GREEN
SEWAGE TREATMENT

HYBRID REACTORS

POLISH

TECHNOLOGY

NEW QUALITY
IN AERATION CHAMBERS

English description.

HISTORY AND ACHIEVEMENTS

History and evolution of the PRO-Aqua company and its used technology is associated with the development of technical ideas of biotechnologies for water and sewage system which began in the last century.

The use of methods for the reclamation and protection of surface waters in the technology of wastewater treatment has brought excellent results, which have been used for many years in the construction of new as well as reconstruction of existing facilities, increasing the capacity of the treatment plant in the existing volumes.

The main elements of the self-steering, hybrid technology of wastewater treatment, which is a biological reactor and an aeration system ASD were noticed and appreciated on international trade fairs. In 2003 the BIOPAX-WBWW company received a gold medal on the International Trade Fair “POLEKO” in Poznań for its Bottom Streaming Aerators ASD and a “GRAND PRIX” reward on the XI International Trade Fair of Machines and Equipment for Water Supply and Sewerage “WOD-KAN ‘2003” in Bydgoszcz for “Circulating device for biological treatment of organic wastewater”.

Due to a big interest in our technology overseas (mainly in Germany), in 2005 the BIOPAX PL company was created with its headquarters in Zielona Góra, by which the overseas contracts and cooperation with the Uniwersytet Zielonogórski are executed.

In 2006 Eng. Tomasz Musiałowicz joined the technology team, who till this day is an active participant in the implementation of the technology, its development and all the work of both companies. He was an active participant in creating scientific articles and presenting them on symposiums with prof. Zofia Sadecka (Uniwersytet Zielonogórski).
Tomasz Musiałowicz himself executed all of the design work and part of the installation work completed by BIOPAX PL (mainly financed by EU) in order to explore many varieties of Bottom Streaming Aerators ASD (project named “Industrial research on optimization of the aeration-mixing process in systems eliminating moving parts”) and optimization of using the mentioned technology (with submerged flow deposits) for recultivation of surface waters (project named „Research in the field of optimizing processes of non-invasive methods for purification and rehabilitation of water bodies”).

From the beginning of his work in the team Eng. Tomasz Musiałowicz develops concepts, calculations and technology projects, guidelines for industries, participates in construction, equipping, technological starting and exploitation of built sewage treatment plants while still increasing his competences with the experience of functioning objects.

Due to a difficulties faced by the BIOPAX-WBWW company, the whole team together with new investors created and started to develop the PRO-Aqua company, which using the company’s achievements and the team’s expertise offers modern solutions in new and rebuilt sewage treatment plants.

Using self-steering, hybrid technology or its elements,
the following projects and implementation were made:

• biological protection of drinking water on Zalew Sulejowski - 1990				
• butchers sewage treatment RSP Radzymin	$Q_d =$	60 m^3/d	in 1991	
• treatment plant for sewage fish CERTA Międzyzdroje	$Q_d =$	60 m^3/d	w 1992	
• sewage treatment Chełm Lubelski	$Q_d =$	7’000 m^3/d	in 1993	aeration system
• Łazienki Królewskie Warszawa	aeration system for ponds in 1995			
• sewage treatment Czerwieńsk	$Q_d =$	1’100 m^3/d	in 1995	
• sewage treatment Wiśniew	$Q_d =$	250 m^3/d	in 1996	project
• sewage treatment Zbuczyn	$Q_d =$	200 m^3/d	in 1996	project
• sewage treatment Tuchorza Stara	$Q_d =$	250 m^3/d	in 1998	
• sewage treatment Zbąszynek I	$Q_d =$	1’000 m^3/d	in 1998	project
• sewage treatment Zbąszynek II	$Q_d =$	800 m^3/d	in 1998	project
• sewage treatment Bargłów Kościelny	$Q_d =$	200 m^3/d	in 1999	
• sewage treatment Cybinka	$Q_d =$	600 m^3/d	in 1999	project
• urban sewage treatment Paczków	$Q_d =$	2’500 m^3/d	in 2000	
• sewage treatment Drzonów	$Q_d =$	200 m^3/d	in 2000	
• sewage treatment Nowy Modlin	$Q_d =$	60 m^3/d	in 2000	
• MPGK Krasnystaw - aeration system for ponds		in 2001		
• sewage treatment Krasnystaw	$Q_d =$	6’000 m^3/d	in 2001	project
• sewage treatment Wiązowna	$Q_d =$	16 m^3/d	in 2003	
• sewage treatment Brzozów	$Q_d =$	800m^3/d	in 2003	
• sewage treatment Hyżne	$Q_d =$	600 m^3/d	in 2003	project
• sewage treatment Pozezdrze	$Q_d =$	350 m^3/d	in 2003	
• sewage treatment OSM Końskie	$Q_d =$	850 m^3/d	in 2004	
• sewage treatment Łękawica	$Q_d =$	600 m^3/d	in 2005	
• sewage treatment Sulejówek	$Q_d =$	3’200 m^3/d	in 2006	
• sewage treatment Jedlicze	$Q_d =$	2’200 m^3/d	in 2006	
• sewage treatment Hyżne	$Q_d =$	600 m^3/d	in 2007	
• sewage treatment Boguchwała	$Q_d =$	1’875 m^3/d	in 2008	project
• industrial sewage treatment for Kamis-Przyprawy	$Q_d =$	315 m^3/d	in 2008	project
• sewage treatment „Cyraneczka”	$Q_d =$	2’400 m^3/d	in 2010	
• sewage treatment Łagów	$Q_d =$	900 m^3/d	in 2011	
• sewage treatment Turze Pole	$Q_d =$	500 m^3/d	in 2012	
• sewage treatment Słopnice	$Q_d =$	600 m^3/d	in 2013	
• sewage treatment Czerwin	$Q_d =$	350 m^3/d	in 2014	
• sewage treatment Brzeziny	$Q_d =$	2’120 m^3/d	in 2015	
• aeration system in Piaszczyna			in 2015	
• sewage treatment LądekZdrój	$Q_d =$	3’500 m^3/d	in 2016.	project
• sewage treatment Smołdzino	$Q_d =$	450 m^3/d	in 2016	project
• sewage treatment Ojrzeń	$Q_d =$	200 m^3/d	in 2019	projekt
• sewage treatment Sulmierzyce	$Q_d =$	400 m^3/d	in 2021	
• sewage treatment Bodzanów	$Q_d =$	400 m^3/d	in 2023	during work

Major objects reclaimed using deep aeration or biological barriers in various periods and by different contractors

-	Jaroszewskie Lake	Wielkopolskie province
-	Kiekrz Lake	Wielkopolskie province
-	Karczemne Lake	Pomorskie province
-	Klasztorne Lake	Pomorskie province
-	Rybnik Energy tank	Śląskie province
-	Sulejowski Tank	Łódzkie province – drinking water intake in Bronisławowo
-	Mogileńskie Lake	Kujawsko – Pomorskie province
-	Pakowski Tank	Pakość, Kujawsko – Pomorskie province
-	Gopło Lake	Kujawsko – Pomorskie province
-	Głębokie Lake	Kujawsko – Pomorskie province
-	Błeszno Lake	Lubuskie province
-	Łazienki Warszawskie	King's Park in Warsaw

URZĄD WOJEWÓDZKI
W ŁODZI

PAŃSTWOWA INSPEKCJA
OCHRONY ŚRODOWISKA
Wojewódzki
Inspektorat Ochrony Środowiska
90-006 Łódź
ul. Piotrkowska Nr 120
Tel. 33-33-43

O P I N I A

o systemach i urządzeniach stosowanych przez P.E.G. EKO - AQUA

Ośrodek Badań i Kontroli Środowiska w Łodzi a obecnie Wojewódzki Inspektorat Ochrony Środowiska prowadzi badanie barier ekologicznych i aeratorów strumieniowych drobnopęcherzykowych. Bariery ekologiczne badaliśmy na dwóch obiektach: zbiornik energetyczny k. Rybnika i sulejowski - ujęcie wody pitnej dla Łodzi w Bronisławowie. W obu przypadkach stwierdziliśmy, że zastosowane rozwązania dały dobre wyniki w zakresie poprawy biologii i chemizmu wody w zbiornikach.
Według naszego rozeznania, nie osiągnięto do tej pory w świecie podobnych wyników przy zastosowaniu tak małych nakładów finansowych.
W/w systemy wzbudziły duże zainteresowanie fachowców zagranicznych, a szczególnie francuskich.
Aeratory strumieniowe drobnopęcherzykowe badaliśmy na oczyszczalni ścieków w Rybniku. W/g opinii naszych specjalistów, zastosowanie ich na szerszą skalę w systemach z panelami biologicznymi wprowadziłoby nową generację sposobów oczyszczania wszelkich ścieków i wód powierzchniowych. Wydajność aeratorów opracowanych przez technologów zatrudnionych w EKO - AQUA była badana w Kanadzie i potwierdzono tam walory użytkowe i eksploatacyjne tych urządzeń. Uważamy, że kierunki w jakich idą rozwiązania w/w firmy warte są poparcia i propagowania, gdyż nie ustępując najnowszym technologiom światowym, są znacznie tańsze, bardziej energooszczędne i co jest nie mniej ważne, bazują na polskiej myśli naukowo-technicznej a budowane są z materiałów ogólnodostępnych, produkowanych także w kraju.

Z up. WOJEWODY
dr inż. Tomasz Malinowski
Dyrektor Wydziału Ochrony Środowiska

Wojewódzki Inspektor
Ochrony Środowiska w Łodzi
mgr inż. Andrzej Drożdżyk

Turze Pole (500 m^3/d)

Słopnice (600 m^3/d)

Łękawica (600 m^3/d)

Łagów (900 m^3/d)

Paczków (2’500 m^3/d)

IPB

IZBA PROJEKTOWANIA BUDOWLANEGO
THE CHAMBER OF CONSTRUCTION DESIGNING

DYPLOM

dla głównego projektanta

mgr inż. Janusza WASIA
wraz z zespołem autorskim

z firmy
B.W.P. "EKOL-BUD-AQUA" s.c.
w Zielonej Górze

za projekt
Oczyszczalni ścieków w Czerwieńsku

którego realizacja uzyskała

WYRÓŻNIENIE
W KONKURSIE **"BUDOWA ROKU' 95"**

Prezes Izby
doc.dr inż. Ksawery Krassowski

MINISTERSTWO GOSPODARKI PRZESTRZENNEJ I BUDOWNICTWA
POLSKI ZWIĄZEK INŻYNIERÓW I TECHNIKÓW BUDOWNICTWA

przyznają
WYRÓŻNIENIE
w konkursie
"BUDOWA ROKU 1995"

uczestnikom procesu inwestycyjnego:
Urzędowi Miasta i Gminy w Czerwieńsku
oraz Przedsiębiorstwu B.W.P. "EKOL-BUD-AQUA"s.c.
w Zielonej Górze
za zblokowane rozwiązanie oczyszczalni ścieków
w Czerwieńsku,
charakteryzującej się niskim kosztem wykonania i eksploatacji.

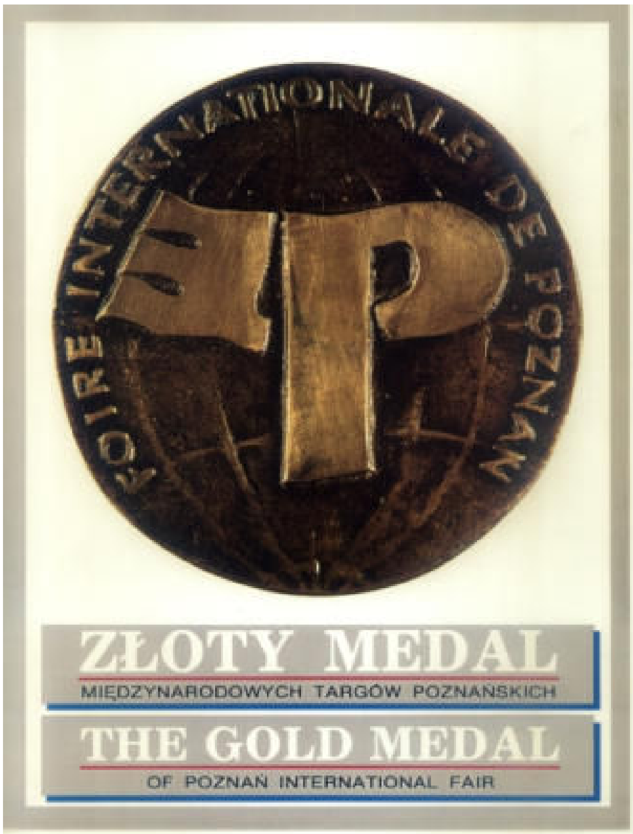
Przewodniczący PZITB
Andrzej B. Nowakowski

Minister Gospodarki Przestrzennej i Budownictwa
Barbara Blida

Przewodniczący Sądu Konkursowego
Kazimierz Cieszyński

Przewodniczący Komitetu Organizacyjnego
Stanisław Kajfasz

Warszawa, 26 czerwca 1996



Targi Międzynarodowe Poznańskie

ZŁOTY MEDAL
Międzynarodowych Targów Poznańskich

za

Aerator strumieniowy denny - system napowietrzania ASD

prezentowany przez
BIOPAX-WBWW Sp. z o.o.
z Warszawy

na
Międzynarodowych Targach Ekologicznych
POLEKO 2003

Poznań, 18-21.11.2003

Przewodniczący Sądu Konkursowego
prof. dr hab. inż. Ferdynand Dembecki

Prezes Zarządu Międzynarodowych Targów Poznańskich
Bogusław Zaleski

Międzynarodowe Targi Poznańskie
Poznań International Fair

The best efficiency of treatment made in our technology evidence are the results of raw sewage and purified - especially in winter:

Lp.	Object	Date	Sewage	Indicators				
				BZT_5	ChZT	Suspended solids	Total nitrogen	Total phosph orus
				mg O_2/l	mg O_2/l	mg/l	mg N/l	mg P/l
NORM:			**purified**	**25**	**125**	**35**	**(15)**	**(2)**
1	Bargłów Kościelny	04.04.2000	**purified**	**5,0**	**-**	**7,0**	**6,0**	**4,4**
2	Bargłów Kościelny	31.07.2001	*raw*	*450*	*1 010*	*277,0*	*95,4*	*15,5*
			purified	**4,4**	**40,0**	**7,9**	**5,8**	**1,5**
3	Brzozów	13.10.2003	**purified**	**13**	**38**	**<10**	**4,29**	**0,56**
4	Drzonów	01.09.2004	**purified**	**18**	**30**	**8,0**	**-**	**-**
5	Paczków	05.11.2002	*raw*	*460*	*3 155*			*18,5*
			purified	**8,7**	**30,8**		**4,0**	**1,5**
6	Paczków	07.01.2003	*raw*	*440*	*963*			*15,8*
			purified	**6,4**	**23,0**		**2,1**	**0,8**
7	Paczków	11.02.2003	*raw*	*930*	*2 925*			*15,0*
			purified	**9,0**	**43,1**		**3,5**	**1,3**
8	Paczków	17.10.2001	*raw*	*215*	*1 038*			*10,6*
			purified	**6,5**	**23,5**		**5,1**	**0,8**
9	Paczków	19.08.2003	**purified**	**1,3**	**22,4**		**6,8**	**1,1**
10	Pozezdrze	29.06.2004	**purified**	**5,0**	**59,4**	**14,3**	**10,0**	**0,4**

These results are possible to achieve at minimum costs through the use of modern, energy efficient our technologies

Energy efficiency of the process is possible due to eliminating unnecessary loads in the technology of electricity such as electric mixers in nitrifying compartment, or sewage recirculating pumps - installed powers do not exceed 40 wat per 1 m^3 of sewage even at low sewage treatment with the capacity of 150 - 200 m^3/day.

Modernization of the existing sewage treatment in Brzozów, where in SBR technology with capacity of 300 m^3/d was installed 47 kW power, after modernization in the same cubatures (!) bandwidth up_to 800 m^3/d, and the installed power has decreased to 31 kW (!), is one of the examples.

DESCRIPTION OF THE TREATMENT

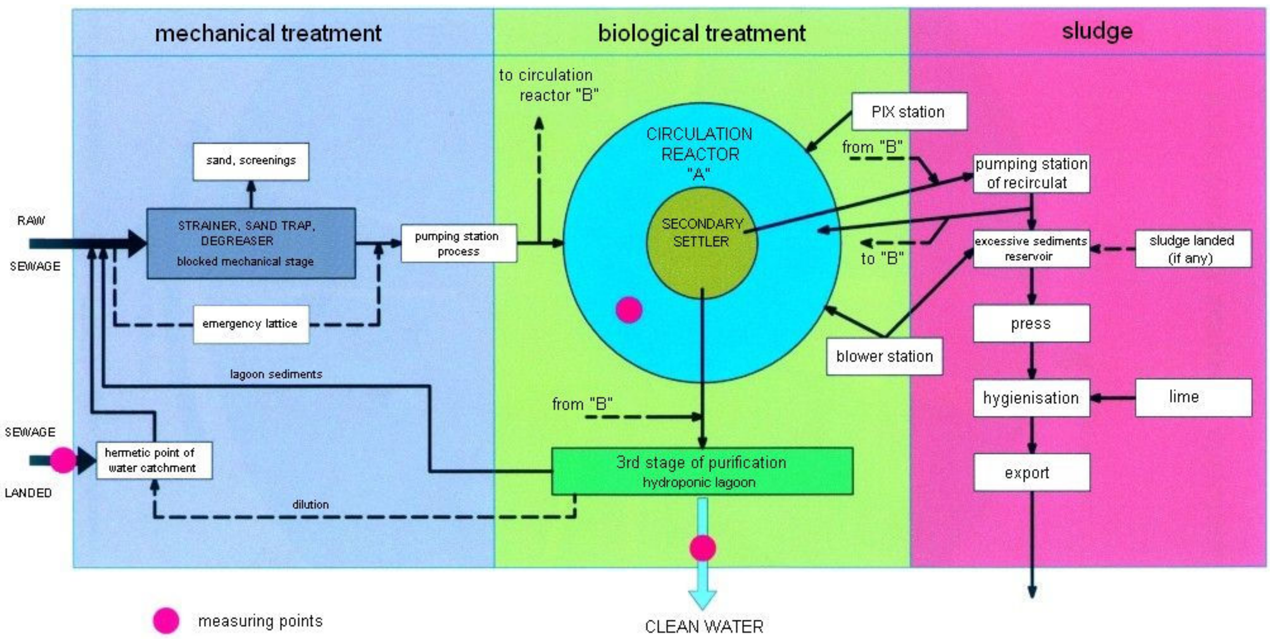
Sewage treatments designed and built by our company are a compact construction object, in which absolutely all of the technological equipment (along with an artificial river), administrative premises, alternatively garages, workshops, etc. are located.
Because of that reason treatment requires a very small area of land and is completely isolated from the environment (do not need a buffer zone).
Architecture of newly built object can be anything, and we try to not only camouflaged the object designate but also to enrich the variety of environment

In the case of sewage treatments modernization in existing cubatures, we increase the capacity twice or three times (!) without the need to expand.

DESCTIPTION OF OUR TECHNOLOGY

The general rule of the sewage treatment process

Block diagram of the sewage treatment



Mechanical part

Mechanical stage is normally resolved, but the company prefers modern, integrated blocks, in which in one tight casing screenings, sand and fats are removed with high efficiency. The company prepares their own construction solutions that are competitively priced, and the quality does not vary from the latest worldwide solutions.

Biological reactor

The technological process is based on the circular, self-steering, hybrid biological reactor using sludge as a flocculent suspension and settled biomass (immobilized) on submerged flow deposits. Standard biological reactor is an annular tank located on the exterior of the secondary settling tank shell (reservoir tank). There are, however, other configurations that can be freely modeled depending on, among others, existing objects.

Secondary settling tank

Secondary settler sludge in standard is a radial settler and is a central part of the annular reactor. It is used to separate a mixture of water and sludge flowing from the reactor. The separated sludge is recycled back into the reactor, and sludge excess is carried away for further processing.

Sludge management

Thanks to immobilization, biological membrane settled on fields has much greater concentration than the suspended structures. After detachment from the field and mixing with floating sediment in the secondary settling tank it gives a higher dry matter content in the excessive sediment. In many cases 98% of hydration was received already from secondary settling tank.

It allows for high condensed in the excess sludge tanks, in which aerobic stabilization process in standard is conducted. Because of the elimination of anaerobic organisms that may pose a risk to humans (spore parasite larvae) at the agricultural use of dehydration sludge it is very beneficial.

The sludge obtained from this process very easily submit to dehydration. Using the chamber press with the lime and PIX application you can receive up to 40% of dry matter. Additionally, the application of lime to sludge at this stage, eliminates unnecessary hygienization stage, and sludge is directly suitable for natural, and even agricultural development.

Hydroponic lagoon – artifical river

The third stage of treatment is a labyrinth flow chamber - hydroponic lagoon, which is an artificial river. It simulates in the intensified form self-purification processes occurring in rivers and its aims are final cleaning and naturalized of treated sewage, and performs an important function of the buffer tank, which will take over the untreated sewage at the time of failure.

Labyrinth flow was obtained by dividing lagoon with biological panels that are used as a habitat for epiphyte organisms (perypchyton) and as a base for root units.

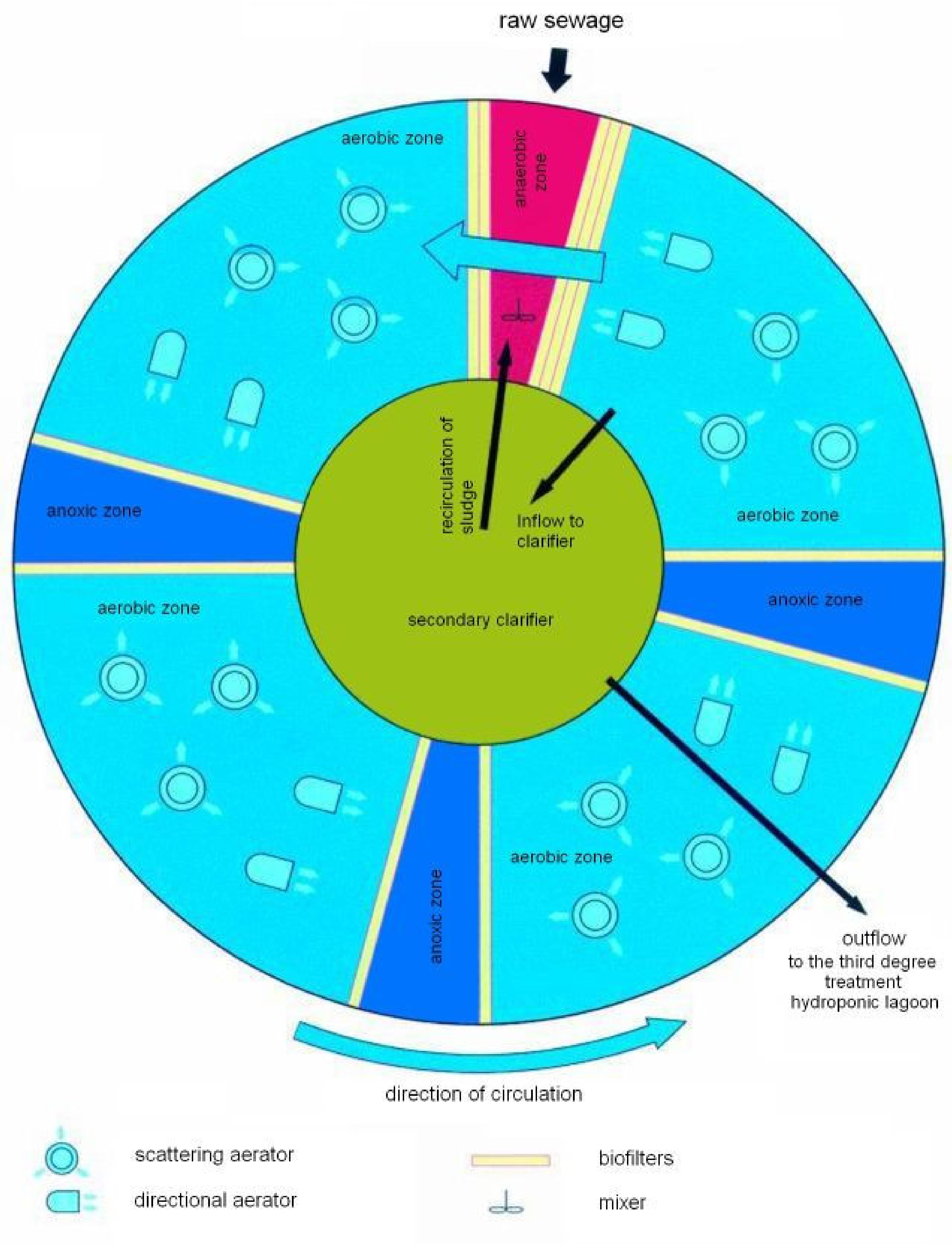
This system is also known and used as a variety of biological barriers.

The flow of treated sewage through such selected and constructed hydroponic lagoon guarantees the highest purity grades of discharge water. Even in situations where the receiver does not fit in this class, this snapshot causes dilution of the water and improves their quality.

To ensure proper operation of the lagoon throughout the whole year, it is insulated from the influence of external conditions. It was achieved by covering lagoon with polycarbonate cellular, which in addition to transparency and very high mechanical strength is also a very good thermal insulator. Moreover, under a common cover of the entire treatment, takes place a kind of micro-circulation: heterotrophic zone gaseous products are absorbed by autotrophic organisms (plants on the field) and vice versa: oxygen produced in this zone is consumed to enrich the air dispensed by aerators blower to aliens fed zone.

It is an almost autonomous system of atmosphere regeneration and it also is of paramount importance in determining the impact of treatment zone to the environment.

Characteristics of the biological reactor



Hybrid, circulation biological reactor - aeration – works in continuous flow and the factor averaging, repeating a complete sequence of common transformations of carbon, nitrogen and phosphorus process. Number of cycles (repetitions) adjusts automatically in proportion to the constantly incoming cargo.
The chamber ring is divided by walls built of the flow fields immersed into functional zones, in which three-phase purification process is implemented. It is possible by the fact that settled biomass bed, arranged transversely to the flow stream, is a trophic and aerobic barrier (oxygen concentration before the barrier: 2 g O_2/m^3 - after passing through the barrier: 0,2–0,3 g O_2/m^3).

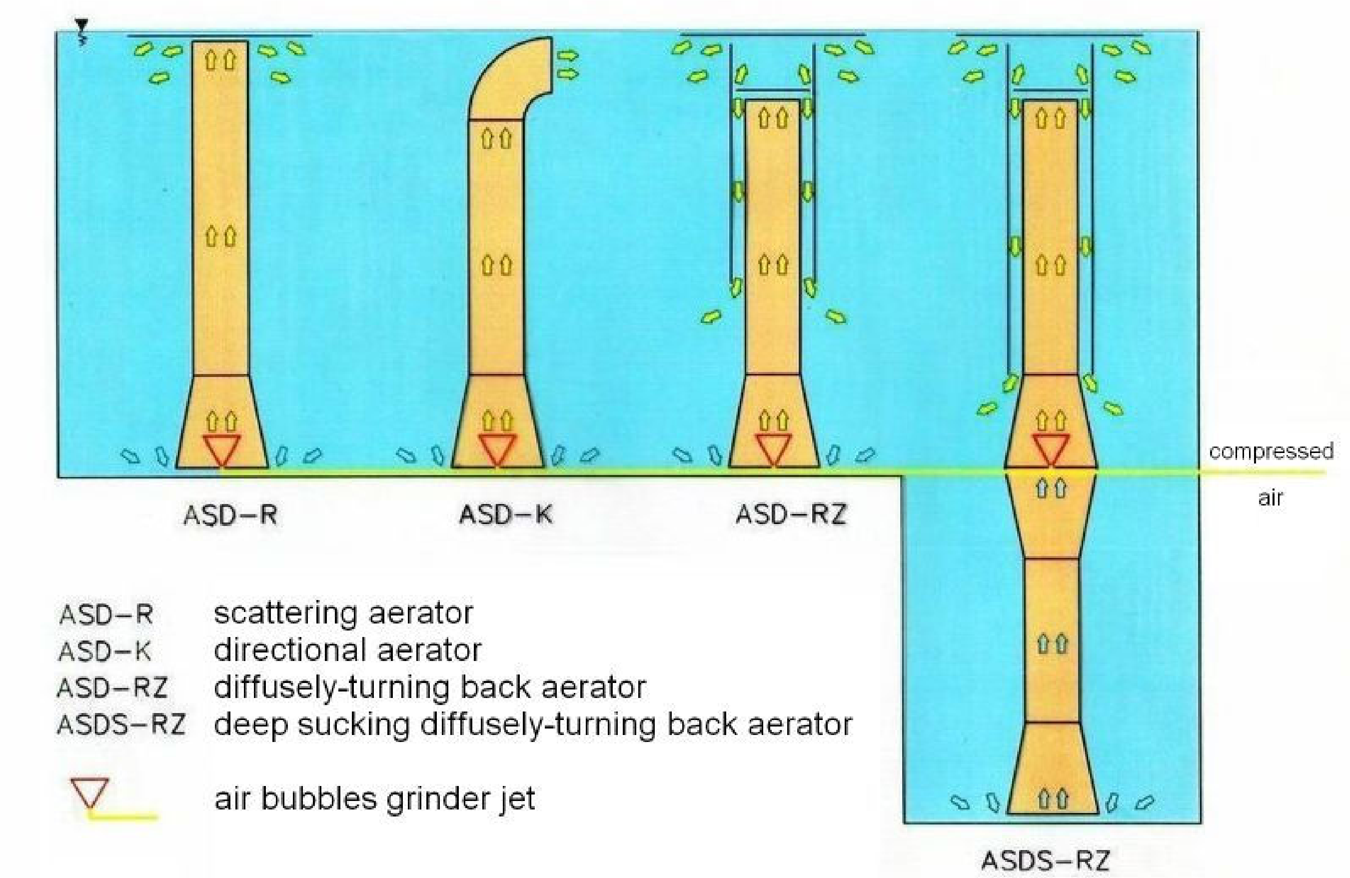
Functional zones of the reactor:

a) anaerobic
b) anoxic
c) nitrification (aerobic).

There is the only one „a” zone, „b” and „c” zones are few and occurs alternatively on the circumference of the reactor.
Completely innovative solution is to separate the different zones by the walls built of submerged flow deposits that formed after the settlement of biomass make the natural oxygen barrier.
Wall „interior” is a kind of ecological niche which is the habitat for the most favorable, from the consumption, pollution and sedentary cultures standpoint.
Vertical and horizontal circulation in the chamber produce bottom jet aerators (ASD), which hydraulically behave like mammoth pump. It means that their circulation output is proportional to the air amount fed by the blower. The amount of pumped air depends on the demand arising from incoming cargo. Blower performance is controlled by the oxygen probe.
Therefore – that what in other technologies required measured control to regulate the degree of control recirculation (piston systems) - here is done automatically, through automatic change in the dynamics of circulation (quantitative), depending on the quality changes. This is done only in a function of oxygen demand.
In this way we obtain a completely self-steering system, without the need to install expensive and often fallible hardware and service interference to the process is not only unnecessary but also inadvisable.
Chamber equipment in deposits flow protects the system against washout in emergency of hydraulic overloads (especially important for sewage system), and in malnutrition periods, sedentary cultures consume weak and dead sludge animals suspended in the circulating stream. Thus, at least 50% of the total biomass, irrespective of the load jumps, constantly is in a very good condition.

Aeration system

BOTTOM STREAM AERATORS (ASD)



The patented and used by our company aeration system, commercially called in short ASD - the name of Bottom Streaming Aerators (Polish: Aeratory Strumieniowe Denne).
The values of ASD system have been recognized and awarded with a gold medal at POLEKO 2003. This is the original solution, which apart from performing basic functions such as providing the greatest amount of oxygen, at the same time intensively mixes sewage in the whole profile (the phenomenon of turbulence).
As can be seen from the description above - these devices are an integral part of self controllable system of keeping the process in circulating chamber of biological reactor. Aeration and mixing functions allow to use ASD in any systems and technologies without mixers (the classic example of fine-bubble) which, except additionally charge of energy, always pose the danger of mixing sludge flocs.
The aeration system properly designed, made and authorized by us guarantees that even at low air expenses undesired sludge sedimentation phenomenon will not occur in the reactor.
ASD aerators are made entirely of stainless steel, steel or PVC. Their construction has no moving or likely to wear away in any other way parts, which ensures its trouble free operation.
Aerators are equipped with specially designed jets that do not suppress the air outlet, which allows selection of a smaller capacity blowers, unlike for example, ceramic emitters. Their efficiency decreases with the time of use, and even periodic cleaning does not restore

the initial 100% efficiency. After a period of up to 5 years aerators should be practically exchanged. However, the our company gives the 5-year WARRANTY (!) for the ASD system. This significant difference should be taken into consideration when calculating the future maintenance costs and aeration system selection.

An additional benefit of using ASD is the mixers elimination and precise air dosing depending on the needs (oxygen probe regulate blower work continuously and there is no air flow throttling).

View of working aerators in sewage treatment in Paczków

Characteristics of ASD aeration system

- ✓ low demand for electricity,
- ✓ mixers elimination of nitrification chambers,
- ✓ high efficiency and flexibility of the aeration system,
- ✓ no air throttling in the nozzles (no pressure loss),
- ✓ use of the phenomenon of turbulence for aeration and mixing without destroying the structure of the mare - more efficient process and greater sedimentation in secondary settling tank,
- ✓ simplicity of construction ensuring reliable operation,
- ✓ absolute resistance to corrosion,
- ✓ no mechanical moving parts submerged beneath the liquid surface,
- ✓ easy installation, without the need for specialized equipment,
- ✓ low investment cost,
- ✓ aeration system guides the flow, forces circulation and mixing, thereby eliminating sludge putrefaction zone in the reactor chamber,
- ✓ special nozzles construction prevents them from clogging, blocking or suppression of air flow - they are absolutely trouble free,
- ✓ multiannual warranty.

Replacing the traditional aeration equipment with ASD system in the older sewage treatment, thanks to energy efficiency, in a short time will cause the total return on investment, and the co use of biological submerged flow deposits allows to increase sewage treatment capacity while maintaining the same measurement.
Our technology is already implemented in Germany, there are planned modernization of the existing ones and construction of new objects in Syria, Ukraine and in other countries.

Benefits of treatment designed and built in our technology

- ✓ low investment costs (smaller measurement compared to other technologies),
- ✓ low operating costs (elimination of unnecessary capacity, employment minimization),
- ✓ high purification level throughout the year, even in winter in any climate zone,
- ✓ **guarantee** for sensational purification results and obtaining ecological effect,
- ✓ keeping the process in the object isolated from the environment,
- ✓ no nuisance odors and aerosols,
- ✓ no protection zone (not required)
- ✓ own, patented, trouble free and highly efficient aeration ASD system,
- ✓ simple to use - self-steering process,
- ✓ high operational reliability,
- ✓ natural mechanical-biological process with third hydroponic stage of purification, which provides protective buffer in emergency cases,
- ✓ high resistance to the jumping loads,
- ✓ treatment easy to launch even after several days in the absence of aeration (failure),
- ✓ ability to work exclusively on sewage ferry,
- ✓ short investment cycle,
- ✓ a very small area of land,
- ✓ attractive architectural form,
- ✓ able to act as an ecological center - this kind of treatment is a place of living for many aquatic and coastal plants, as well as for animals.

Pure water as can be seen

ASD – a new quality in the aeration chambers

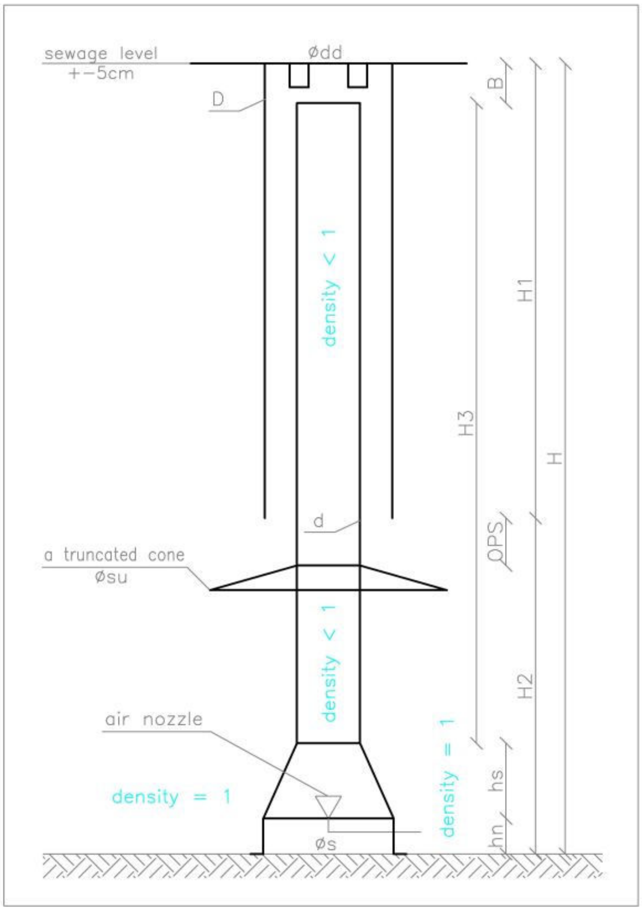
There is a new generation of equipment for aeration and sewage transport in biological chambers showed below. This equipment has been named ASD (aerator stream bottom, Polish: aerator strumieniowy denny) by the creators. **ASD is protected by the Polish Patent Office under number WP-16071.** Besides applied in the various forms of construction mentioned above they may be use as one of the main elements of surface water reclamation systems.

The types of ASD, with animation and video, possible to construct and use are shown on our website, while for discussion construction and operation rules and use we include some schematic drawings with necessary description.

Characteristic dimension for each ASD is the riser diameter „d" (pict. 1).
With this dimension we define the size of the aerator. For sewage treatment we often use the ASD 200 and ASD 300 This means that the d diameter has 200 or 300 mm dimension. Other dimensions (except H height) remain in strict dependence and proportion with those. The H height of the accuracy of 5 cm must be equal to an average depth of sewage in the aeration chamber (dimension individually designed).

In the current practice in sewage treatment we have used ASD at depths from:
H_{min} = 1.50 m - circular ditches - Czerwin, to:
H_{max} = 6.50 m - municipal sewage treatment in Słopnice
and other intermediate depths.

It is not difficult to guess that all other dimensions of the H group change with the change in the tank depth, except that the proportions are strictly saved: H: H1 and H: H3. The B dimension also evolve a bit.



Picture 1

It can be concluded that ASD is built according to a strictly defined rules, but depending on the depth of the tank **it is subject to individual design.**
Design rules, thanks to which presented effect was achieved stay as a secret of the company. The way and action rules that affect the efficiency of the device will be presented in here.

The efficiency of oxygen transfer from air to sewage (water)
The efficiency of this transfer is determined by the factors, on which at the time:
a) we have no influence, which are:
- type of liquid (sewage),
- temperature of liquid,
- viscosity,
- tank depth in terms of hydrostatic pressure.

b) we have the influence, which are:
- interfacial surface area (total surface of air bubbles),
- turbulence (interphase surface renewal),
- path and the contact time, despite of given depth.

From the above it follows that the overall aeration system performance can be increased while manipulating in the areas defined by (**b**) paragraph. How it is implemented in ASD and fine-bubble system it is present in the following table:

Table 1

Factors	Realization with ASD	Realization with fine-bubbles difusers
size of the interface (sum of the air bubbles surface)	fragmentation of the air stream is achieved with the free discharge from the cable and the use of buoyancy, which causes air fragmentation of the special design of the a nozzle located above **It is a very energy efficient method**	fragmentation of the air stream by pumping it through the porous structure of glass, ceramic or flexible membranes **It is a highly energy consuming method**
turbulence (interphase surface renewal),	high turbulence is achieved automatically during aerators.operation **No need of additional energy expenditure, there is no mixing of sludge flocs**	to obtain the turbulence, it is necessary to apply additional lateral stirling . **Needed extra energy expenditure**

path and the contact time for a particular depth	using ASD we obtain TWICE longer contact path to the depths! **No need of additional energy expenditure, there is no mixing of sludge flocs**	The way, and thus, the contact time with fine bubble diffusers work can be increased only by adding horizontal component of air bubbles movement with using mixing side **Needed extra energy expenditure**
Additional benefits of using the ASD	Pneumatic sewage conveying **(causing the internal circulation)**	Internal circulation possible with using the pumps or pumping mixers. **Needed extra energy expenditure**
Additional benefits of using the ASD	**no dead zones at the bottom of the reactor** (medium extraction from the bottom),	Dead zones below the diffuser **Without the possibility of elimination.**
Additional benefits of using the ASD	**complete mixing of the reactor chamber** (automatic vertical and horizontal circulation),	The mixing chamber is possible only with additional mixers. **Needed extra energy expenditure**

There are specific numeric values, calculation of demonstrative of different ASD applications, sketches and comparative calculation of fine-bubble system shown below..

WARNING! We do not compare ASD to surface aeration in here because it is a class of energy less efficient than any deep aeration.

During the practice of using these devices, we were making measurements on our own having on spot disposal to laboratories - as in the dairy, or butchery, where we could determine the degree of oxygen from the air utilization, but also efficiency as kg of BZT_5 removed per 1 kWh of energy used.

Based on several years of observation we may say that the degree of oxygen from the air utilization, to biological processes (rather than pure water) is not less than:

Table 2

Depth of the reactor	**ASD efficiency**
[m]	[%]
3	**12**
4	**20**
5	**25**
6	**30**

There is about 0,28 kg of oxygen in 1 Nm^3 of air. Therefore, taking the values given in table 2, from one cubic meter of air each injected into the sewage we will get respectively:

Table 3

Depth of the reactor	Amount of dissolved oxygen
[m]	[g O_2]
3	**33,6**
4	**56,0**
5	**70,0**
6	**84,0**

In order to give that air, the blower with a specific static pressure and engine power has to be used. In contrast to any fine-bubble system, construction of the nozzle in the ASD **DOES NOT PRESENT ANY RESISTANCE ACCOMPANYING THE ESCAPE AND SHREDDING AIR IN THE LIQUID!**

WE SELECT BLOWERS ON STATIC PRESSURE EQUAL THE HYDROSTATIC DEPTH FOR ASD.

This static pressure and flow resistance must be overcome ONLY when booting. It can be noted that the blower operates at a pressure reigning in ASD vertical pipe of d diameter (Pict. 1). During ASD operation, the tube is filled with a mixture of air and sewage (density <1). Therefore, the pressure in the ASD at the depth of the air nozzle is smaller than outside of the aerator (density = 1). It is so lower than hydrostatic pressure that even after taking into account the air flow resistance in the pipeline, manometers on blowers indicate smaller pressure than the hydrostatic pressure of the water column.

In relation to the classic fine-bubble aeration there is about 2 m water head difference on the pressure that blower has to produce, to the detriment of fine bubble diffusers.
Such a difference has a direct impact on the power used to achieve the same effect of aeration.

To show how it looks in energy aspect we will use the example.

EXAMPLE:

The active reactor depth: 5,0 m.

For easier comparison, in the example below, we assume that the degree of utilization of oxygen in fine bubble diffusers is the same as in the ASD.

Demand for air: about 7,5 m^3/min.

We take blowers from SPOMAX catalog, because their parameters are very precisely written out there.

Blower selection **for ASD**:	Blower selection **for fine bubble diffusers:**
Blower DR 113T-5.5	**Blower DR 113T-7.5**
Qp = 7,66 m^3/min.	Qp = 7,30 m^3/min.
$P_{installed}$ = 11 kW,	$P_{installed}$ = 15 kW,
P_{taken} = 8,5 kW	P_{taken} = 11,6 kW

efficiency denominated in kg O_2/1 kWh for these two cases will be:

ASD:

7,66 x 0,28 x 0,25 = 0,5362 kg O_2/min = 32,172 kg O_2/h

32,172 kg O_2/h / 8,5 kWh = **3,785 kg O_2/1 kWh**

fine bubble::

7,30 x 0,28 x 0,25 = 0,511 kg O_2/min = 30,66 kg O_2/h

30,66 kg O_2/h / 11,6 kWh = **2,643 kg O_2/1 kWh**

ASD efficiency: 3,785 kg O_2/kWh

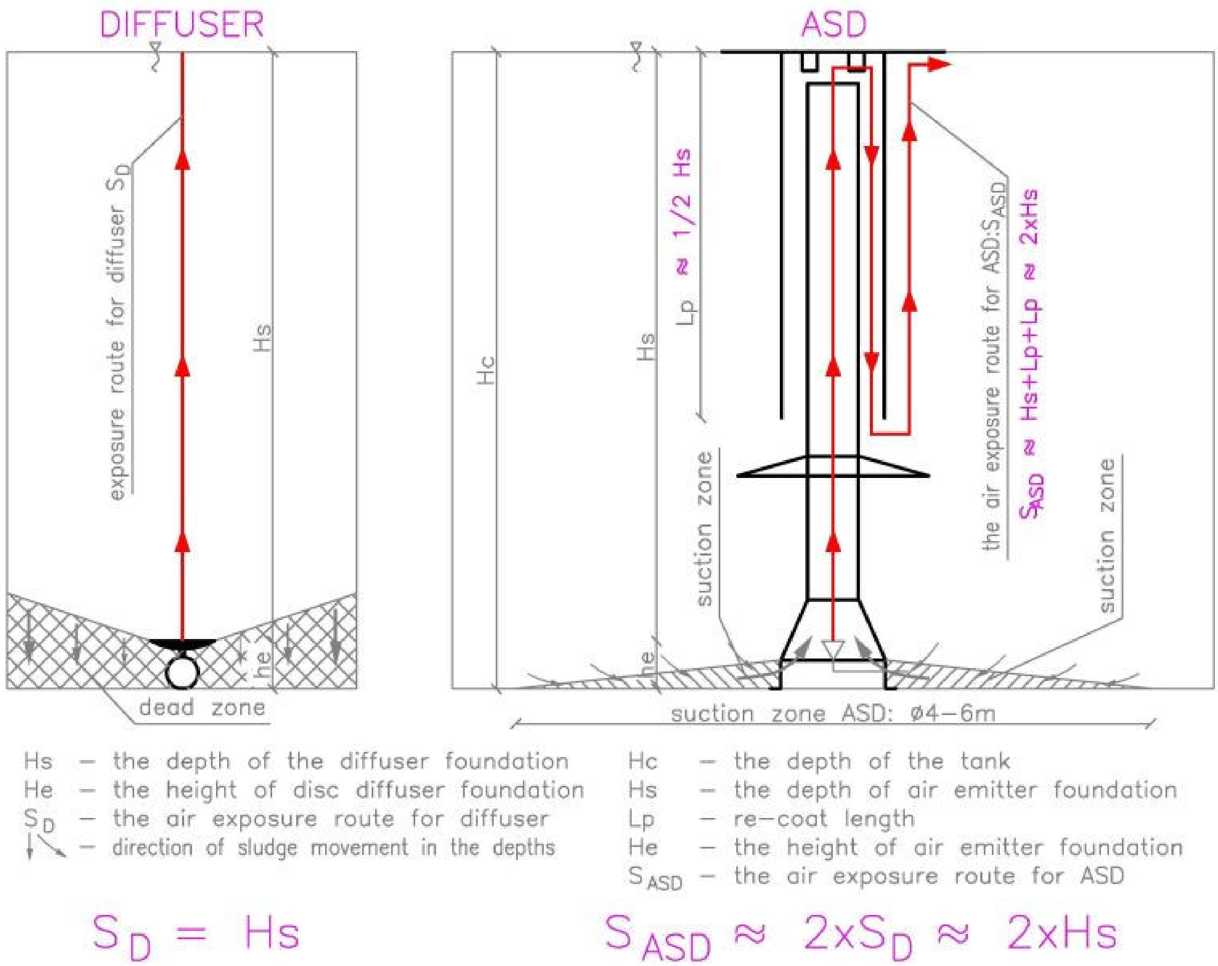
Diffusers efficiency: 2,643 kg O_2/kWh

efficiency ratio ASD/ diffusers: **1,43**

Due to the fact that the real use of oxygen in the ASD is (much) larger than taken here to calculate, in practice, this ratio is also larger and even exceed two. What does this mean? Well, it means that while using ASD aeration system, electricity consumption at aeration itself is approximately twice lower than with traditional fine-bubble aeration. How is it possible? This follows from the factors listed in table no. 1.

Below we present the difference of the exposure route in the two compared systems, as well as the dead zone of a single diffuser, in contrast to the extraction zone of sediment from the bottom during ASD operation:

Comparison of the air exposure route with sewage



Picture 2

In order to calculate the OC (aeration ability) for each separate unit or units group, where, for OC we take the amount of kg O_2/1 kWh, just a simple calculation arising from the following information will be enough:
Regardless of depth, we may charge pneumatically 1 ASD within the limits of:

Table 4

Aerator size	minimum load* [m^3/h of air]	maximum load [m^3/h of air]
ASD 200	**20**	**50**
ASD 300	**45**	**120**

* - minimum load shall be applicable due to appropriate sucking, mixing and turbulence

Therefore, excluding the indicators of percentage oxygen utilization for a given depth listed above and choosing from a blower catalog with the best power-to-performance ratio for the same depth, we can optimize the ASD selection for the given conditions, ie, excluding the depth and dimensions of the chamber in the plan. The specific ASD 200 and ASD 300 values of „aerobic capacity" for various pneumatic loads, are summarized in tables 5 and 6.

There is a way of calculating and expenses hydraulic of ASD given below. In the calculations we assume that the minimum flow velocity in ASD aerator is 2 m/s. ASD pumping efficiency is:

$$\mathbf{Q = V} \times \mathbf{S - Qp}$$

when:

Q [m^3/s] - pumping efficiency ASD

V [m/s] - flow velocity in ASD (2 m/s)

S [m^2] - cross section (ASD200: 0,0314 m^2; ASD300: 0,0707 m^2)

Qp [m^3/s] - air loading

With an average load of 1 ASD, Q is:

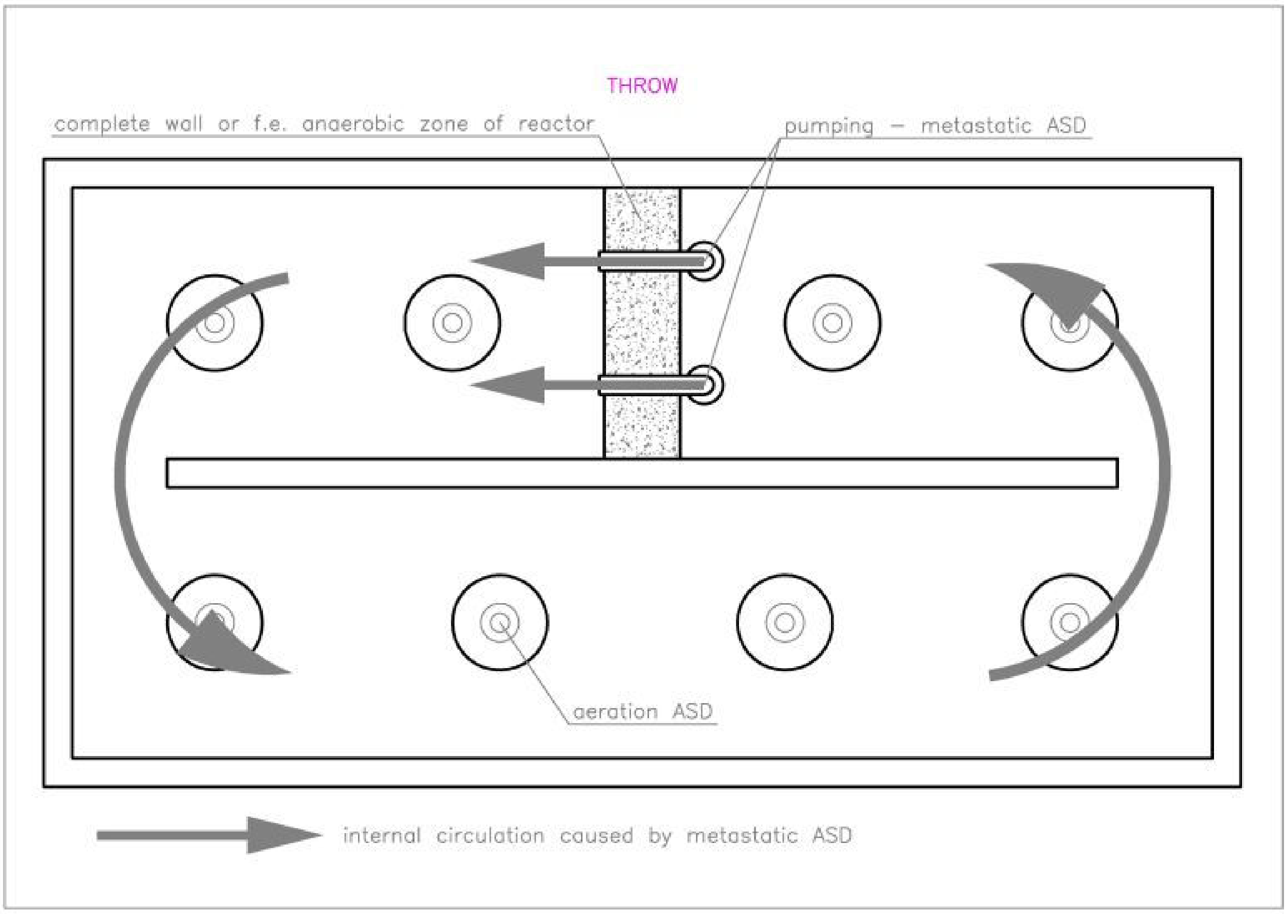
ASD 200: Q_{200} = 191 m^3/h

ASD 300: Q_{300} = 427 m^3/h

When we realize that in the aeration chamber works from several to dozens of ASD and we correlate it with the volume of the chamber, then for any case comes out that the entire volume of the chamber is pumped by the ASD mostly in several minutes. It also shows the dynamics of system operation in the context of not admitting the sludge deposition and allows to establish circulation rate of constructed systems for integrated removal of carbon, nitrogen and phosphorus.

It should also be remember (as it is also mentioned earlier) that ASD not only aerate and mix the sewage in the volume of the chamber, but they are also powerful pumps (a „mammoth" type). It is also known that nitrogen transformations require repetition of the process (recirculation). This recirculation, for different conditions, varies from 300 to even 600 percent. In traditional systems (without ASD) should be the entire volume of sewage inflow pumped up to six times to the beginning of the process.

It means a very large energy expenditure. While using „metastatic" ASD aerators to drive the internal circulation we obtain this recirculation without-energetically (without spending extra energy on pumps or pumping mixers) and in the size directly proportional to the incoming cargo (that is, only as much as it is necessary for normal process).



Picture 3

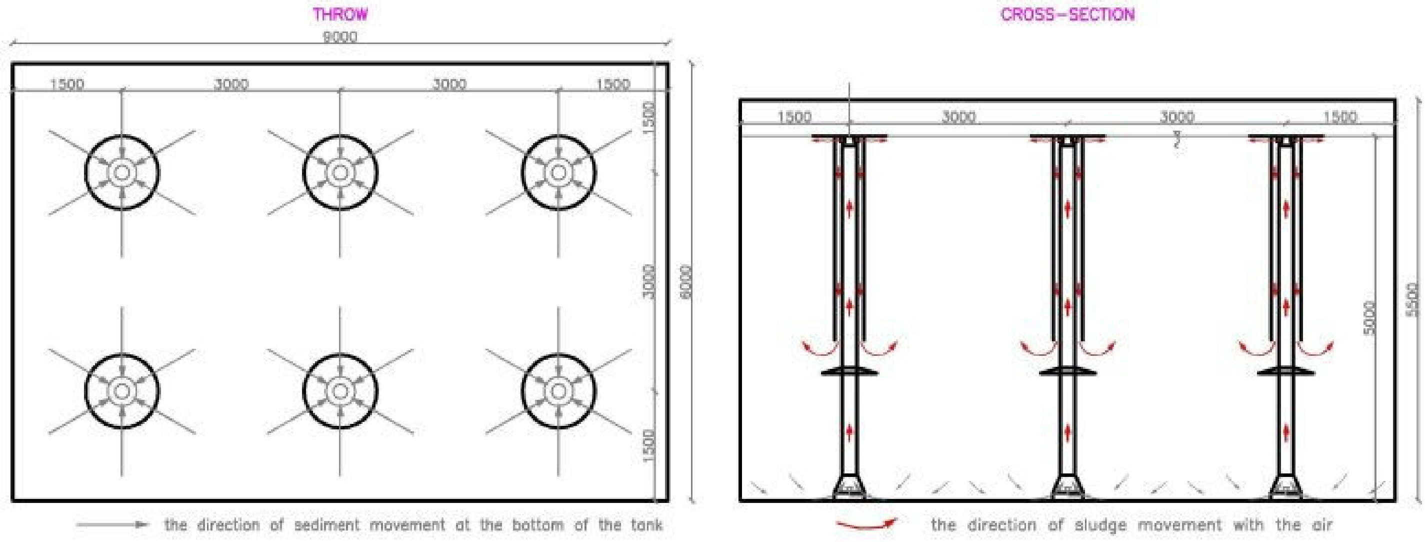
The rule of the reactor operation, which regardless of its size (even in small sewage treatment) achieves high efficiency of nitrogen removal we described on our website.

Except that **it is wrong to** attempt to calculate the horizontal component of flow velocity in the chamber, caused by metastatic ASD (circular), as responsible for preventing sedimentation of the sludge (as in the trenches circulation). This would be synonymous to checking whether such a speed causes recirculation pumps work in other systems.

The fact that ASD do not allow to unfavorable sedimentation and deposition of sludge in the chamber is mainly due to the suction action and the local, vertical velocity component of sludge (see the sketches above).

Below there is an aeration chamber of exemplary volume and depth to show how mixing chamber while only using an aeration ASD system looks like (with no additional mixers).

Example of an aerated tank



picture 4

$$V_{of\ chamber} = 6 \times 9 \times 5 = 270\ m^3$$

Calculation of complete mixing time (it means, pumped the entire volume of the reservoir by ASD) for this chamber equipped with ASD 200:

amount of ASD - 6 pieces

rate flow of 1 ASD with an average load - 191 m^3/h

total expenditure ASD - 6 x 191 = **1'146 m^3/h**

Time of complete mixing:

$$T_w = 270 : 1'146 = 0{,}2356 \text{ hour} \approx \mathbf{14\ minutes}$$

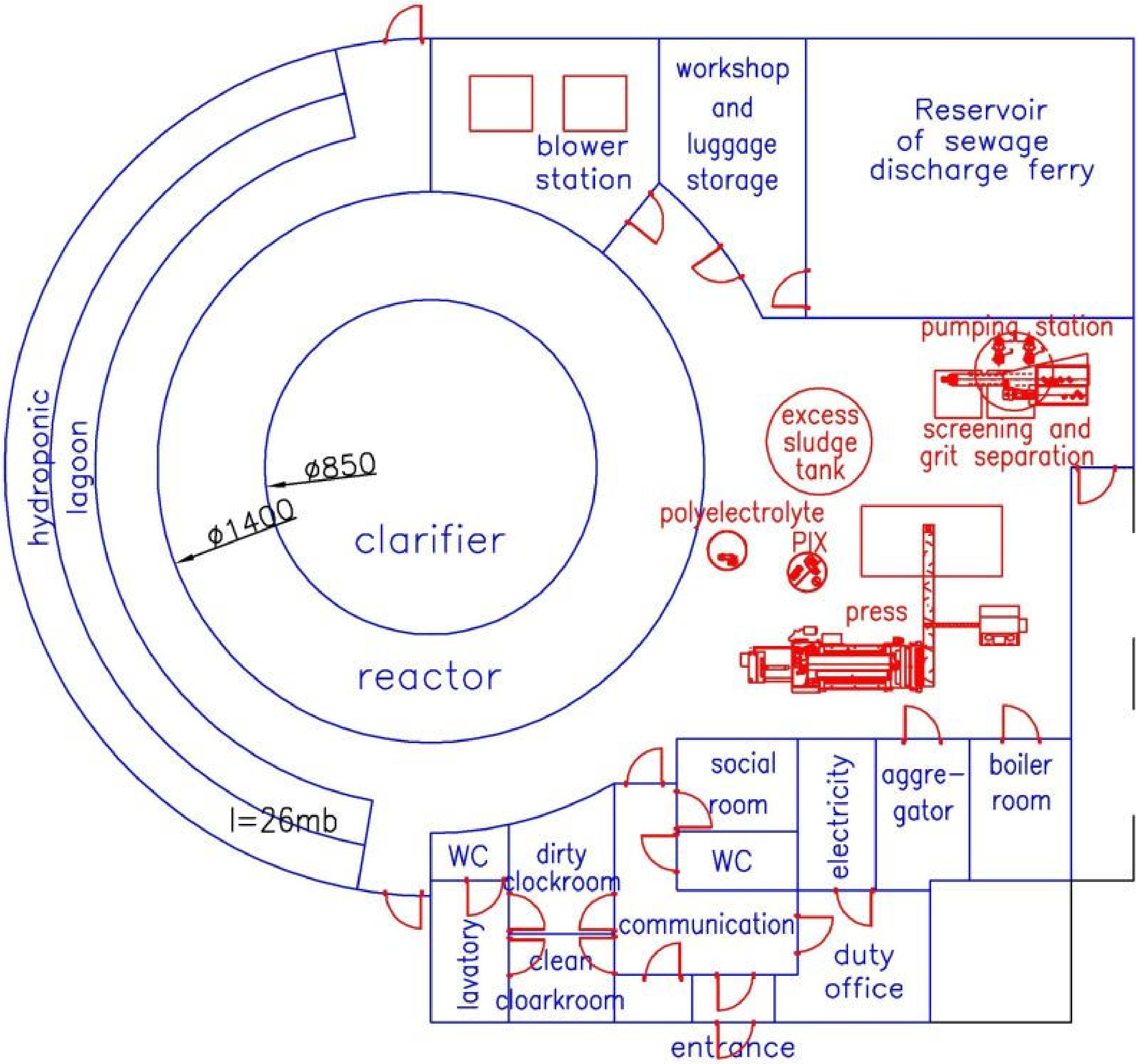
Multiplicity of mixing:

$$n = 60 : 14 \approx \mathbf{4/hour}$$

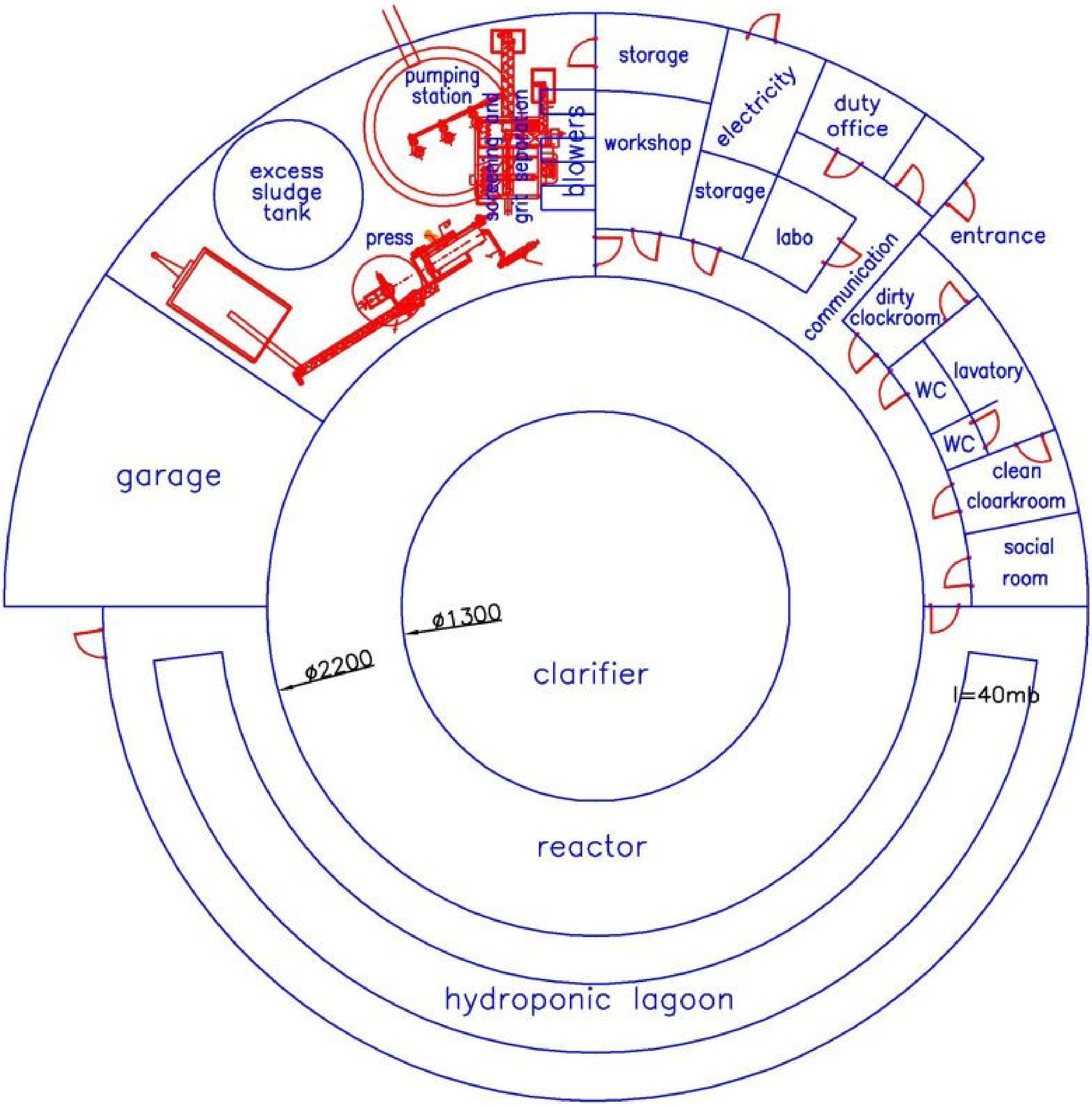
It follows that in every 14 minutes (which is more than 4 times per hour) thru the aerators passes the ENTIRE volume of the chamber, which is sucked from the bottom and in very turbulent motion is ejected at the surface (small part) or in the middle of the tank (much larger part) and together with a cloud of air bubbles goes up.

Some examples of solutions of newly designed sewage treatment with different capacities:

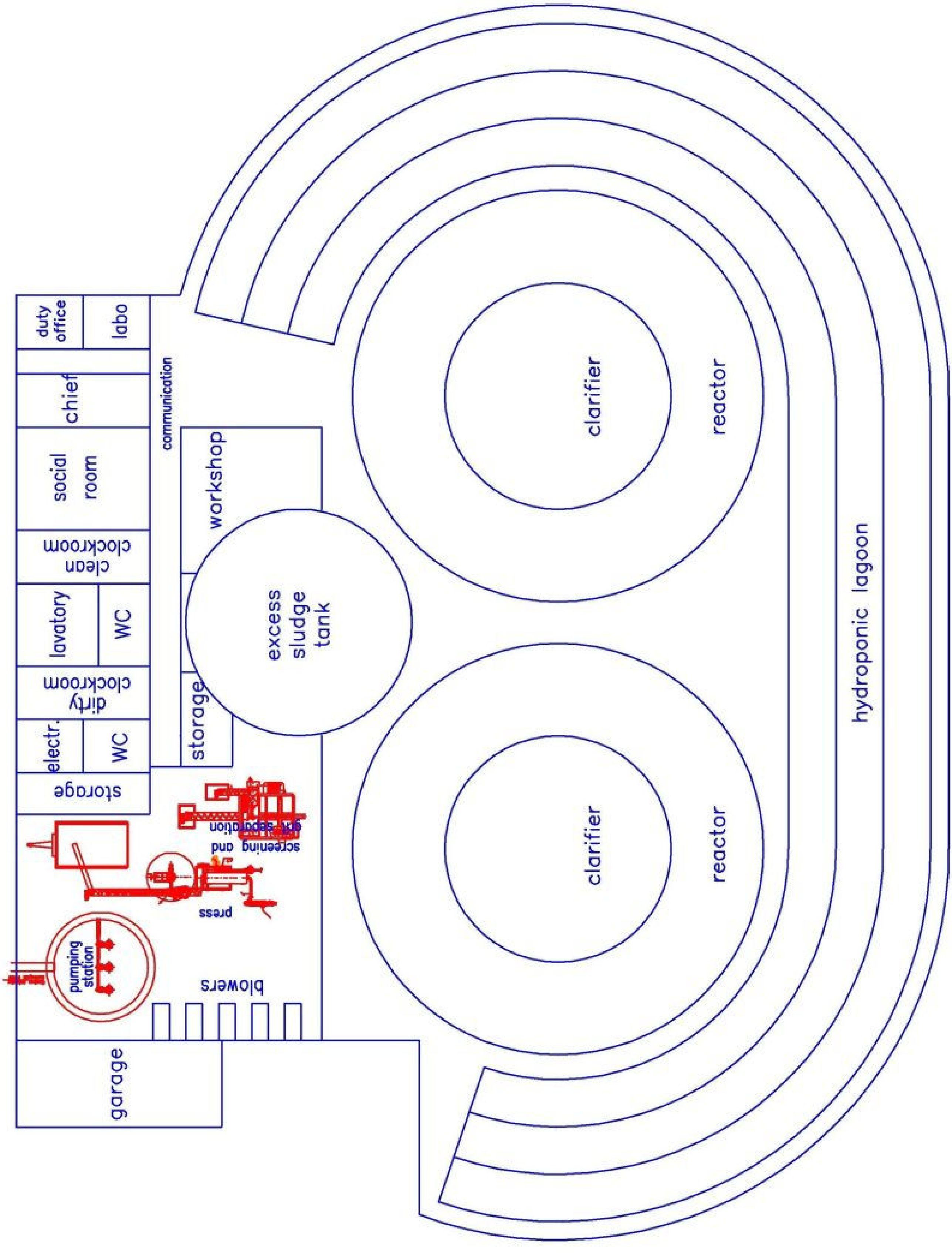
Capacity 600 m^3/d



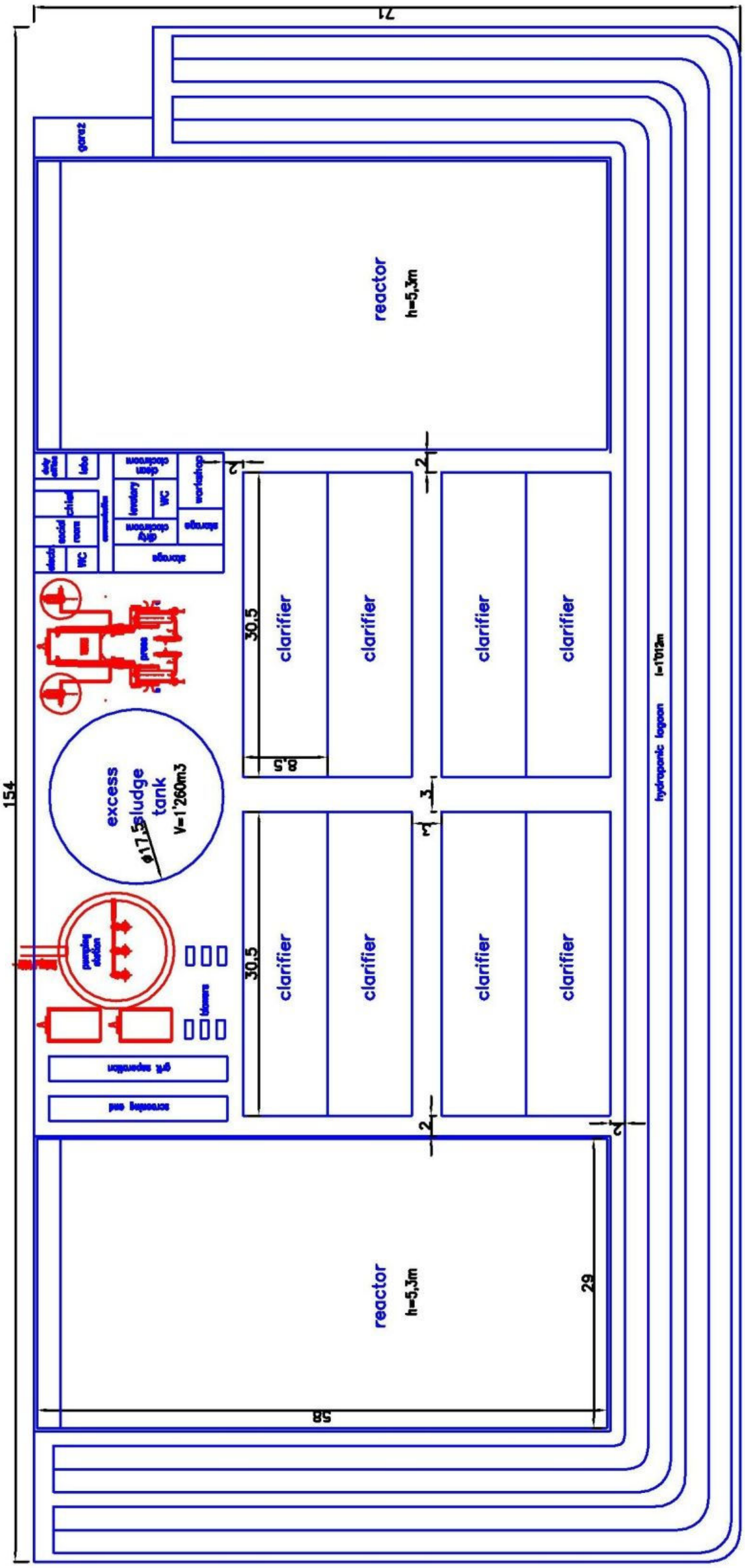
Capacity 1 200 m^3/d



Capacity 2 500 (till 5 000) m^3/d



Capacity 20 000 m^3/d



We hope, that presented by us, our innovative in the world Polish technology, will find your approval.

with regards,

PRO-Aqua team