand must be placed at the dedicated connection point of the wastewater treatment plant and secured to the equipment with the supplied screws. You need to install the electric wire that comes in the ground through the protective tube through the 3X1.5 MT cable into the switch cabinet. At the end of the electrical cable, an IP 54 plastic connection box should be installed 6. A. with fixed connection with terminal block. The colour-coded stumps of the air valve in the control cabinet must be connected to the air outlets protruding from the tank in accordance with the colours.

The unit can be operated from a 230 V protective earthing network. The operator is responsible for eliminating any major voltage fluctuations. When installing the equipment, a contact protection test must be carried out and the report drawn up by the operator of the equipment must be kept. Work on the machine only in the power-off state.

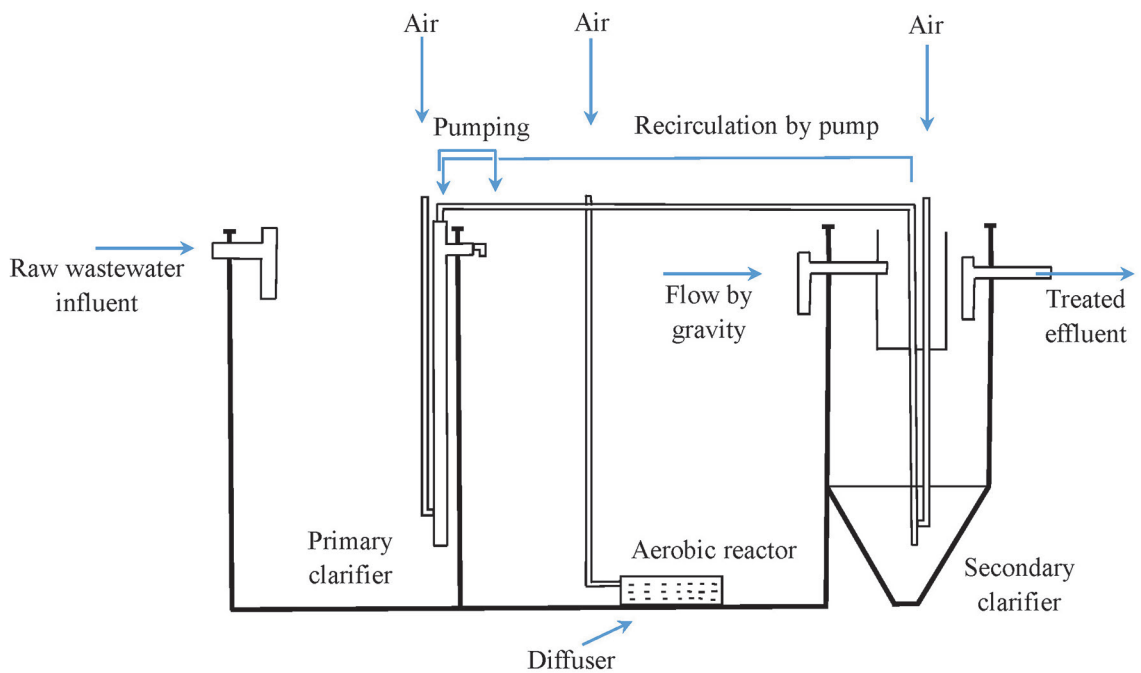

Figure 2
Polydox 6 and Polydox 12 operating principles [2]

Operational conditions

Wastewater is treated by bacteria that break down, use up the wastewater constituents during their metabolism. Bacteria are very sensitive to antibiotics and disinfectants because they destroy them in great quantities. The following rules must be observed for the survival and reproduction of degrading bacteria:

- use up to 1 dl daily of chlorine-based cleaning and disinfecting agents (e.g. Hypo, FloraSept, Domestos, Clorox, Bref Duo Active, Devil, Tiret Professional, Cillit Duo); we can keep our home with natural tools and environmentally friendly cleaners
- avoid using acids and alkali (e.g. drain cleaners)
- up to 2 washing machine programs per day are recommended
- dangerous, therefore, it is forbidden to pour toxic or flammable substances into the drain: thinners, paints, pesticides, motor oil, etc.
- do not throw away any non-degradable materials, e.g. cigarette butts, paper diapers, wipes, cleaners, office paper, packaging materials, foils, etc.
- do not pour the cooking oil, food residue, fruit or vegetable residue used in the wastewater treatment plant, do not use food waste grinder
- do not let water from swimming pools or boilers into the unit
- wastewater from animal husbandry is forbidden to mix with household wastewater
- rainwater is not wastewater, do not discharge into the unit; it is advisable to collect in a separate closed rainwater collection tank, which could be used for irrigation

Maintenance instructions

A Polydox biological wastewater treatment unit does not require continuous monitoring, dedicated safety equipment such as conventional sludge biological systems, but periodic inspection is also required for these types. It is necessary to check and possibly replace the aeration elements every 5–6 years. No hazardous gases can be formed in the reactor space; no special protection requirements are needed. If the unit is not placed in an enclosed area, it must be surrounded by a fence to prevent unauthorised intrusion.

In case of settlement-level operation, a responsible person in charge of the equipment must be appointed and the operation must be solved in an organised manner. It is the responsibility of the operator to carry out the necessary checks, treatments, work and to keep the operation log up-to-date. The inspection should also cover the connecting structures outside the equipment.

Table 3

Inspection frequency of a small equipment by the owner of the residential property (compiled by the author)

Name of activity	Frequency
Visual inspection of equipment	Weekly
Checking of flows	Monthly
Checking the quality of treated wastewater	Monthly
Supply of electricity	Ongoing
Providing access to equipment	As needed

Table 4

Inspection frequency of the unit by the operator (compiled by the author)

Name of activity	Frequency
Measuring sludge blanket level in sludge storage	Monthly
Checking the turbidity of the settling tank, removing the floating materials	Every 3 weeks
Sampling and determine the quality of the influent and effluent	With the frequency specified by the inspectorates
Excess sludge removal	Annually
Correcting possible operational errors	As needed

Polydox 30 and 50 biological wastewater treatment unit

Polydox 30 and 50 wastewater treatment units are larger than the types discussed above, both in size and capacity. The manufacturer recommends it to smaller schools and pensions, but it can also be installed in small industrial plants.

It is enough to install a 2.5 × 2.5 m work pit, which should be placed above the groundwater level at least one meter from the building. When choosing the location of the installation, it should also be noted that the 2.5 m area should be woodless because the roots can push the side of the tank, which can lead to damage.

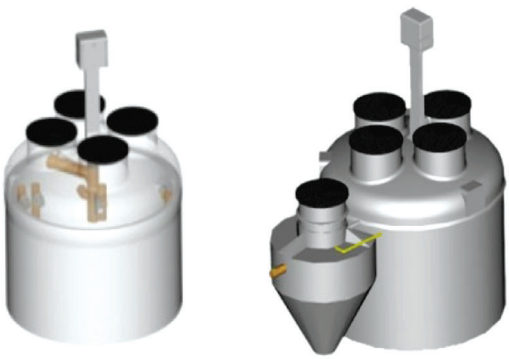

Figure 3
Polydox 30 and 50 wastewater treatment unit [2]

Table 5
Specifications for the Polydox 30 and 50 wastewater treatment unit (compiled by the author)

	Polydox 30	**Polydox 50**
Capacity	30 PE (population equivalent)	50 PE (population equivalent)
Hydraulic daily load	4 m^3/day	6 m^3/day
Material	Polyethylene	Polyethylene
Size	2,500 mm	2,400 × 3,550 mm
Height	2,000 mm	2,000
Volume	7 m^3	8.4 m^3
Electric connection	230V	230 V
Effective connector size	DN160 PVC pipe	DN160 PVC pipe
Effluent connection size	DN110 PVC pipe	DN110 PVC pipe
Energy use	6 kWh/day	7.596 kWh/day
Field of application	retail	retail
Treatment efficiency	COD: 90% BOD_5: 90% Total suspended solid: 90%	COD: 90% BOD_5: 90% Total suspended solid: 90%
Disposal of treated wastewater	infiltration release into surface water	infiltration release into surface water

The structure of the Polydox 30 and 50 wastewater treatment equipment

Primary clarifier: It is responsible for mechanical treatment; removing solids and store excess sludge from biodegradation.

Anaerobic tanks: Here, the hydrolysis of biodegradation takes place, transforming the slowly degradable organic materials into readily degradable organic materials. The homogeniser (mixer) placed in the anaerobic space promotes denitrification and some nitrification can begin.

Aerobic tanks: The two volumes of the same size and design are in series, where the complete biodegradation is realised and the complete nitrification process takes place. Flow through aerobic

volume is via fixed contact elements. The biofilm carrier, PVC-bonded multi-cell module is installed in cast polyethylene cylinders, fixed as a stand-alone cartridge to the bottom of the treatment unit. Air bubbles captured in the "cartridge" in the aerobic space, through the mammoth pump effect, continuously flow upstream of the wastewater. This circular flow provides the nutrient and oxygen supply to the biological membrane adhered to the surface of the contact elements. The aged, mineralised part of the biofilm is constantly detached and flows into the secondary clarifiers with the biologically treated sewage.

Secondary clarifier: Its task is to separate settleable materials and sludge. Recirculation of the settled sludge is provided by the mammoth pump placed in the secondary clarifier. The recirculating sludge enters the anaerobic space. The excess sludge is transferred to primary clarifiers for stabilisation through the recirculation.

Operation of the Polydox 30 and 50 wastewater treatment equipment

The wastewater is transported between the tanks by gravity. Treated wastewater also flows out of the system by gravity. Compressed air is provided to fulfil the requirement of dissolved oxygen. The compressed air is provided by a membrane compressor, which is housed in a common box with the electrical control unit. The supply of compressed air under fixed battery cartridges is performed on a round, elastic membrane with fine bubble aeration elements. The device control system provides air supply and control of the mammoth pump.

The system can also operate in manual and automatic mode. In automatic mode, the aeration unit, the homogenising pump and the sludge pump are operated by the pre-programmed controller as follows:

- switches the aeration unit on/off
- operates the homogenizing pump
- switches sludge circulation pump on/off

The stabilisation of sludge (raw, primary sludge, excess sludge) occurs under anaerobic conditions at the bottom zone of the primary clarifier. Depending on the PE, the sludge zone provides a residence time of 10–12 months. This stabilises the sludge. The stabilised sludge is transported by a suction tank vehicle. Treated wastewater flows to an infiltration zone or may be discharged into surface water. The sizing of the infiltration zone is the task of the designer.

The placement of the equipment is underground, the number of openings for inspection and maintenance is 4 for Polydox 30 and 5 for Polydox 50.

Regulation (EC) No 28/2004 of the European Parliament and of the Council on limit values for pollutants and certain rules for their application (XII.25.) and according to the Hungarian KvVM Decree, the quality of the effluent discharged from the equipment complies with the limit values defined in Area Categories 2, 3 and 4 for direct introduction into the recipient.

If phosphorus removal is also required in case of introduction into the recipient, an additional chemical dosage should be installed.

Selecting the location of the small wastewater treatment unit

A free space of at least 3.5 m in diameter should be provided to accommodate the reservoir so that the pit can be made free of obstructions.

It is recommended to keep a minimum clearance of 1 m between the tank and the nearest building. If the depth of the pit exceeds the depth of the foundation, this distance should be increased to 3–6 metres. Do not build above the tank!

Avoid installing the tank in the groundwater area. If this is unavoidable, the tank may need to be anchored and ask for assistance from a specialist.

The tank can be placed under a traffic route exposed to pedestrian traffic, but cannot be installed in the area exposed to motor traffic, and should be completely excluded!

In the vicinity of trees and plants, the tank should not be closer than 2.5 m to the tree trunk. Plants can be planted above and below the tank only in case their roots will not be in the way of the tank or the root of the container will not push the container wall.

In case of slopes, a specialist should be inspected to determine if a support wall is needed within the 5 m range of the tank.

Placement of a sewage treatment tank

To create a foundation pit

Create a foundation pit with a flat base with a diameter of 0.3 metres in all directions for the maximum diameter of the tank (ø 2.5 m) due to the need for work and the space needed for filling/backfilling and compacting the bedding material.

To avoid the risk of collapse, the wall around the excavation should be expanded at an angle of 35 to 80 degrees.

When determining the depth of the work pit, it must be taken into account that a minimum flat concrete bed of 20 cm is required and that the tank can be loaded with a maximum of 30 cm of ground cover.

After lifting the ground, lower the bottom min. 20 cm flat concrete bedding.

Placing the tank

Carefully lower the tank (using straps) into the pit and check the level. The lifting tabs on the tank can only be used when the tank is empty (mass is approximately 400 kg).

Fill the tank with water half.

Place the manhole covers so that no gravel or sand gets into the tank during top recharging.

Fill the tank around the filler – sand and sand-aggregate mixture (in the range of 0.8–0.32) evenly over the tank at –0.2 metres. Tighten all layers manually and evenly. Machine compression is prohibited! It is forbidden to return the soil to the immediate vicinity of the tank.

If filling the side bed has reached the height of the water in the tank, the tank must be fully filled with water after the tank's inlet and outlet pipes are connected and then closed.

You can then continue – as described above – to develop the side bed.

Check the connected pipes. These must be securely fastened.

You can use the soil out of the pit to fill the last 20 cm layer, but it cannot contain sharp stones.

Installation of the electrical control cabinet of the unit

Then place the control cabinet at max. distance of 5 m of the unit, electrical connection shall be provided by connecting the 3 × 0.75 MTK ground cable to the control cabinet. The electrical power supply must be fixed. This operation should only be carried out by a qualified electrician. The numbered stubs of the air valve in the control cabinet must be connected to the numbered air connectors on the tank. The unit can be operated from a 230 V protective earthing network. The operator is responsible for eliminating any major voltage fluctuations. When installing the equipment, a contact protection test must be carried out and the report drawn up by the operator of the equipment must be kept. Work on the machine only in the power-off state.

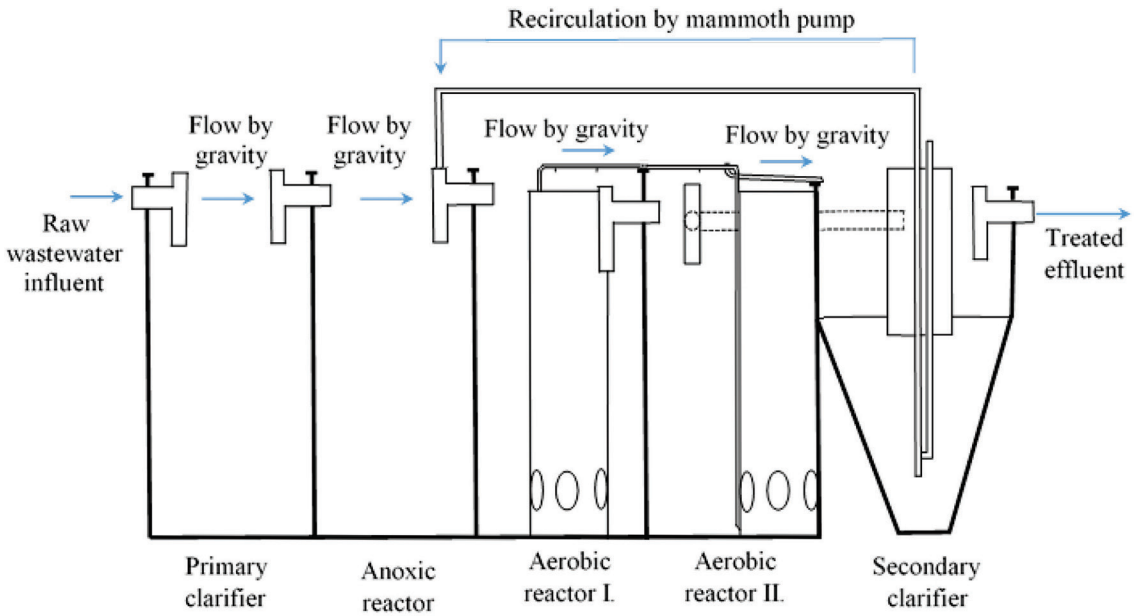

Figure 4
Operation principle of Polydox 30 and Polydox 50 [2]

Operational conditions

Wastewater is treated by bacteria that break down, "eat" the wastewater constituents during their metabolism. Bacteria are very sensitive to antibiotics and disinfectants because they destroy them in greater quantities. The following rules must be observed for the survival and reproduction of degrading bacteria:

- use up to 1 dl daily of chlorine-based cleaning and disinfecting agents (e.g. Hypo, FloraSept, Domestos, Clorox, Bref Duo Active, Devil, Tiret Professional, Cillit Duo); we could use our naturally degradable and environmentally friendly cleaners
- avoid using acids and alkalis (e.g. drain cleaners)
- up to 2 washing machine programs per day are recommended

– dangerous, therefore, it is forbidden to pour toxic or flammable substances into the drain: thinners, paints, pesticides, motor oil, etc.
– do not throw away any non-degradable materials, e.g. cigarette butts, paper diapers, wipes, cleaners, office paper, packaging materials, foils, etc.
– do not pour the cooking oil, food residue, fruit or vegetable residue used in the wastewater treatment plant, do not use food waste grinder
– do not let water from swimming pools or boilers into the unit
– wastewater from animal husbandry is forbidden to mix with household wastewater
– rainwater is not wastewater, do not discharge into the unit; it is advisable to collect in a separate closed rainwater collection tank, which could be used for irrigation

Maintenance instructions

A Polydox biological wastewater treatment unit does not require continuous monitoring, dedicated safety equipment such as conventional sludge biological systems, but periodic inspection is also required for these types. It is necessary to check and possibly replace the aeration elements every 5–6 years. No hazardous gases can be formed in the reactor space, no special protection requirements are needed. If the unit is not placed in an enclosed area, it must be surrounded by a fence to prevent unauthorised intrusion.

In case of settlement-level operation, a responsible person in charge of the equipment must be appointed and the operation must be solved in an organised manner. It is the responsibility of the operator to carry out the necessary checks, treatments, work and to keep the operation log up-to-date. The inspection should also cover the connecting structures outside the equipment.

Table 6
Inspection frequency of a small equipment by the owner of the residential property (compiled by the author)

Name of activity	Frequency
Visual inspection of equipment	Weekly
Checking of flows	Monthly
Checking the quality of treated wastewater	Monthly
Supply of electricity	Ongoing
Providing access to equipment	As needed

Table 7
Inspection frequency of the unit by the operator (compiled by the author)

Name of activity	Frequency
Measuring sludge blanket level in sludge storage	Monthly
Checking the turbidity of the settling tank, removing the floating materials	Every 3 weeks
Sampling and determine the quality of the influent and effluent	With the frequency specified by the inspectorates
Excess sludge removal	Annually
Correcting possible operational errors	As needed

In case of faulty operation of the equipment, the fault must be eliminated, the sampling must be repeated and the smooth operation must be verified by inspection.

Basic operations and machines for operating the equipment:

– air blower, whose air supply can be controlled by a blower valve
– control-operated homogeniser
– recirculating mammoth pump; operated according to the specified time program

Removed stabilised sludge does not pose an environmental hazard if disposed of in accordance with legal regulations.

Öko Tech Home Kft.

Figure 5
A.B. Clear wastewater treatment unit [3]

The company Öko Tech Home Kft. has been dealing with biological wastewater treatment since 2004. It has a pioneering role in promoting and spreading small size wastewater treatment units in Hungary. The installation and commissioning of the wastewater treatment units also belong to the company's profile; therefore, in this area considerable experience has been accumulated over the years. After several years of practical experience, a self-developed biological wastewater treatment equipment has been created. Using the operational and maintenance experience of the installed wastewater treatment units, an equipment has been developed which, with high treatment efficiency, has a minimum maintenance requirement. Efforts have been made to minimise the possibility of failure and the wastewater treatment plant does not contain wear parts. The product also has a CE conformity certificate. It is important that using a small biological wastewater treatment unit, the chemicals dosed in the household should be precisely selected. Also, citizens who have not previously favoured environmentally friendly detergents now have to switch to biodegradable products. This will help to save energy and protect the environment at the same time.

A.B. Clear biological wastewater treatment specification

The following data are from a report prepared by VITUKI (Water Science Research Institute in Hungary). Based on these, A.B. Clear biological wastewater treatment plants comply with 28/2004 (XII.25.) KvVM Decree (Annex 2, Category 3), which applies to intermittent watercourse.

Table 8
Treatment efficiency of A.B. Clear 6–8 and 10 wastewater treatment unit (compiled by the author)

Treatment efficiency	COD	BOD_5	Total suspended solid	$N\text{-}NH_4$	TN	TP
A.B. Clear treatment efficiency (%)	95	95	95	92	87	67
A.B. Clear effluent quality parameters (mg/l)	55	20	18	10	20	8

Table 9
Technical data of A.B. Clear 6–8 and 10 wastewater treatment unit (compiled by the author)

Technical data	A.B. Clear 6	A.B. Clear 8	A.B. Clear 10
Daily capacity (m^3)	0.78	1	1.3
Diameter (mm)	1,330	1,330	1,500
Height (mm)	1,900	2,200	2,530
Inlet pipe height (mm)	1,380	1,680	1,715
Outlet pipe height (mm)	1,220	1,520	1,555
Diameter of inlet and outlet pipe (mm)	110/110	110/110	110/110
Air blower pressure (Δp in mbar)	230	230	230
Air supply capacity (l/min)	30	37	52
Microbubble aeration unit (ø63 mm) length (mm)	0.3	0.36	0.5
Air power supply (W)	60	60	80

Field of uses recommended by the manufacturer

Detached houses

In case of family houses, it is easiest to implement self-sufficient biological wastewater treatment. Water can also be recycled easily and cheaply, and the garden can be watered with the treated effluent. If effluent water is used to rinse the toilet, drinking water consumption can be reduced by 30–40%. The device tolerates load fluctuations within wide limits, so neither a few days, a week's holiday, nor a larger visitor number can be a problem, they can be bridged by the introduction of a microprocessor control unit. The minimum space required for equipment and accessories such as artificial grass covers make the equipment almost invisible in any garden.

Holiday homes, weekend and hunting houses

The fluctuation of load in these properties is often significant in many cases. The holiday home is almost continuously used from spring to autumn, but in winter it is seldom visited. In this case, the microprocessor control unit is recommended for bridging smaller, few-day, weekly fluctuations. In this case, the wastewater treatment plant must be prepared for winter, drained and then filled with clean water. The device must be restarted upon re-use.

Pensions, motels

Biological wastewater treatment is also a good investment in the service sector, whether we look at wastewater drainage or savings from recycling. Due to their nature, these facilities may also be subject to strong load fluctuations, and many facilities have a seasonal variation. In such cases, the installation of two small wastewater treatment units could be a solution. Thus, in a low-load period, only one of the units is running, and at higher loads, the other equipment can be started, so the capacity of the system can be varied within wide limits. In addition, individual biological wastewater treatment for those who wish to provide ecotourism is also a good choice.

Apartments

Similarly to family houses, biological wastewater treatment units can be used for condominiums, and in this case, even the load fluctuations are lower.

Industries, offices

Treated water can be recycled: rinsing the toilets as well as irrigation of the green area around the site could be an option. However, it is important to note that the unit is suitable for treating household wastewater, so if any other industrial, technological wastewater is disposed of, it is necessary to agree with the service provider on possible pretreatment and other solutions.

Farms

For farms far away from central sewer networks, cesspools are currently widespread but individual wastewater treatment units could be an inexpensive and environmentally friendly solution. Treated water can also be used for irrigation. The power requirement of the equipment is minimal; therefore, it can be easily gained from solar, wind or other alternative systems. In case of farms, tendering opportunities are often published.

Treated wastewater reuse

With our biological wastewater treatment, municipal wastewater can be reused for many purposes after the treatment. The best way for reuse is irrigation to plant root zone. After post treatment, the biologically treated wastewater can also be used for toilet flushing or car wash.

For example, in a four-person household, toilet flushing accounts for 35–40% of the water consumption. This can be saved by using treated water; where an existing cesspit is replaced, it can be used as a treated wastewater storage, making water management easier. If the water is not reused, it can drain into the gravel bed or be released into surface water if water permit allows it.

One of the easiest ways is to drain the rainwater or the treated wastewater. Water is drained into the soil through an underground pipe system. On the one hand, the system can be applied at the overflow of the storage tank, and on the other hand, it can ensure the root zone irrigation of the garden plants.

The main part of the drainage system is a pipe of at least 10 metres (perforated PVC pipe), one end of which is connected to the outlet pipe of the rainwater collecting tank and terminated in the ground, going down with a small slope at the end of the system above the ground with a vertical pipe. For better drainage efficiency, a large, washed (pebble) gravel should be wrapped around the pipe. It is recommended to make a 40 cm wide, 60 cm thick bed under the drainpipe. The drainage trench must be covered with geotextile over the pebbles and the drainage pipe to avoid spillage. The remainder can then be retracted with the originally extracted soil to provide a pedestrian or vehicle-accessible surface.

Incoming rainwater pipe is under the frost limit. The overflow must be below the inlet, at least with 2 cm. The pipe thus goes under the frost limit. Its minimum incline is equivalent to the sewer tubes, i.e. half a centimetre per meter. It is advisable to dig the trench required for laying the leaking pipe with a grab so that it is even, as its bottom should be completely horizontal. The drainage system can only be built on soils that have not been agitated or have been sufficiently compacted over the years.

Material requirements for drainage system, ideal for soil conditions at 10 metres:

- 10 m drainpipe, 100 mm in diameter
- geotextile, 10 metres long, 50 cm wide for covering the ditch
- 2 m^3 of gravel

For a soil with good water absorption, such as sand, a 10 m long drainpipe is sufficient. However, if the soil is clayey and water is difficult to drain, then a system of 20 or even 30 metres may be needed.

It is important that drainage can only be solved on your own site.

If treated wastewater is drained, the residual organic matter could feed the plants.

These wastewater treatment units use a unique technology to treat the sludge. The essence of the innovation is a structure that dewaters the excess sludge and collects it in a bag that is easy to handle, inside the container. This eliminates the need for sludge removal, and the collected sludge can be composted and utilised as a plant nutrient even in the home. Another advantage of this technology is that it automatically maintains the sludge amount in the system, so that in case of regular emptying of the sludge bag, neither the excessive sludge of the sewage treatment plant nor low sludge level is possible.

Operational principle of A.B. Clear 6–8 and 10 wastewater treatment unit

The technology used in the biological wastewater treatment unit is based on activated sludge technology. The wastewater coming from the household (kitchen, bathroom) discharges to the treatment unit, where the constituents are decomposed with the help of activated sludge under anaerobic and aerobic conditions.

The units apply total oxidation similarly to large urban wastewater treatment plants. All processes take place inside a tank, separate chambers correspond to different wastewater treatment processes. The decomposition is carried out by microorganisms. Where aeration is necessary, an air pump is installed.

The entering wastewater first flows through a coarse filter located in the anaerobic tank and retains the large solid particles. The soluble materials are fragmented here due to the water movement and along with the wastewater through the filter and through the chamber into the anoxic space. Here pollutants degrade without air.

Thereafter, the fluid enters the aerobic zone, which is aerated. Here, a microbubble aeration tube supplies the bacteria with oxygen; due to these processes, the device does not have an unpleasant odour. The wastewater enters the secondary clarifier after this last degradation process. Here the treated water and sludge are separated, water flows out at the upper part, sludge is taken out at the bottom of the chamber. Treated water that meets environmental standards and limits outflows through an outlet pipe.

The purpose of the mammoth pumps is to circulate the produced sludge within the tank and to remove excess sludge. Excess sludge is dewatered and stored until emptying. Treated water can also be placed directly in the final disposal (e.g. drainage) or stored in a cistern for subsequent recycling.

In A.B. Clear units, all processes are operated by air pumps. There are no other moving parts in these units. The electrical components are as follows:

- diaphragm air pump (factory part): low power, quiet, 230V power supply; it is constantly running with standard equipment; clean your air filter quarterly, every 50,000 operating hours replace the membrane
- AC motor (factory part): the air pump is normally supplied to the wastewater treatment unit, but directs all air to the mammoth pump of the sludge bag at pre-set times (default value is once a week), removing and dewatering excess sludge
- microprocessor controller (optional): it is recommended to use when the unit is underloaded or the load is fluctuating; it operates as a three-position timer; the modes must be set by the user on request

Advantages of A.B. Clear 6–8 and 10 wastewater treatment unit.

- The units provide an environmental solution equivalent to centralised wastewater treatment.
- Easy to install and operate. Installation takes only a few hours and anyone can learn how to operate it.
- Low investment and maintenance costs, the production and commissioning of the wastewater treatment unit do not exceed the average cost of connection to a central channel.
- Minimal dry solid – stabilised sludge – is produced during the decomposition of wastewater, e.g. about 0.5 m^3 per year for four people.
- The operation of the wastewater treatment plant is quiet, so it can be installed inside the building, no separate sound insulation is required.

– In addition to being easy to install due to the polypropylene plastic material, the biological wastewater treatment unit is highly resistant to environmental impacts and has a long service life.
– There is little chance of failure.
– The unit does not contain any substances harmful to the environment and operates without the use of additives.
– Low operating costs. The energy consumption of the household version of the unit is about 14–16 kWh/month.
– Biologically treated water can be re-used for root zone irrigation or for other purposes, and there is no channel fee, so the investment will pay off in one or two years.
– Minimal maintenance requirement.

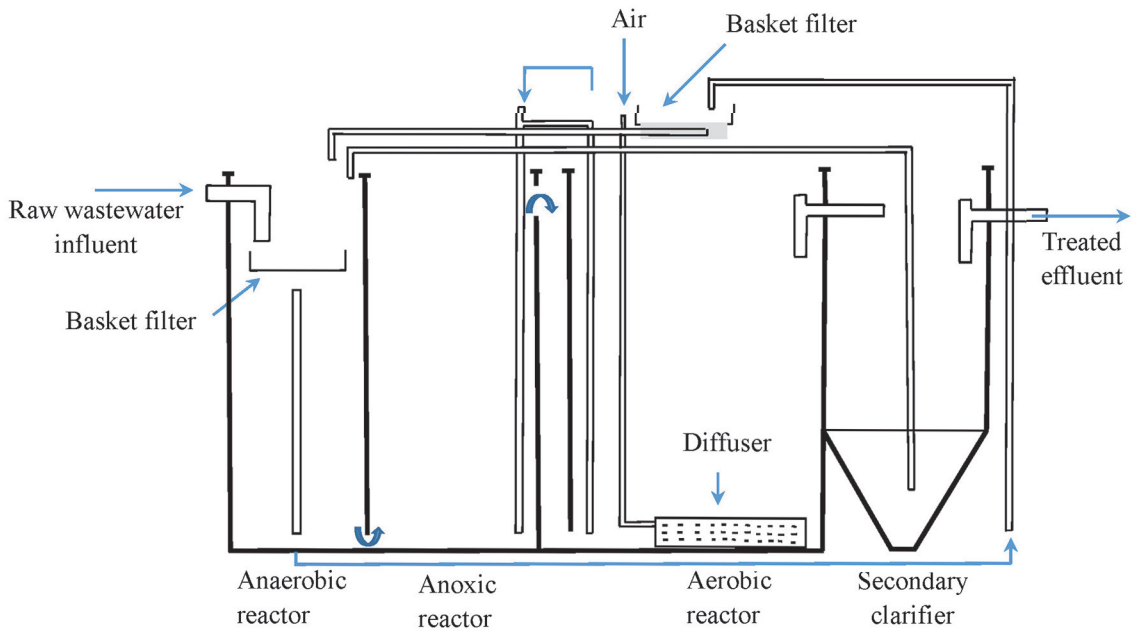

Figure 6
Operating principle of A.B. Clear units [4]

Inspection and maintenance of the sewage treatment unit

During operation, the equipment must be inspected visually at least weekly. The things to check are:

Odour

If there is no unpleasant smell at all when the equipment is opened, there is a biological equilibrium in the equipment. In case of strong odour (channel odour), the biological equilibrium is likely to be overturned, in which case please check the efficiency of the aeration, do the sludge probe.

Aeration

Aeration is one of the most important operating conditions for equipment. The air from the air diffuser is distributed by the valves to the chambers, so each component is monitored and checked. The microbubble air inlet is located at the bottom of the right and left semi-circular portions of the aerobic chamber. Normally, a large number of small bubbles will rise to the surface, and the water surface will be "bubbly". If there is no aeration at all, you need to make sure that the power supply is on, if there is voltage, then the valves need to be adjusted. If, instead of the many small bubbles, some large ones rise to the water surface, it means that the air intake element has been damaged so that it must be replaced.

Mammoth pump

Pumps without moving parts (Ø D 50 PVC thinner grey tubes) circulate the sludge inside the unit, as well as breaking up solid water-soluble wastes and sludge collection. They must operate continuously as they are set up during installation, but they need to be checked and adjusted if necessary. If the sludge concentration reaches 600–700 ml/l, it may cause blockage, which can be eliminated in several ways. The easiest solution is to temporarily open the appropriate valve. The mammoth pumps operate with significantly less air than the microbubble aeration, but in case of plugging, the tube can be blown through the complete closure of the other valves and full opening of the clogged pump valve. If this is done, remember to reset the valves as required. If the purging is not successful, you can also prevent a defect by pigging or pushing the hose inside.

Basket filter

This is a flange-shaped perforated sheet directly below the inlet pipe. This captures the large solids from the wastewater entering the sewer, its soluble components are largely fragmented due to air mixing from below. The insoluble wastes are retained and have to be removed from time to time. The cleaning cycle of the basket filter is determined by the amount of material that comes from the household, but it is generally recommended to clean it once a week. The filter can simply be removed from the tank. If there is not enough fluid in the filter due to plugging, the overflow will allow the water to flow, but this can lead to further blockages.

Water level

The unit is in continuous operation, therefore the water level can be considered constant. At higher loads, the water level in the chambers may rise slightly, which is normal. On the other hand, if we find that the walls separating the chambers are all under water, a coherent water surface has been created in the system, there is a blockage at the inlet or outlet. (This is usually the drainage system.) The obstruction in the unit is caused by the blockage outflow section, which can be removed with a Ø 10–12 mm rod. The blockage of the drainage system can be detected by looking through the aeration pipe on the system.

Foaming

It is necessary to distinguish between two types of foaming; one is white foam, which refers to the state of sludge deficiency (a phenomenon characteristic of post-inoculation, which disappears within one month after adaptation), while the other is brown foaming, which occurs if the sludge concentration is above 400–500 ml/l or the aeration is not sufficient. While detergents may cause excessive foaming due to the fluid flow, this does not cause any problem. If there is a thick, hard foam on top of the secondary clarifier, it must be removed and broken with a water jet and, if possible, eliminated. (This may be due to low or high aeration.)

Air valves

If we find that any aeration system components (grinders, mammoths R1 and R2, braking outflow and suction mammoths) are not working properly, for example, fine-bubble aeration is hardly working, or the mammoth pumps are not working enough, the valves in the unit will not work properly. Based on the user manual, all valves can be adjusted in the correct way. For other reasons, the valves shall not be adjusted: the process control cannot be solved by adjusting the valves.

Excess sludge

If we find a sludge ratio above 50%, it is worth removing the excess sludge with the help of a specialist (septage removal). If this is done, the aeration allowing the settling process to work has to be stopped. This takes half an hour or so in the same way as in sludge probes. In this case, the upper part of the fluid is almost completely clear in all the chambers, and the settled sludge is clearly visible at the bottom. The suction tube must be squeezed to the bottom of the chambers to remove the large part of the sludge. In this case, the fittings, pipes and connectors at the bottom of the chambers have to be handled with care to avoid damaging them during work. Sludge should not be completely pumped out because it contains the largest number of bacteria, which are responsible for biodegradation. The septage removal should be performed resulting that the water level is reduced by 40–50 cm in each chamber. It is important to move progressively during the emptying of the chambers; it should not be possible to have a difference of more than 30 cm between the water levels of each chamber, as this can damage the walls due to excessive pressure. The same applies to pumping and filling. The unit has 3 “chamber pairs” that are connected at the bottom, resulting in the fact that the pumping in one chamber has effect on the other chamber’s water level.

After removing the sludge, the water level in the unit must be restored. The easiest way to do this is by opening a garden hose or by opening the taps in the house or flushing the toilet. With the normal water level reset, the valve settings, aeration, mammoth pumps, etc. must be checked again according to the above-mentioned aspects. If we found everything right, the aeration should be restarted and the cover of the equipment returned.

Depending on the loading rate, sludge must be removed 1–3 times a year.

GRAF wastewater treatment unit

For over 50 years, the GRAF brand represents high quality plastic products. Established in 1962 and originally selling agricultural plastic boxes, it became the European market leader in rainwater harvesting. The GRAF Group currently employs a workforce of over 500 employees. It employs 310 people in Germany and has a turnover of over EUR 105 million. GRAF products are exported to more than 70 countries across the globe. They have been manufacturing and distributing small sewage treatment equipment since 2001.

Figure 7
One2Clean wastewater treatment unit [5]

Table 10
Technical data of the One2Clean wastewater treatment plant (compiled by the author)

Technical data	One2Clean 1-3 EW	One2Clean 4-5 EW
Maximum capacity	3 PE	5 PE
Maximum daily BOD_5 load	0.18 kg	0.30 kg
Maximum daily hydraulic capacity	0.45 m^3	0.75 m^3
Q_{hmax}	0.03 m^3	0.05 m^3
Maximum daily energy consumption	0.6 kWh	1 kWh
Line voltage	230 V	230 V
Installed power	42 W	48 W
Capacity built	450 l/d	750 l/d

Field of application of the One2Clean wastewater treatment unit

One2Clean wastewater treatment unit is a compact and easy-to-use biological wastewater treatment equipment that is suitable for the biological treatment of household wastewater between 1 and 50 inhabitants. One2Clean biological wastewater treatment units are ideal for treating communal wastewater from family homes, holiday resorts, restaurants, hotels, other service industry, public

institutions (kindergartens, schools). It can be used under any circumstances, intermittently, with variable loads.

The One2Clean wastewater treatment unit complies with the requirements of MSZ-EN 12566-3 and has a CE Declaration of Conformity. This equipment provides an excellent environmental solution and does not have any harmful effects on the environment; it is quiet, odourless, with minimal external electrical energy input. The parts of the equipment are easy to install on the site and require no special expertise. It does not require continuous supervision during the operation, and the inspections and maintenance work can also be carried out by the owner of the property. The maintenance task consists primarily of the annual septage removal collected in the storage tank and the control of the aeration system.

System benefits:

– can be used under any circumstances
– programmable max. 90-day break (e.g. for weekend houses)
– operates with minimal external electricity input
– in the event of a break of more than 90 days, the system does not need to be drained
– CE certifications according to ISO 9001 and MSZ-EN 12566-3
– 5 years extended operating warranty
– excellent cleaning efficiency
– low operating and maintenance costs

Installation of the sewage treatment unit

The equipment must not be connected to the electricity network during the installation period. The equipment and the wastewater connection system must be protected from frost and must therefore be installed with a minimum of 50 cm of ground cover; if this cannot be ensured, a suitable insulating material has to be applied.

The installation of the equipment's electrical units must always be carried out by a specialist. All joints must be completely sealed, because leakage from the unit could contaminate the environment and adversely affect the performance of the equipment. Avoid excessive effort when tightening screws, as this may cause damage. When making connections, make sure that weight, vibrations, or stresses do not fall on the unit.

Connection to the wastewater inflow

Connection to the wastewater network is only possible after the entire system has been installed and after a successful operation test. Connector pipe size: NA 110 mm. The connection wire must always be sloped. When raw wastewater is discharged, the slope can be 1:100, and for treated wastewater the slope is 1:200. Avoid 90° bends, if necessary, install cleaning element or use 45° fittings. The connection pipe material can be KG-PVC or KPE. When using a pump, the recommended pipe diameter DK 32, material KPE, pressure class 6 bar.

Electrical connections

The power cord of the equipment must only be installed by an electrician. When installing the connection cable, it is necessary to provide the appropriate contact protection (FI relay and circuit breaker). The power cord can be permanently attached to the power cord. Never use the cable to pull the plug out of the socket. Protect the plug and the power cord from hot surfaces, oil pan and sharp edges.

The values given in the technical data must correspond to the mains voltage at the installation site. During installation, the person in charge must check whether the electrical connection has a grounding that meets the standard. Network connection can only be extended with the standard extension cable. The power plug and connections must be designed to protect against splashing water.

Installation and commissioning of the sewage treatment unit

The winter months should be avoided as far as possible during the commissioning of the equipment (December, January, February). The installation of the appliance must be carried out as described in the manual, otherwise the installation may cause malfunction. Nobody may remain in the container(s) and shaft(s) while operating the equipment. The appliance may only be used in a power range specified in the guarantee leaflet. Commissioning may only be carried out by trained persons aged 18 and over. The basic safety and health regulations must be adhered to during installation. Wash hands with disinfectant after contact with all sewage and sludge. It is important that the load capacity of the tanks and shaft covers is max. 70 kg, so it is forbidden to drive on the cover.

It is forbidden for the installer to consume alcohol before and during work.

Organic matter of wastewater is decomposed by cultured microorganisms in activated sludge. Starting the system needs to fill the unit with clean water. Water filling must also be carried out in the connecting pipes. Filling can be accelerated so that raw wastewater can be fed into the system, but it should not exceed 50% of the daily load. If it is only filled with clean water, 50% of the total amount of planned wastewater must be fed into the unit. If the total amount of wastewater arriving is not more than half of the planned value, of course the whole quantity can be discharged.

The introduction of wastewater into the aerobic zone begins the formation of activated sludge. This will increase to 3–4 weeks in summer and 6 to 8 weeks in winter to ensure maximum treatment efficiency, but within 10 days you can achieve an acceptable efficiency. Switch on the aeration unit after the raw wastewater has been discharged. The aeration unit is not in continuous operation and is switched on (programmed) by the controller. Hold in case of a power failure (no wastewater is generated for more than ten days), the program has to be switched to “holiday” operation.

Operation of the One2Clean wastewater treatment unit

Due to their low weight, small sewage treatment systems made of plastic can be installed without heavy equipment. This means that it is easy to transport and install in places that are difficult to access. Plastic wastewater tanks also have smooth internal surfaces that make treatment easy. What is more, plastic containers are 100% waterproof.

These systems are based on the idea that purification processes take place naturally if we provide the right conditions for operation. Oxygen is essential. If there is an oxygen deficiency in the system, the "good bacteria" that are needed for proper treatment are "replaced" by "bad bacteria" that grow in low oxygen conditions. These bacteria produce a black, sticky sludge that will gradually clog the system. Therefore, good oxygen supply of the system is absolutely necessary to prevent clogging.

The wastewater from the property is used for biological treatment and for storing the sewage sludge in the treatment tank. Biological treatment of wastewater is carried out by bacteria. An important part of the operation of the equipment is the creation of the proper aeration to ensure that the bacteria in the activated sludge have sufficient air (oxygen). The supply of a sufficient amount of fresh air (oxygen) is provided by a programmed control unit controlled by a compressor and a fine bubble aeration unit. The sampling point for the effluent wastewater quality is in the control cabinet.

The One2Clean wastewater treatment unit is based on the SBR principle (Sequencing Batch Reactor) and it has a batch operation. The equipment consists essentially of an aerobic unit (control cabinet). This unit is divided by a baffle wall and is divided into an activated sludge zone that is in contact with the lower part of the container, so that in this process the total amount of wastewater is directly controlled by an aerobic wastewater treatment. The whole equipment is aerated by a fine bubble aeration, and the bacteria that grow up in the activated sludge treat the wastewater biologically.

Wastewater treatment in the One2Clean is done without pretreatment; therefore, no anaerobic processes can develop. The operation of the wastewater treatment plant is controlled by a microprocessor control unit that controls the compressor and the air distribution.

SBR technology is a series of different phases that follow each other and run at least once a day.

Phase 1. Aeration: The incoming raw wastewater flows directly to the biological zone. There is no lifting, delay, the aerobic microorganisms immediately start wastewater biodegradation. Aeration is performed by a compressor that uses the ambient air. Aeration is a batch process that allows controlled wastewater treatment. Thus, the equipment can be adapted to different environmental conditions and loads.

Phase 2. Sedimentation: There is no aeration in the second stage. The activated sludge and other sedimentation materials settle by gravity. In the upper part, there is a clear water zone and the sludge is at the bottom. Possible floating sludge is above the clean water zone.

Phase 3. Removal of treated wastewater: At this stage, the biologically treated wastewater is discharged from the SBR tank. This pumping process is performed with compressed air according to the "mammoth pump principle". The device is designed not to absorb any floating sludge that may be formed at the top. The device provides the minimum water level without a separate structural element.

After Phase 3 is completed, Phase 1 starts again with the biological treatment. It runs 2 cycles a day. The individual selection of switching times can be set by the operator–maintenance personnel.

When using the biological sewage treatment unit, the followings should be considered:

- for bacteria, the optimum pH is between 6.5 and 7.5; detergents from households increase the pH, therefore, a maximum of 2 to 3 washing machine programs per day is allowed
- large amounts of concentrated acids and alkalis (> 0.5 l/day) should not be used, e.g. channel and drain cleaners; drainage of condensation and other heating boiler water and water used

in heating pipes; high concentrate organic pollutants, e.g. milk and dairy products, scraps of food, fruit and vegetable residues
- it is forbidden to introduce rainwater, swimming pool and Jacuzzi water, wastewater from animal husbandry and animal slurry, toxic substances: thinner, flammable substances, pesticides and motor oil into the sewer
- dispersal of non-degradable materials into sewers e.g. paper napkins, office paper, sanitary napkins, packaging material, foils, tomato shells, sunflower shells is not allowed
- limit the release of cooking fats and edible oils into the sewer (max. 2–3 dl/day); on the one hand, they can block the sewer system and, on the other hand, it is very unfavourable for microorganisms if they get into the sewage treatment unit; it is recommended collecting and composting them

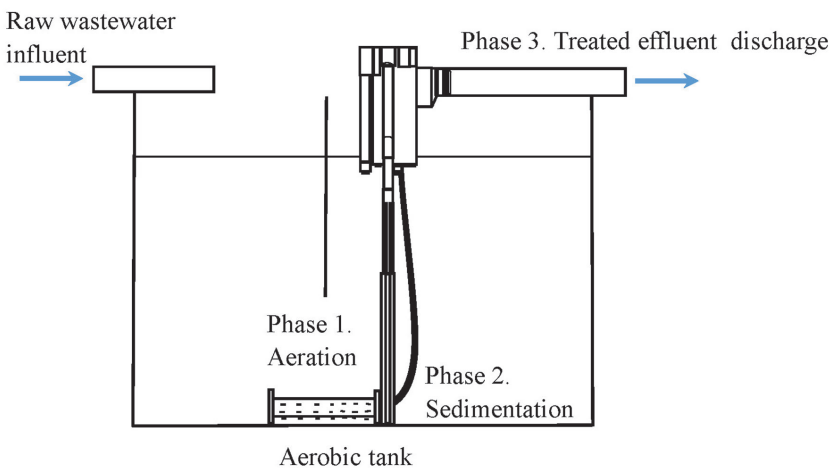

Figure 8
Operation principle of the One2Clean wastewater treatment unit (compiled by the author)

Monitoring and inspection frequency of the wastewater treatment unit

One2Clean does not require continuous monitoring, but periodic inspections are required for these types of equipment. These controls are partly carried out by the owner of the residential property (if any). No special safety equipment is required for general inspection and maintenance, but dangerous gases can be generated in the tanks and manholes, so it is forbidden to enter them. If maintenance or repairs are required in the tank or manhole, they may only be entered wearing suitable protective equipment after draining and adequate ventilation.

It is advisable to thoroughly inspect the entire system every 5 years. If the operator responsible for operating the equipment is designated, the operator is responsible for carrying out the necessary checks, treatments and other work.

The inspection should also cover the connecting structures outside the equipment. Winter operations and controls are similar to those in summer. Make sure that plastic products at low temperatures usually reduce their resistance to impact and mechanical forces.

The equipment must always be switched on. The operator's duty is to operate the equipment without error. Almost all malfunctions lead to a reduction in the treatment capacity of the equipment.

Therefore, errors should be recognised in time and corrected immediately or repaired by a qualified service technician. The periodic inspection shall be carried out as follows:

Daily checks: Daily check that the unit is operating properly. This is true even if the operating light is green and there is no audible alarm.

Monthly checks: Visual inspection of the sludge, there should be no turbidity or discoloration in the effluent. Checking the clogging of the influent/effluent (visual inspection). Read the air compressor operating hours (all hours of operation), aeration and drain valve, and record it in the event log.

Table 11

Inspection frequency of the unit by the operator (compiled by the author)

Name of activity	Frequency
Visual inspection of the unit and the control	Daily
Checking of flows	Every 6 months
Check sludge blanket level	Every 6 months
Sludge removal	Annually
Checking the aeration system	Every 6 months
On-site inspection, maintenance for all equipment	Every 6 months

Maintenance of the wastewater treatment unit

Wastewater treatment systems can operate in an active and passive manner depending on the installation. These wastewater treatment systems are reliable, robust, withstand extreme loads and load fluctuations, are durable and significantly reduce pollutants in raw wastewater. Their operation is simple; the maintenance covers the checking and fixing the errors in the tanks and in the aeration system.

However, the system may fail if there is clogging, and sewage could leak from the tank and raw wastewater may reach the infiltration area, but this malfunctioning is easily detectable. This phenomenon can be avoided by regular maintenance and inspection.

Control cabinet

From the supplied property, the wastewater flows directly into the treatment unit, where biological treatment takes place, and suspended solids and excess sludge collects. From the top of the manhole, it should be checked visually that the water level in the tank is adequate, there are no deposits around the openings and there is no hard layer on top of the wastewater. Visually, we need to make sure that there are no greasy or accumulated floating sludge at the inlet and outlet and around the water lift. If the lower level of the floating sludge approaches the upper end of the ending of the water lift, the floating sludge should be removed immediately. Other deposits should be removed

with a long-edge brush or high-pressure washer. Check sludge levels at least twice a year. Excess sludge should be removed once a year. The tank should be filled with water after the sludge removal.

Dangerous gases can be generated in the unit; therefore, it is forbidden to enter. If maintenance or repair is needed, it can be entered wearing protective equipment after draining and adequate ventilation.

Lift station and pump

Visually determine that there are no deposits in the shaft and on the pump, check that the level switch is working properly. It is advisable to remove any deposits on the pump and pump shaft annually, making sure that any solids that may fall out of the pump do not enter the system. It is a common mistake that the level switch does not switch properly due to the deposited solids, and thus the water level in the shaft will rise, which will swell the system and the oxygen supply will be insufficient. The pump may remain permanently switched on due to deposits, resulting in damage to the pump.

Infiltration zone

Visually, in the area around the infiltration zone, the earth's surface must be dry and free of precipitates and should be odourless. If water appears on the surface of the infiltration zone, and the sampling shaft is filled with water, this indicates that the drainage area is blocked, overloaded, or the groundwater level has risen. In case of clogging, the infiltration zone must be flushed with a high-pressure washer through the cleaning opening at the end of the zone. If there is no visible result, the infiltration zone must be dismantled and clogging must be stopped; if this is not possible, the clogged pipes or gravel layer must be replaced. If the elevated groundwater level or the system is permanently overloaded, a new zone must be used. If there is a wastewater smell in the area, it indicates that the ventilation system is blocked.

In order to determine whether there is a need to remove excess sludge from the wastewater treatment unit, a sedimentation test should be carried out according to the maintenance interval. The SV30 must be determined for the sedimentation test. SV30 is the amount of sludge that can be measured after 30 minutes of sedimentation of 1,000 ml of sludge. The amount of sludge in the wastewater treatment plant can be determined on the basis of SV30. The SV30 is measured in a 1,000 ml stationary cylinder.

The following steps must be followed when measuring:

1. Switch on aeration – if not active – and let the sludge mix briefly.
2. Immerse the sampling vessel in the container and take a sample of the activated sludge.
3. Fill the sludge sample into the stationary cylinder to the 1,000 ml mark.
4. Allow the sample to settle in the stationary cylinder for 30 minutes without agitation.
5. Read the sludge height. If the level is > 900 ml/l, then the excess sludge should be removed.

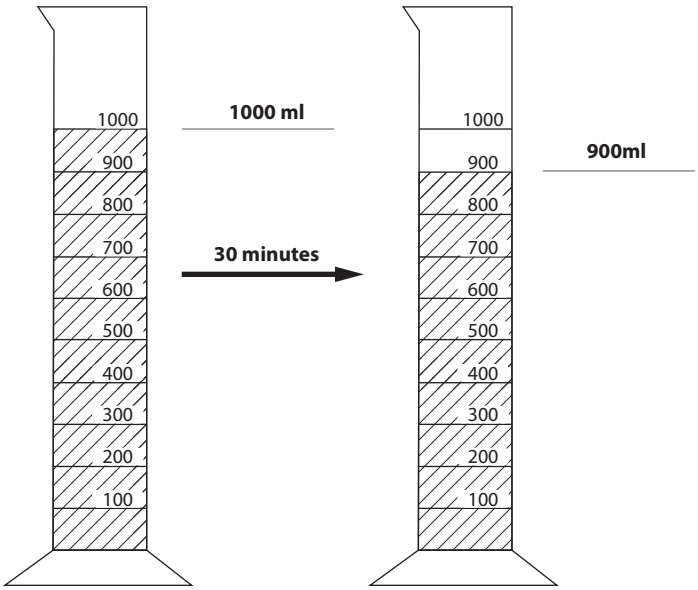

Figure 9
Sludge settling test (compiled by the author)

ASIO AS-VARIOcomp wastewater treatment units

ASIO Hungária Kft. is present on the domestic market as a member of the ASIOGROUP group of companies, which has nearly 20 years of professional experience and significant international background. Their main profile is the distribution and production of polypropylene wastewater treatment equipment. Their activities range from the preparation of licensing and implementation plans, through production, to commissioning, but they can also help with long-term, reliable operation with the maintenance service. The technologies distributed are becoming more widespread; these have been used worldwide in many places.

In addition to their wastewater products (grease, oil separator, industrial and communal wastewater treatment units), the company deals with conventional storage and buffer tanks, as well as rainwater recycling systems, which can be customised according to the needs of the customers. As opposed to expensive regional systems, AS-VARIOcomp is the perfect solution for small settlements, as well as for the private and public sectors where there is no public sewer connection or a central sewage collection system. At these locations, the AS-VARIOcomp biological wastewater treatment plant operates as a classical utility replacement, providing a technically and environmentally sound background for cost-effective treatment of wastewater treatment.

Figure 10
AS-VARIOcomp K [6]

Table 12
Technical specifications of AS-VARIOcomp K (compiled by the author)

Type	Population Equivalent (PE)	Q (m^3/day)	BOD_5 (kg/day)	Size (diameter × height) (mm)	Weight (kg)	Energy demand (W)
5K	3–5	0.6	0.24	1,320 × 2,020	160	60
8K	6–10	1.2	0.48	1,480 × 2,020	260	80
15K	11–17	2.25	0.9	1,700 × 2,800	450	110
20K	18–24	3	1.2	1,945 × 2,810	700	120
5K ULTRA	3–5	0.6	0.24	1,320 × 2,020	195	150
8K ULTRA	6–10	1.2	0.48	1,480 × 2,020	275	170
15K ULTAR	11–17	2.25	0.9	1,700 × 2,800	480	390
20K ULTRA	18–24	3	1.2	1,945 × 2,810	730	400

Table 13
Process guarantee on effluent – AS-VARIOcomp K and K ULTRA (compiled by the author)

Parameter	AS-VARIOcomp K	AS-VARIOcomp K ULTRA
$BOD_{5\,(}$mg/l)	25	5
COD (mg/l)	90	40
Suspended solids (mg/l)	30	3
P_{total} (mg/l)	2	2

Application of AS-VARIOcomp K

There are many ways of application of AS-VARIOcompK treatment unit such as:

- single-family houses
- motels
- restaurants
- smaller industrial facilities

Can be used in residential areas that are only temporarily occupied – e.g. holiday and weekend houses, ranches, hunting houses – where there is no continuous wastewater load.

Figure 11
AS-VARIOcomp unit [6]

Table 14
Technical specifications – AS-VARIOcomp

Type	Population Equivalent (PE)	Q (m^3/d)	BOD_5 (kg/d)	Size (LxWxH) (mm)	Weight (kg)		Energy demand (kW)	
					N	N/PUMP	N	N/PUMP
30N	25–33	3.75–4.95	1.62	2,000 × 2,160 × 2,830	1,250	1,320	0.33	1.2
40N	34–44	5.1–6.6	2.28	3,000 × 2,160 × 2,830	1,400	1,470	0.33	1.2
50N	45–55	6.75–8.25	3	4,000 × 2,160 × 2,830	1,750	1,820	0.75	1.4
60N	56–70	8.4–10.5	3.6	4,000 × 2,160 × 2,870	1,900	1,970	0.75	1.6
80N	71–90	10.65–13.5	4.8	5,000 × 2,160 × 2,870	2,200	2,270	0.75	1.6
100N	91–110	13.65–16.5	6	6,000 × 2,160 × 2,870	2,450	2,520	1.5	2
125N	111–135	16.65–20.25	7.5	7,000 × 2,160 × 2,870	2,700	2,770	1.5	2
150N	136–155	20.4–23.25	9	8,000 × 2,160 × 2,870	2,950	3,020	1.5	2

For AS-VARIOcomp N/P and AS-VARIOcomp N/P/PUMP equipment, the phosphorus concentration of the effluent treated water must not exceed 2 mg/l.

Table 15
Process guarantee on effluent – AS-VARIOcomp

Parameter	Effluent
BOD_5 (mg/l)	25
COD (mg/l)	100
Suspended solid (mg/l)	25

Installation of the AS-VARIOcomp wastewater treatment unit

The equipment may not be installed in a location where the integrity of the equipment is endangered, such as territory with earthquake hazards and floodplains.

The installation must be carried out in accordance with the approved design or construction plan. Deviations from the licensing or export plan may only be made with the written permission of the designer.

In case of installation, the depth of the foundation pit shall be determined so that the sandstone gravel levelling layer and the reinforced concrete substrate determined by the designer are located. Under the reinforced concrete min. 10.0 cm thick sandy gravel (grain size: 2–10 mm) shall be placed for balancing purpose. The construction of the concrete slab can be a ±1 mm flat (±1–3‰ slope) surface. The surface of the reinforced concrete is determined by the designer depending on the surface and weight of the unit.

The level of the reinforced concrete for the stability of the equipment must be determined.

The perimeter of the pit is approximately 50 cm greater than the perimeter of the equipment to be installed.

In case of high groundwater level, the installation must be concreted around. The height of the concreting is determined by the designer based on the maximum groundwater level.

Installation steps:

1. The dimensions of the pit and the buoyancy force must be determined by the designer taking into account the groundwater level.
2. There must be no water in the work pit. Otherwise, its level should be lowered to the base level.
3. After preparing the concrete foundation, check the unevenness of the concrete foundation (tolerance ±1 mm) and record the result of the measurement. In case the unevenness does not correspond to the allowed tolerance, the installation should not be continued. Provision must be made for adequate tolerance.
4. Prior to insertion, the condition of the equipment should be checked, especially for welds. In case of potential damage, do not proceed with installation and contact the manufacturer/ distributor. Damages must be repaired before being placed in the work pit.
5. Make sure there is no foreign material or rainwater in the unit. The foreign objects must be removed; the rainwater must be pumped out.
6. Make sure that there are no objects, stones, earth, etc. on the concrete. These should be removed if necessary. If this “dirt” cannot be removed from the concrete base, the installation should not be continued.
7. The release of the unit onto the concrete slab should be carried out evenly and slowly.

8. After the tank has been placed, the surfaces must be cleaned of dirt by mechanical means.
9. Then the piping – the inlet and outlet pipes – must be connected to the tank. The connection seals must be made with silicone oil.
10. The equipment consists of one compressor, installation or connection (electrical and air pipe connections) by the designer based on the design documentation. For larger equipment, the machine consists of several units (compressors, pumps, control panel). They must be installed by the customer, but their connection is always undertaken by the manufacturer/distributor and will be carried out at an agreed time after completion. The manufacturer/distributor makes a first setting on the control panel after wiring the electrical equipment. However, during the subsequent operation, the operator must be provided by the manufacturer/distributor for the maintenance or servicing of electrical equipment.
11. The electrical connection must be carried out by a qualified technician using the original connection cable. During concreting, the tank must be stiffened from the inside against the pressure of the concrete. The need for stiffening is determined by the designer. Prior to concreting, the tank must be filled with water up to a height of 1 m and then the height of the water level must be raised continuously along with the rate of concreting so that the water level above the concreting level should be at least 30 cm.
12. When recharging with the ground, the tank must be filled with water up to a height of 1 m and then the height of the water level must be raised continuously, along with the rate of discharge, so that the water level above the concreting level should be at least 30 cm. Compression of individual layers max. 30 cm layers – the compactness (Trφ) specified in the design – can only be done with a light compacting machine (e.g. cart), making sure that the packing machine does not touch the container. When compacting the ground, make sure that the pipe connections are not damaged. If the pipe end of the unit is damaged or broken during the earthwork, the manufacturer/distributor is not able to carry out warranty repairs, and the manufacturer/distributor will correct the defect for a fee.
13. In case of concreting or backfilling with earth, the tanks above the discharge height must be stiffened from the inside. It is recommended to place the supports at a height of 0.5 m, horizontally, at 1.0 m.
14. If the slab is concreted, it must be supported by the slab to prevent the tank from falling.
15. After installation, the MSZ 172-1: 1989 contact and ground resistance test must be performed.
16. The installation, touch protection and grounding protocols must be retained by the operator.

Commissioning of the AS-VARIOcomp wastewater treatment unit

Installation must always be carried out by the manufacturer/distributor before putting the equipment into operation. In the commissioning, customers (operators) are trained by the distributer.

The commissioning consists of:

– full control
– checking the base
– staff training
– giving the original documentation

The commissioning report is prepared, which contains the data and signatures of the trained persons.

- proposal for commissioning
- operational log book

The waterproofness of the container must be checked by a seal test. The water tightness test is carried out by the manufacturer/distributor during manufacture, and the water tightness of the equipment is covered by the warranty.

The operation of the unit starts with the initiation of biological processes. To start the aeration, the cable of the air compressor is to be connected to the electricity grid. The appropriate connector is selected during the installation of the wastewater treatment plant.

In the event of any damage of the power cord, unplug the air compressor immediately from the connector and ensure that it is properly replaced. Once the air compressor is switched on and the tank is filled with clean water, it is possible to start the equipment.

The air pump must be kept permanently switched on, otherwise the required efficiency cannot be achieved.

The treatment efficiency gradually increases and reaches maximum efficiency in about 4–8 weeks. The time can be reduced by applying activated sludge from an external source. It is advisable to obtain sludge from a well-functioning plant for inoculation. In this case, contact the manufacturer/distributor.

Purpose and tasks of the testing period

Purposes

The test operation is a definite period of time prior to the final commissioning of the equipment. The purpose of the test operation is to drive the equipment, to set the parameters of the treatment technology, to prove the performance of the equipment in practice, and to develop the optimal operation of the entire system.

Tasks and responsibilities

During the test operation, professional supervision must be ensured. The task of the operator in test mode is to carry out measurements and tests necessary to achieve the specified objective, to evaluate the system and to prepare the final handling and maintenance instructions based on the set parameters.

Test run conditions

The proper installation of the equipment is a prerequisite for starting the test period. The operation must be checked in advance with tests, where the designer, the constructor, the investor, the actual operator, the future operator and the representative of the administration must be present. During the operational tests, the durability of the performance shall be verified.

Operation of the AS-VARIOcomp wastewater treatment unit

Parts of the equipment:

Primary clarifier: The incoming settable solids are retained. The sediment from the sewage and the activated sludge are stored here. Mineralisation takes place here; the high molecular substances are broken down.

Biological tank: Mixture of microorganisms, called activated sludge, are "fed" from organic and inorganic substances, using the oxygen of the air. The more the amount of the activated sludge increases, the more the content of organic matter in the wastewater decreases.

Secondary clarifier: Settling process separates the activated sludge from the treated wastewater. In reality, this is a relatively complicated biochemical-technological process that works when an optimal amount of air is introduced into the system, optimal concentration and sludge age is maintained.

The processes of the wastewater treatment plant are integrated into a tank. In order to improve the treatment efficiency, a biomass carrier can be placed in the biological volume, which is a solid grid that retains and grows microorganisms that feed on the substrate (nutrient) in the wastewater like the activated sludge. For pumping, mammoth pumps (a tube with air at the lower end that goes up and takes up the fluid to be pumped) are used.

The wastewater flows into the pre-settler where the mechanical, floating and settable materials are removed. The primary effluent flows to the biological zone, where activated sludge and attached biomass are responsible for biological treatment. The activated sludge flocs consist of bacteria (autotrophs, heterotrophs, within that nitrifiers, denitrifisers: Pseudomonas, Nitrozomonas, Nitrobacter). The mixture of fluid and activated sludge flows from the biological reactor to the secondary clarifier, where the treated water is separated from the activated sludge by sedimentation. Treated water is transferred to the outflow tank by means of the mammoth pump, from which it leaves the sewage treatment plant. The majority of the settled sludge is recirculated to the biological zone. The excess, aerobically stabilised sludge is reverted back to the primary clarifier.

The equipment is able to equalise the diurnal flow fluctuations. The air used by the aerator is provided by the air compressor. The air from the aeration is used to drive the mammoth pumps.

Temporarily, when the unit is underloaded (during holidays), instead of letting out the treated water, the flow is reverted back to the clarifier.

AS-VARIOcomp wastewater treatment units in series

If two units with 100 PE are in series, the first one is highly loaded, the second one receives less load. In this case, each stage has its own sludge recirculation, so at the end of the technological process, the sludge age could be increased by 2/3 of the original sludge age resulting in better efficiency.

It is worth to use an anaerobic pre-selector zone, where the recirculated sludge could be introduced. This results in more efficient phosphorus removal. In the first stage, aeration has a higher intensity and the sludge age is lower compared to the second stage. The biological processes are identical compared to the one stage system.

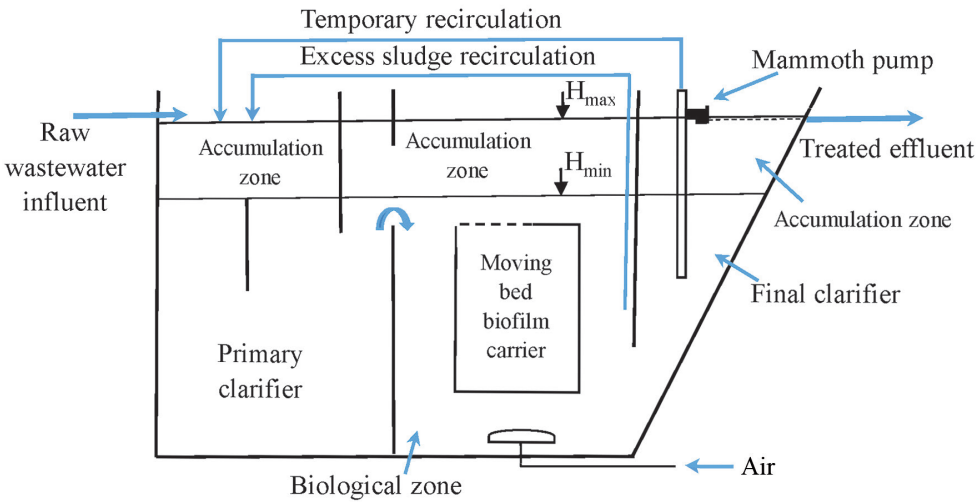

Figure 12
Operation of the AS-VARIOcomp (compiled by the author)

Processes in the AS-VARIOcomp

The composition of the household wastewater depends on the lifestyle of the people living in the area, but in general it can be stated that raw wastewater discharge is not allowed into surface water. In most cases, combinations of physicochemical and biological processes should be used to treat the wastewater. Non-soluble, floating or coarse matter should be filtered with screens, sand settled in grit chambers, prior to further treatment. Aerobic biological processes produce excess sludge, which must also be separated from the aqueous phase by mechanical means.

Depending on the sensitivity of the recipient, treatment should always be done in a controlled manner, which should be provided by a combination of the above methods. Removal of nitrogen compounds means spatial or temporal alternation of aerobic and anoxic conditions. Under these conditions, the sludge recirculation from oxic to anaerobic zones can significantly increase the phosphorus removal without chemical addition. Municipal wastewater treatment is a complex system in which all the nutrients necessary for microbial growth are available.

There are few products in the human activity, the quantity of which is close to the amount of wastewater and simultaneously, continuously generated and processed. In dry weather, household wastewater actually contains only the wastes removed by the population together with liquid. This comes from toilet use, bathing, hand washing and washing.

Treatment stages of the AS-VARIOcomp wastewater treatment plant

Mechanical pretreatment: Its purpose is to protect the equipment from larger solids. This is usually solved with a screen installed in front of the unit. This screen has to be cleaned from time to time; screening is a hazardous waste due to its microbiological activity.

Clarification: Its purpose is to remove suspended materials and related adsorbed pollutants, thereby reducing the load on the biological unit. The load of the equipment is, of course, dependent on the length of the sewer system; we do not include it in the evaluation and analysis, since in this case there is no sewage transport. In large wastewater treatment plants, it is a huge problem that wastewater travels for half a day or even longer, before it arrives to the wastewater treatment plant, causing unpleasant anaerobic processes. For a 10-km-long gravitational public sewer, it will take 3 to 6 hours for the wastewater to get to the sewage treatment plant. This is not the case here, because the channel is very short.

Biological treatment: Its purpose is to remove inorganic and organic pollutants in the wastewater by microbiological processes, using oxygen. The products of the processes are carbon dioxide, sludge (inorganic and organic matter containing nitrogen and phosphorus, cells of dead microbes), nitrogen gas, nitrite, nitrate and sulphate compounds.

Secondary sedimentation: Its purpose is to separate the sludge from the treated wastewater. Sludge is a mixture of water and solid particles with varying dispersions and shapes, which are expressed in dry matter, approximately 2–9%.

The effluent from the primary clarifier flows to the aeration unit. Organic matter is removed in the aerated zone. The process is performed by autotrophic and heterotrophic microorganisms. Air is injected with an atomiser and the purpose of aeration is twofold, one is aeration, another purpose is to mix the sludge so that it does not settle in the equipment and there is no digesting process in the anaerobic anoxic micro-environment at the bottom of the tank.

The removal of ammonia is carried out by Nitrosomonas europeae, the product of the process is nitrite ion, which is converted into nitrate by the Nitrobacter winogradsky. Phosphorus is in the form of phosphate, inorganic polyphosphate, organic phosphate (ATP, ADP, AMP). With lime, aluminium salts can be precipitated, or pre-precipitated in the system, but in the latter case, the amount of sludge should be increased.

Conversely, phosphorus may be present in critical quantities, which can be a problem for treated wastewater as phosphorus causes eutrophication (nutrient enrichment) in surface water.

The treatment process is carried out by the biomass, i.e. sludge, composed of microorganisms. These are autotrophic or heterotrophic bacteria, including anaerobic, aerobic or facultative anaerobic microbes in the biomass. This is a microorganism community in the sludge, each of which depends on the other: the nitrifiers and denitrifiers live in symbiosis. Activated sludge develops spontaneously; if we inoculate our system with sludge from a well-functioning plant, this process can be significantly accelerated.

The critical operating condition is the amount of substrate, i.e. the material to be removed from the wastewater and temperature. Obviously, the processes are faster when the temperature is high, but of course, the temperature of the water does not need to be continuously measured with a thermometer, as the temperature depends on the time of day and weather. (Warm water used for washing and bathing is likely to heat the water to a satisfactory temperature). Most of the microbes feel mesophilic at 20–40°C and can reproduce and function.

We have already mentioned the load on the equipment as an important parameter for large plants. We can also talk about the load here, but in the present case, the key factor is not the easily biodegradable organic matter, but the flow fluctuations.

During the day, most people are not at home, they go to work. If we look at the overall use of water, we can see that in the morning when we are preparing, there is much greater water use than at noon when only young and older people in the inactive age are at home. The other peak is

in the evening: we arrive home, wash, bathe, cook. At weekends, cleaning is responsible for the high water consumption. We should consider these fluctuations in the wastewater treatment unit as well. When the waterflow is low, water stops in the equipment, as there is no pumping. The other case is when suddenly the amount of water flowing in increases putting a higher load on the substrate: it is advisable to set the aeration to a higher degree.

An additional advantage of the aeration is to prevent sludge bulking. This phenomenon occurs when a low amount of nutrients is found in microorganisms. In nutrient-deficient media, microbes are long; they grow like yarns to reach the nutrient. This prevents flocculation and the filtering of flocculated sludge.

If the aeration intensity is low, it is not possible to apply high sludge load (nutrient-rich sludge), because it may cause sludge bulking. To prevent sludge bulking, two separate zones have to be ensured, one is nutrient rich, the other one has low nutrient concentration. This means in practice to have an anoxic zone prior to the aerobic zone.

The sludge will be starved in an anoxic system since the aerobic microorganisms could only gain oxygen from nitrate.

It is important to remember that raw wastewater does not contain nitrate since human activity produces ammonium ion. Nitrates are produced during the operation of microorganisms in wastewater.

The result of the wastewater treatment is the effluent water, carbon dioxide and other gases. Another product is the sludge. From the biological unit the water flows to the secondary clarifier, where phase separation occurs. The essence of this is that the solids settle down and the clear water is discharged at the top. It can happen that biological processes occur in the secondary clarifier. Anaerobic conditions may develop, where methane and other gases are produced and the sludge rises.

Such a problem cannot occur if the sludge comes from a well-aerated system. It is recommended that sludge be removed twice a year and transported. The volume of excess sludge is high, its infectibility and pollutant content are varied.

In order to ensure the smooth operation of the equipment and the effluent quality, the following materials should be avoided in the household:

- infectious and toxic substances
- paint, solvents and chemical sprays
- non-dissolved acids and alkalis
- other chemicals such as chemical developers, adhesives

Take care of disinfectants: Sanitary hygiene disinfectants should be used very carefully. Not only viruses and bacteria in the household are destroyed, but also bacteria in the wastewater treatment equipment that perform the treatment.

Care should be taken to avoid excessive washing: The treatment process in the wastewater treatment unit is adversely affected by the sudden waterflow containing large amounts of detergents and surfactants.

Take care of fats and grease: In addition to chemical factors, large amounts of animal fats and vegetable oils also pose a threat to the performance of the treatment process. During the decomposition of fats and grease, the environment becomes acidic, deteriorating the treatment efficiency.

Take care of the water discharged from pools: Large amount of clear water discharge, even if it has no pollutants, could cause “microorganism wash-out”.

It is advisable to separate the rainwater from the wastewater network, because it increases the fluid volume and dilutes the wastewater causing nutrient-poor zones.

In nutrient-poor zones, filamentous bacteria may develop with low settleability. Water from swimming pools should not be allowed to discharge.

The operating and maintenance instructions of the equipment must cover the maintenance of each technological equipment and components. Sludge management shall be also addressed.

The operation of the equipment shall follow technology, safety and public health regulations and the conditions for the operation shall be specified in a separate manual.

The operating rules must include regulations on:

– daily operation
– technological processes
– periodic inspections and checks, record and evaluation of operating data
– personal conditions
– security, rules for emergency and health protection, preliminary and periodic medical examinations

The operator must have:

– equipment documentation
– labour protection and protection against physical contact documents
– technical documentation and commissioning protocol

Implementation of the operating instructions must be recorded in an operational log. The log is managed by the operator recording sampling and other events. After power-up, regular checks and activities specified below should be performed.

Table 16

Maintenance frequency (compiled by the author)

Name of operation	Time interval
Checking air compressor operation	Daily
Visual inspection of the unit	Weekly
Check and adjust sediment cycle	Monthly
Sludge removal	Every 6 months
Air filter cleaning	Every 3 months
Dewatering the aerator	Every 3 months
Cleaning of interior parts of the unit	As needed
Removal of spilled sludge	As needed
Sampling	As needed

Check air compressor: It must be verified, whether the air compressor is working. Unusual noise could be a sign of failure.

Visual inspection: Visual check has a high importance in the successful operation.

After opening the lid, the followings should be checked:

Mammoth pump: The mammoth pump is a submerged pipe, having air at the bottom responsible for sludge recirculation and the treated water effluent. In case of proper operation, the water flows continuously through the respective outlets. In case of trouble-free operation, the outlet openings must not be fed. If any malfunction is suspected, the mammoth pump must be cleaned.

Aeration operation: For proper functioning of the aerator, the basin surface contains a layer with fine bubbles. If this layer is not formed, the air compressor operation shall be checked (clogging the filter, electrical connector cable).

Checking the outlet pipe: No sludge or solids should be present at the outlet. This may be due to high aeration intensity, high flowrate, small amount of biomass. If it occurs, it needs to be cleaned. The presence of water in the outlet manifold indicates that the effluent pipe is blocked. If this happens, it needs to be cleaned.

Checking the level of secondary clarifier: The sediment precipitated on the surface of the clarifier may occur. If this phenomenon occurs often, this could be a sign of the excess sludge in the clarifier. In this case, the sludge level should be checked and provide sludge removal. In addition, the floating sediment may also refer to anaerobic condition. The gases produced could lift the sludge to the surface of the clarifier. In this case, the sludge recirculation should be increased or an anaerobic zone should be created.

Check and set sludge recirculation: The wastewater treatment process requires an optimum amount of activated sludge. Activated sludge is made up of microorganisms and the excess biomass should be removed. Removal of excess sludge is done by the mammoth pump. Removal of the floating sludge is achieved by means of a dipping device.

The amount of sludge in the biological tank should be checked:

– using a ladle attached to a handle, water should be removed from the unit and the sample should be poured into an Imhoff cone or 1 l cylinder
– the full Imhoff cone (or measuring cylinder) should be set to level ground and left for approximately 30 minutes to settle

The sludge blanket level should be checked. The result of the observation provides information on the concentration of activated sludge.

Optimal concentration of activated sludge: The volume of settled sludge is 1/3 to 1/2 of the volume of the Imhoff cone, which means that about the same amount of sludge is removed than produced.

Low concentration of activated sludge: The volume of settled sludge is smaller than 1/3 of the volume of the Imhoff cone, which means that more sludge is removed than produced. Therefore, sludge removal should be reduced.

High concentration of activated sludge: The volume of settled sludge is larger than half of the volume of the Imhoff cone, which means that less sludge is removed than produced. Therefore, the amount of excess sludge should be increased.

No activated sludge developed: There is no exact sludge blanket. This means that no activated sludge has been formed. This could happen in the commissioning period. Or, it had been formed, but washed out (for example, a larger amount of detergent discharged). In both cases, another week is needed to observe whether the situation develops or not.

The activated sludge did not settle after 30 minutes: There is no exact sludge blanket level because the sludge is found in the full volume of the cone. The sludge has poor sedation capabilities. It will improve during the operation of the wastewater treatment unit.

The poor settling ability of the sludge can also result from improper loading of the equipment (for example, by introducing sweet water).

Sludge removal: Wastewater and related products are hazardous waste and the treatment should be in accordance with legal requirements. Sludge removal can be done only by a licensed company. Sludge removal is done by a septage truck. The suction basket is placed at the bottom of the unit.

The sedimentation volume becomes available after opening the odour-closing lid. To properly remove the sludge, the upper hard cover of the sludge layer must be broken and the contents of the clarifier must be mixed and then can be the sludge removal performed. Switch off the air pump before inserting the suction basket.

Care should be taken so that the suction basket is carefully placed in the clarifier not to puncture the bottom of the container or the baffles.

Sludge removal shall not exceed 60–70% of the sludge; the rest 30–40% is needed for recirculation. After the sludge removal, fill the sedimentation area immediately with clean water and switch on the air pump. No fluid from other compartments should be removed.

Air filter cleaning: The air compressor can be damaged by dust accumulated on the air filter. This can be prevented by blow out or sucking off dust.

Dewatering the aerator: Condensed water from the aerator shall be removed. Carefully open the screw on the aeration valve and leave to make all water flow out. In that moment when only air is leaving the pipeline the screw must be pulled back firmly again. The air pump unit must operate during decompression.

During winter operation, the containers should be closely monitored and when icing is visible, the ice must be broken.

Cleaning of interior parts of the unit: Clean the walls of the tank; dirt and settled solids should be removed by brush and by rinsing the surface.

Cleaning mammoth pumps: The deposited solids on the openings can be removed with a brush. The individual parts should also be rinsed with clean water. The outflow "elbow tube" of the mammoth pump must be turned upwards in the outlet tank before cleaning.

Removal of spilled sludge: For example, sediment from the level of the filling zone can be drained with a ladle and this sediment shall be returned to the primary sedimentation.

BV-I wastewater treatment unit

The BV-I individual wastewater treatment unit is a reliable solution where connection to the sewage collection system is not economically sound. Domestic wastewater is treated locally at such a degree that the effluent could be used for irrigation or could be emitted into a suitable recipient. Due to its simple structure and low operating costs, this equipment is widely used. BV-I achieves 95–98% organic matter removal and its operation is highly reliable.

Its structural design ensures the quantitative and qualitative equalisation of the wastewater; the aeration-mixing equipment maintains the necessary oxygen content and keeps the sludge suspended; sludge recirculation does not require sludge pump.

The hydraulic capacity of the BV-I is 1.3 m^3/day; therefore, it is suitable for treating communal wastewater of family houses, small condominiums, pensions, hotels, plants, offices.

Its function is odourless and not noisy; it fits into the overall picture of the garden, so it can be placed in the immediate vicinity of the apartment buildings.

Sludge removal is enough once a year in order to remove the inorganic pollutants as well as the floating grease and fat. The BV-I treated effluent can be further used by root zone irrigation as per the current legislation. BV-I consists of a pre-fabricated concrete basin and a technological unit built on it. Due to the prefabrication, no installation is carried out at the place of installation, only the placement of the reinforced concrete structure and the technological installation.

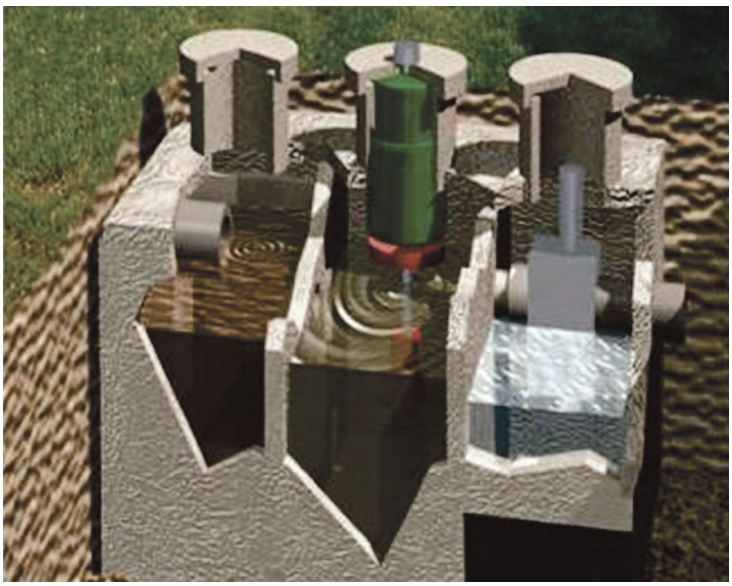

Figure 13
BV-I wastewater treatment unit [7]

Table 17
Technical specifications of BV-I (compiled by the author)

Size	2,800 × 1,680 × 1,800 mm
Performance	180 W
Electric connection	230 V
Inlet size	DN110 PVC pipe
Outlet size	DN110 PVC pipe
Energy use	1 kWh/day
Hydraulic capacity	1.3 m^3/day
Treatment efficiency	COD: 90% BOD_5: 90% Total suspended solid: 90%
Disposal of treated wastewater	Draining Root zone irrigation

BV-I treatment process

The BV-I domestic wastewater treatment unit applies activated sludge. The deep aeration system and mixer stabilisation of the sludge provides an optimum living space for the microorganisms performing the treatment. Its base unit is a prefabricated reinforced concrete tank equipped with an aerator–mixer and a clarifier.

Wastewater discharges to the first tank, where the flow equalises and anaerobic processes happen. Here phase separation of inorganic matters and grease also occurs.

The pre-treated wastewater passes through a "T" tube and flows into the aeration tank. The lower part of the through-pipe ensures that the further flow is from the most homogeneous layer, and its upper branch is used to eliminate any clogging.

In the aerobic chamber, the aeration mixer provides the necessary oxygen content and keeps the sludge in suspension.

The amount of oxygen supplied is 3 g/h based on the research of the National Institute of Public Health.

The aeration mixer with 180 W power ensures constant mixing and air intake. Its structure is extremely simple, it does not contain wear parts (valves, pistons), and it is particularly corrosion resistant. Its operation does not require automatic constant treatment.

Sludge settles down to the inclined bottom surface, where it slopes back to the aeration basin through an opening with a 300 × 150 mm dimension. This design ensures constant sludge recirculation without the use of separate equipment (sludge pump).

The treated wastewater flows upwards and goes out of the system through a post-filter. The post-filter removes the remaining suspended solids.

Options to accommodate the treated water:

– root zone irrigation
– infiltration

Technical specifications of the BV-I

The BV-I base unit is a prefabricated concrete basin delivered to the installation site.

Dimensions: 2.8 × 1.68 × 1.8 m.

For prefabrication, the reinforced concrete basin is divided horizontally from the lower plane to 1.15 m. The lower tank element is 1.15 m, and the upper pool element is 0.65 m high.

There are various technological openings on the upper basin element, and domes and cover plates for handling are connected to it.

The material of the basin elements is C16-12/k.VZ. concrete, 150 mm × 150 mm, single-core welded mesh with 6 mm thickness. The corners are reinforced with a 12 mm concrete core.

The material of domes and dome covers is of the same concrete quality with the tank, but does not contain reinforcement.

Blast openings are provided for the introduction of wastewater in such a manner that the wastewater treatment plant can be placed parallel to or along the longitudinal axis of the sewer. The outlet(s) required for use will break out at the application site.

Between the anaerobic and aerobic chambers, a hole of 110 mm diameter for the positioning and fixing of the "T" lead-through tube is located at the top of the wall in the upper basin.

At the top of the anaerobic chamber there is a 300 mm diameter opening for the service of the unit. The dome is placed when the equipment is installed. For fixing, the part of the dome that contacts the pelvic element is covered with cement mortar. The cover does not require a separate fixation.

There is enough space for the periodic cleaning of the suction tube next to the T-shaped transfer tube. The useful volume of the anaerobic chamber is 1.8 m^3.

In the upper plane of the aerobic chamber, a dome is provided in the upper plane of the anaerobic chamber to provide the location of the aeration mixer, the upper planes of which are provided for holding the nests and the groove for introducing the electric cable.

An aperture 300 mm × 150 mm is provided on the lower plane of the wall between the aerobic and clarifier chambers to provide sludge backflow. The useful volume of the aerobic chamber is 2.5 m^3.

The top filter is built into the upper part, which is used to collect the floating sludge. For the clarifier placement, a plastic element of 110 mm in diameter is embedded in the product.

At the top of the clarifier, there is an aperture of 300 mm in diameter, where the dome is placed. The dome is fixed in the same manner with the anaerobic chamber.

The useful volume of the clarifier is 0.8 m^3.

The total useful volume of the BV-I is 5.1 m^3.

The outer diameter of the dome is 460 mm, the inner diameter is 300 mm, their height is 400 mm. Its material is the same quality of concrete as the basin elements without reinforcement.

Dome covers are 520 mm in diameter and 80 mm in thickness. The ventilation line of the air inlet is concreted in the axial line of the lid of the dome lid supporting the aeration mixer.

The BV-I wastewater treatment plant is placed in the ground. Choosing a field level of 0.0, the main level data is:

- bucket bottom level: –2.35 m
- gravel bed top plane: –2.20 m
- treated wastewater outlet level: –0.80 m
- sewage influent bottom level: –0.70 m
- reinforced concrete basin upper plane: –0.40 m
- top plane of dome covers: +0.08 m

If the depth of the sewer is not 0.70 m, the above level data should be corrected with the difference.

Installation of the BV-I wastewater treatment unit

The BV-I domestic wastewater treatment plant is suitable for the treatment of communal wastewater from existing or new buildings, family houses, boarding houses, offices and industries. For wastewater exceeding 1.3 m^3/day, it is also possible to install multiple units in parallel.

Choose your installation location so that only passenger transport is possible later on.

Raw wastewater and treated water pipes must be laid in a ditch.

The unit can normally be connected to a 0.7 m deep sewage pipeline. In case of a deeper sewage line, the equipment must also be placed deeper so that the connecting sewage pipeline meets the inlet of the equipment. At this point, the machine's dome must be extended to the field level.

The dimensions are shown in the installation diagram in the appendix. In case of unfavourable soil conditions, the protection of sidewalls should be ensured.

The foundation of the equipment is a 15 cm thick gravel bed with a horizontal surface under normal ground conditions. In case of unfavourable soil conditions, the necessary foundation is determined by the adaptive designer.

The reinforced concrete structure arrives at the truck from the prefabrication plant and places the crane in the work pit.

The order of installation of the reinforced concrete works is as follows:
- location of the bottom element and checking the horizontal position
- cleaning the lower element from any material that may have fallen
- wetting surfaces and placing sealant
- attaching the upper element and checking the fittings
- attaching the dome and covers
- wiring and sealing of wastewater and treated water pipes
- attaching and electrical connection of the aeration-mixer
- soil refill, compression
- electric supply
- BV-I power supply is provided from the normal 230 V network; the connection to the network is made through a standard grounded socket
- the BV-I; the intermittent operation of the aeration-mixer motor of the wastewater treatment plant is provided by the control unit; the control unit is connected to the mains with a plug
- the control unit and the mixing-aeration device are connected by a 3 × 1.5 mm cross-section cable; it is advisable to place the cable in the duct workpiece
- the electric motor of the mixing-aeration device has a rated voltage of 220 V, an output of 180 W, a speed of 2,800 rpm, an IP 55 protection class, and an insulation class
- the rated motor current is 0.8 A

Start-up

Tasks of the builder:
- adaptation of the type design by an authorised person
- construction of sewage pipeline
- preparation of the work pit
- the foundation
- preparation of structures for the treated wastewater
- land reclamation and landscaping
- provide an electrical connection for positioning the control unit

Tasks of the supplier:
- transportation of equipment to the site
- positioning in the pit
- electrical wiring, commissioning

Buildings related to the treatment and disposal of wastewater are subject to a building permit in accordance with the legislation in force. Accordingly, the builder must submit a building permit application to the competent construction authority.

The appendix to the application is the licensing plan documentation prepared by the adaptation designer. This Type Approval Plan contains the data needed to conduct the building permit process.

Tasks of the adaptive designer:
- establishment of the site layout and additional technical description
- developing a foundation plan
- the requirement of the builder and the design of treated water according to the requirements of the authorities

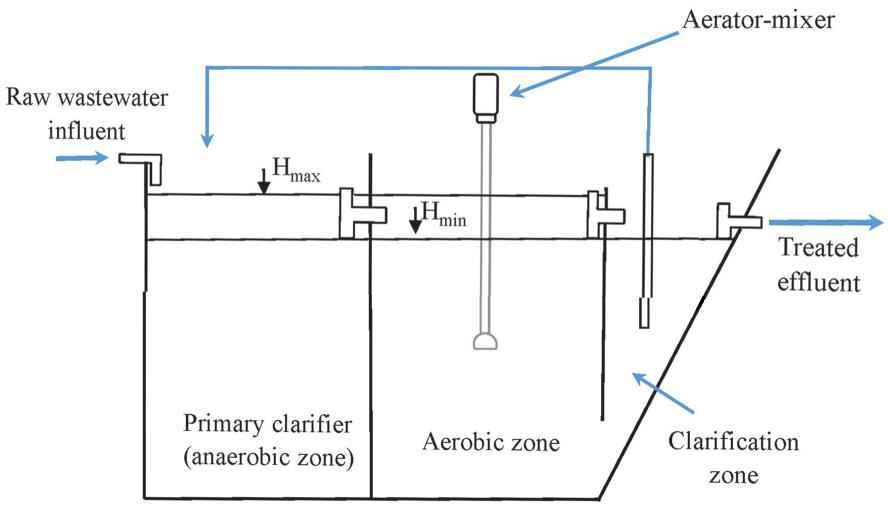

Figure 14
Operation principle of the BV-1

Operating and maintenance instructions

The BV-I unit for domestic wastewater treatment. In order to function properly and to be able to use its properties, the operator and the user must comply with this chapter.

Wastewater regulations: The BV-I is only suitable for domestic wastewater treatment. Proper operation cannot be guaranteed if it is contaminated by any industrial activity.

It can also deteriorate the treatment efficiency if aggressive household chemicals (bleach, hydrochloric acid, descaler, etc.) are used in large quantities at the same time.

It reduces the efficiency of the equipment when solid waste is deposited in large quantities (e.g. kitchen towel) into the wastewater. Protect the environment by placing the remainder of the grease used in baking into the solid waste.

Toxic substances (e.g. chemicals used in amateur photography) that can damage the living sludge or pass through the wastewater treatment plant should not be allowed to enter sewage.

The equipment works with the following wastewater quality parameters as required:

COD: 450 mg/l
BOD_5: 225 mg/l
Total suspended solid (mg/l)

The wastewater treatment plant requires automatic, periodic interventions/maintenance. It is necessary to check the state of the clarifier once a month. If the level of the water surrounding the clarifier is higher than the water level inside, then the filter is clogged:

– lift the dome cover of the clarifier and place it on the ground
– insert a hose into the inside of the filter and wash it with a strong jet of water for at least 10 minutes
– replace the dome cover

With this, the filter cleaning is complete, the unit will operate again.

It is necessary to remove the sludge once a year. This is done as follows:

- defuse the system
- lift the lid of the centre engine mount dome
- disconnect the cable connector
- lift the aeration-mixer and raise it to the ground with the aeration shaft and clean the aeration shaft from the dirt that has been deposited; the four-way nozzle at the end of the aeration shaft can be unscrewed and the hollow shaft hole can be checked; if the hole is blocked, it must be cleaned by compressed air blowing or by pulling the wire
- lift the dome cover of the pre-settling chamber
- remove the wastewater from the chamber; make sure that grease collected on the surface is removed
- similarly, remove the contents of the aeration chamber; due to the lower connection it also eliminates the contents of the clarifier
- replace the aeration-mixer, making sure that bottom parts are returned to the trays designed for this purpose, and then connect the cable
- check that the aeration system is not clogged, if yes, use a water jet
- replace the dome covers
- plug the mains plug into the socket to restart the unit

Other requirements:

- keep children away from the unit while removing dome covers
- the wastewater treatment plant and its 2 m area are only suitable for passenger transport
- work on the equipment requires thorough cleaning

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