



EMULATING NATURE **A BIOLOGICAL PROCESS ELIMINATING THE PRODUCTION OF SLUDGE**



GREEN INNOVATION IN WASTEWATER TREATMENT

TURBO4BIO BY AL BAWANI WATER & POWER (AWP)

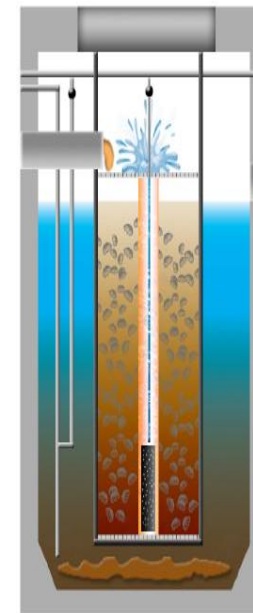
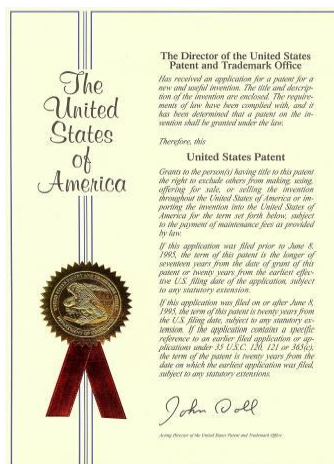
TODAY'S REVOLUTION IN WASTEWATER TREATMENT



**COMPACT
TURBO
MBR
SMARTER
CLEANER
QUIETER
SCENTLESS**

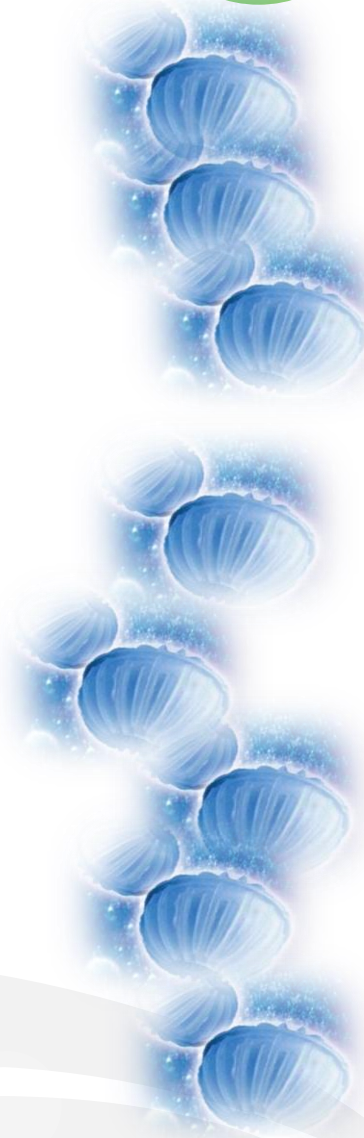
TURBO4BIO

**+40 WWTP's totaling 500,000m³/day with
"NO-SLUDGE-Production Guarantee"**



DESIGN & MANUFACTURE OF TURBO4BIO TURBO REACTOR BASED WWTP'S.

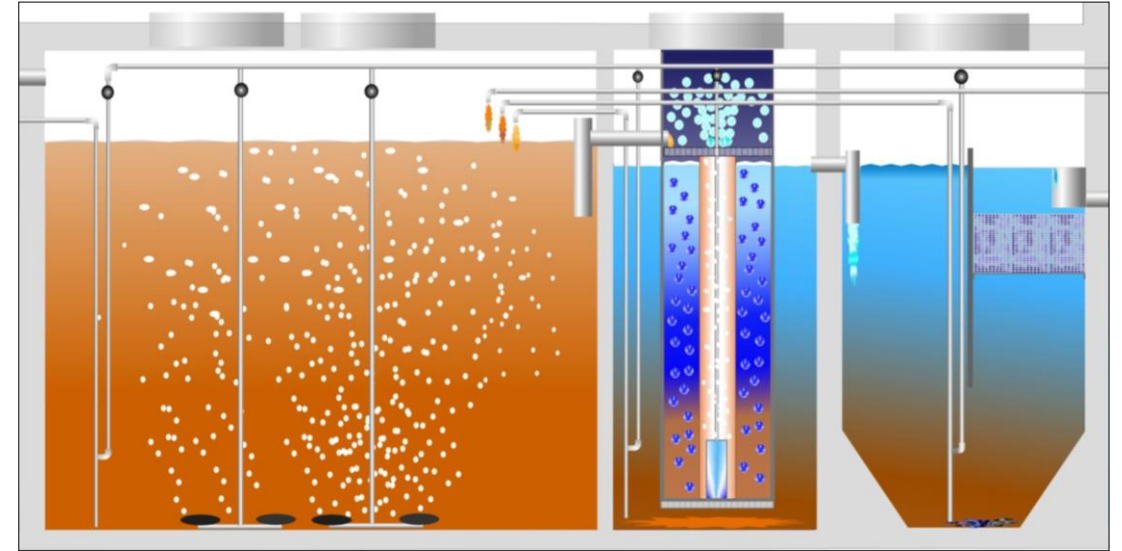
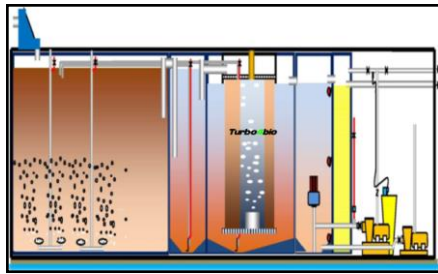
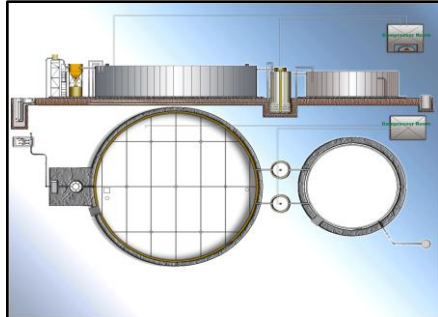
UK	PATENT	2002
USA	PATENT	2009
EU	PATENT	2013



SYSTEM FOR THE TREATMENT OF SEWAGE & ORGANIC EFFLUENTS



SIMPLICITY: 3 - STEPS



EXECUTIVE SUMMARY



The **TURBO4BIO** system has been patented in the UK and Europe by Hans Bioshaft Limited, a UK company based in Cardiff, South Wales.



The **TURBO4BIO** was developed in the early 1990's using partially European funding to find a low cost sustainable solution for sewage treatment plants with minimal sludge yields and ease of maintenance. This has now developed into a commercially proven technology with numerous **TURBO4BIO** installations working successfully worldwide with trouble free operation. The proprietary **T4b** tech is continuously improved with new patents pending.

The **TURBO4BIO** effluent treatment plant is an advanced, high intensity, sludge aeration system. The plant is totally enclosed and is essentially non-mechanical in operation, ensuring a virtually odor-free, simple operation, environmentally friendly and long-life solution for the treatment of domestic, commercial and municipal sewage and, where appropriate, organic industrial wastewater.

The modular nature of the **TURBO4BIO** provides a high level of flexibility in application. Installed in single, or in multiples either in parallel or series, the plant can be above or below ground to suit the local environment, site conditions and the available footprint.

The plant is able to treat flows from relatively small domestic populations up to large scale municipal sewage works and the modular concept allows phased installation where appropriate. The optimal loading rates compare favorably with traditional processes and allow for small footprints including long sludge retention times.

EXECUTIVE SUMMARY



The **TURBO4BIO** system offers very competitive plant material capital costs, combined with simple and cost effective installations to provide an attractive turnkey package. This is backed by very low operational costs with minimal sludge yields and extremely efficient oxygen transfer and correspondingly small motors and optimal power consumption.

The technical benefits also include a fast biological start up so that the plant is treating the full flows and loads almost instantly compared to many package plants that need to ramp up over several days and often weeks.

The **TURBO4BIO** system is ideal for new installations and can be applied as a retrofit / upgrade to existing installations for capacity increase and/or improved treated effluent quality requirements.

The uniqueness of the patented **TURBO4BIO** system process eliminates the need for tertiary treatment while producing the same or better treated effluent quality.

ABOUT MBBR, IFAS OR HYBAS & RBBR



The **TURBO4BIO** RBBR as advanced Hybrid CAS outperforms all competition including MBR & MBBR on issues as energy saving, footprint, sludge, odor....



- MBBR/**IFAS** processes employ the same proven biofilm carrier technology employed in all MBBR systems but within a conventional activated sludge process. This combination, commonly known as integrated fixed film activated sludge (IFAS) or as hybrid activated sludge (HYBAS) maintains a higher mixed-liquor suspended solids (MLSS) than single-pass MBBR processes - ideal for upgrading and enhancing municipal wastewater treatment facilities. The result is a hybrid process of activated sludge and biofilm carrier technology, achieving biodegradation performance unequalled by similarly sized conventional activated sludge systems.
- The equivalent MLSS in an MBBR is 6,000 to 10,000 mg/l so the footprint of MBBR process is already one-third to one-half of the activated sludge process; the IFAS/HYBAS MLSS will be higher and the **TURBO4BIO** as most advanced Hybas even goes till 30.000!
- **TURBO4BIO** coined its process RBBR, 'return biomass bio reactor' as the only 100% attached growth process it returns no sludge but biomass to the aeration tank resulting in zero organic sludge.

WHY UTILIZING TURBO4BIO?

(ADVANCED MBBR TO UPGRADE & RETROFIT MUNICIPAL WASTEWATER TREATMENT PLANTS)



- **T4B is not F/M-parameter-sensitive**. It can fully maintain its stability in organic loads several times higher than conventional systems such as activated sludge, trickling filters, RBCs, ABF, etc. This is considered a very important advantage of the process.
- Compared to the old conventional processes, this system requires less HRT to reduce wastewater organic load to the optimal level. This can lead to reduced volume of aeration tank. Therefore, MBBR can be used to increase the capacity of WWTPs and upgrade them to improve effluents quality.
- Furthermore, by combining this system with anoxic and anaerobic systems (in remaining aeration tank) the output nutrient rate can be reduced to an acceptable level. Thus, the current WWTPs can be upgraded.
- The specific surface of the carriers is a crucial parameter. When selecting carriers, enough attention should be paid to choose the appropriate specific area in order to reduce the required time for treatment process and consequently reduce the treatment costs.
- T4B (advanced MBBR) does not have common problems such as sludge bulking and rising, foaming, poor sludge settling, carriers clogging and the need for backwashing with regard to the operational characteristics.
- Strong resistance to impact and no need to return the sludge make the system much easier to operate.
- Considering the effluents quality, even with HRT of 2 h, the system can meet the country standards and EPA in elimination of organic materials

TECHNICAL REVIEW



PROCESS SUMMARY

Traditional Treatment Processes

Biological treatment of human (domestic) waste water using an activated sludge process is a very effective and relatively low cost method of purification and is a proven and trusted solution for the treatment of waste water in most of the developed countries.

All activated sludge processes are based on a simple biochemical reaction, shown simply in the diagram below.

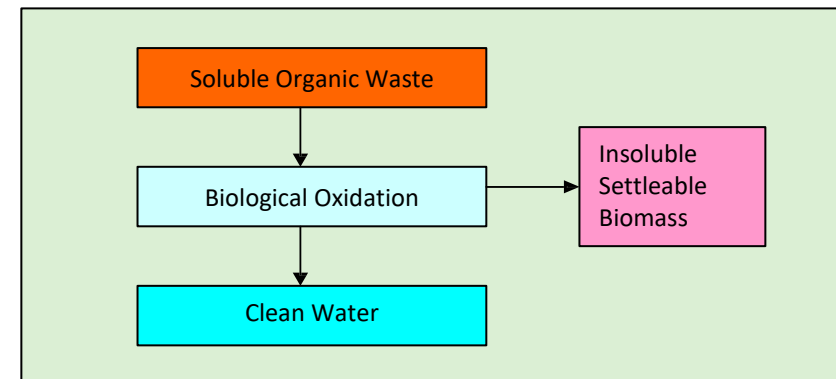


Figure 1: Biological Oxidation of Organic Effluents.

The process is to provide food, in this case our organic influent (the raw wastewater stream), for the microorganisms, ensure they have the correct nutrients and aerate to provide oxygen and this then yields biomass, carbon dioxide, water and energy.

In schematic form, the activated sludge process can be shown as per the following diagram:

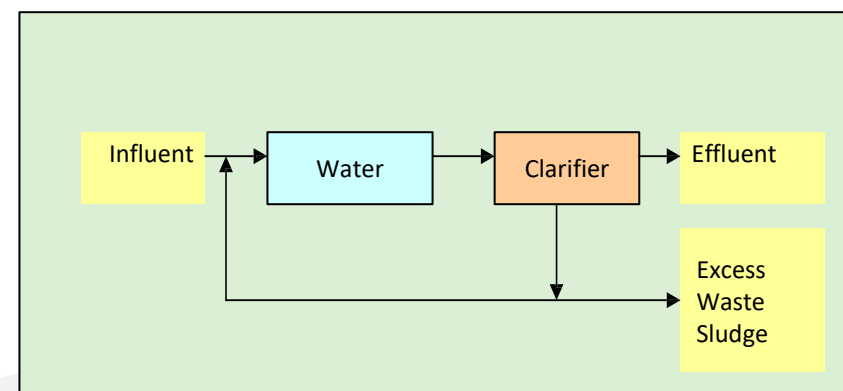


Figure 2: The Activated Sludge Process

TECHNICAL REVIEW



However, conventional systems need large aeration and sedimentation volumes, which are reflected in the large land-space needed to provide the required surface areas and volumes for effective process operation. Conventional activated sludge systems are also inefficient in terms of energy used per volume of treated effluent water.

THE ENHANCED **TURBO4BIO** PROCESS | SUMMARY

The areas and volumes required for efficient treatment have been remarkably reduced by the introduction of sludge carriers, which create activated sludge more rapidly, more efficiently and hence more economically. The corresponding reduction in land-space can be very significant; this is one of the key differentiations of the **TURBO4BIO** process.

The sludge carriers are also directly responsible for the second unique feature of the **TURBO4BIO** reactor. The design of the sludge carriers incorporates cavities that allow the existence of anaerobic bacteria even in the oxygen rich turbine environment. These anaerobic bacteria are essential for the process to minimize the production of sludge that needs to be removed off site and the process has very low sludge yields compared to competitor conventional processes. In addition to the low sludge production an **enormous reduction of phosphorus** is obtained during the anoxic process inside the turbine. The high saturation on oxygen in the biomass works as a nitrifying process and reduce the ammonia (total Nitrogen) to zero level.

Two additional bio-reactions take place when the anaerobes are present; firstly the anaerobic bacteria acts upon the soluble organics in the effluent, these bacteria are 'acid formers' and the result is the production of volatile acids. The anaerobic bacteria then further metabolize the volatile acids; this results in the release of Carbon Dioxide and Methane. However the digestion of biomass will occur, when the conditions of low-levels of fresh organic foods exist. This means that in the **TURBO4BIO** process, self-digestion of the produced biomass is simultaneously occurring, resulting in lower sludge production rates compared to other processes.

TECHNICAL REVIEW



Figure 3: A flow diagram of a **TURBO4BIO** Biological Process

PHYSICAL CHARACTERISTICS OF THE **TURBO4BIO** PROCESS

There are four principal components needed for the system:

An **Inlet Balancing Tank** - provides 24 hours (or less) storage of influent for the pretreatment, flow balancing and sludge retention

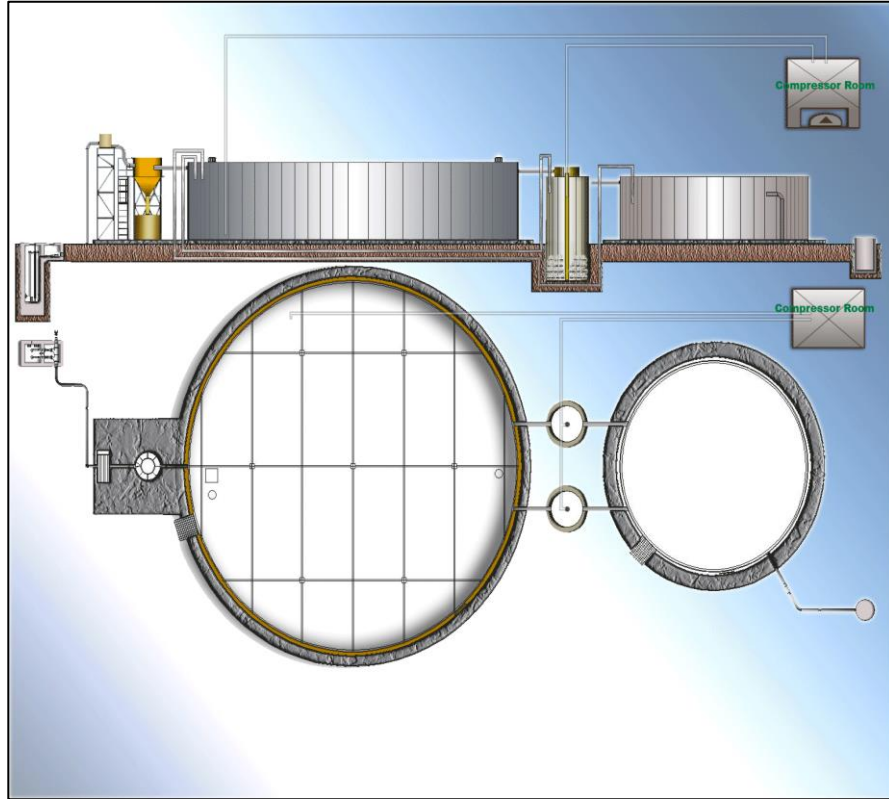
The **TURBO4BIO turbine** - this is the biological reactor that carries out the majority of the treatment

A **Final Clarifier** - this is used to remove the residual suspended solids to polish the treated effluent and recycles collected sludge back round the system

Air compressors - these are normally provided in duplicate on a duty/standby arrangement and the air provides the oxygen to the bacteria and provides mixing and pumping of liquors

A screen (10 mm) - to be installed upstream of the turbine reactor.

TECHNICAL REVIEW



The system produces far less sludge than conventional treatment plants and the less frequent sludge removal is a major saving on running costs. The patented membrane aerator inside the turbo reactor secures the oxygen requirement for the decomposition process and additionally ensures an efficient flow of effluent through the biological filter, thus preventing blockage.

A simple vane compressor supplies the air required for the process. It is dispersed in the turbine by the diffusers to form an enormous number of micro bubbles. The majority of the air employed is injected directly into the central riser tube (**see diagram**), this creates the desired flow and recirculation within the turbine. Finally air is also used to move sludge around the plant, a design feature which eliminates mechanical pumps wherever possible. The following cross section shows the preferred installation configuration, with the turbo reactor (**shaft**) partially sunk into the ground to allow gravity flow through the system and the only pumping required is into the Inlet Balancing Tank.

PLANT PERFORMANCE

All effluents treatment plants are designed to achieve certain, measurable pollutant levels in the final outfall. The Turbo4bio is no exception to this and must strictly conform to all local, national and international discharge levels to be a viable process technology. Typically the system will treat domestic sewage up to a treated effluent quality of 10 mg/l BOD5 (ATU) and 10 mg/l suspended solids standards with Ammonia nitrogen of less than 5 mg/l. Each system has a computer model design check to include local Consent to Discharge standards and where necessary the plant can be combined with tertiary treatment solutions such as reed beds, wetlands and sand filters for very high quality treated effluent requirements suitable for industrial applications such as district cooling etc..

MATERIAL OF CONSTRUCTION



TURBO4BIO is manufactured from GRP, HDPE or occasionally stainless steel material for specific applications. The picture below shows a combination of concrete tanks and the GRP turbine for a large scale municipal sewage treatment works in the Middle East .



Figure 5: **TURBO4BIO** Installation at Kufa



Figure 6: **TURBO4BIO** in Stainless steel

BENEFITS SUMMARY

The **TURBO4BIO** system claims several benefits; these are summarized below.

- Design simplicity | the design of the plant is elegantly simple, there are no complex control systems and process flows are simple. Sludge recycle rates are set using a simple timer and implemented with an airlift system.
- High Performance | The plant has demonstrated that it is capable of very high degree of purification – **97%** in a single stage. Treated effluent is suitable for non- restricted irrigation applications.
- High reliability | Mechanically the plant is very simple with almost no moving parts, consequently there is little to fail during operation.
- High durability | very long operational life, the choice of constructional materials, GRP for the shaft and polypropylene for the sludge carriers, ensure structural strength and excellent corrosion resistance.
- Minimal sludge production | best in class performance, this means that sludge disposal problems are minimized.
- Low capital cost | The system has proven to be significantly lower in cost compared to other conventional & advanced processes, such as extended aeration Activated Sludge process, SBR, conventional MBBR and MBR.

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- Low operational cost | A high efficiency plant, with very low energy consumption, leading to minimal operational costs.
- No chemicals required & No chemical cleaning needed. Only disinfection by low dosage of Chlorine is required to maintain residual Chlorine level.
- Minimal maintenance | virtually the only item for maintenance is the air compressor system.
- Rapid shock recovery | High rates of biomass generation lead to rapid recovery of the plant from toxic shocks, although this is only applicable to industrial effluents No operators required – the plant runs unattended and requires no special training for those that do make infrequent checks on the system.
- Underground installation | Can be completely concealed below ground, particularly useful where land is at a premium or where no visual disturbance is required.
- Flexible to any capacity desired | suitable for small domestic installations ranging 10 – 1,000 m³/day and can be installed in modular parallel design to cover larger installations from 1,000 - 100,000 m³/day.

COMPARISON BETWEEN TURBO4BIO VS OTHER TECHNOLOGIES



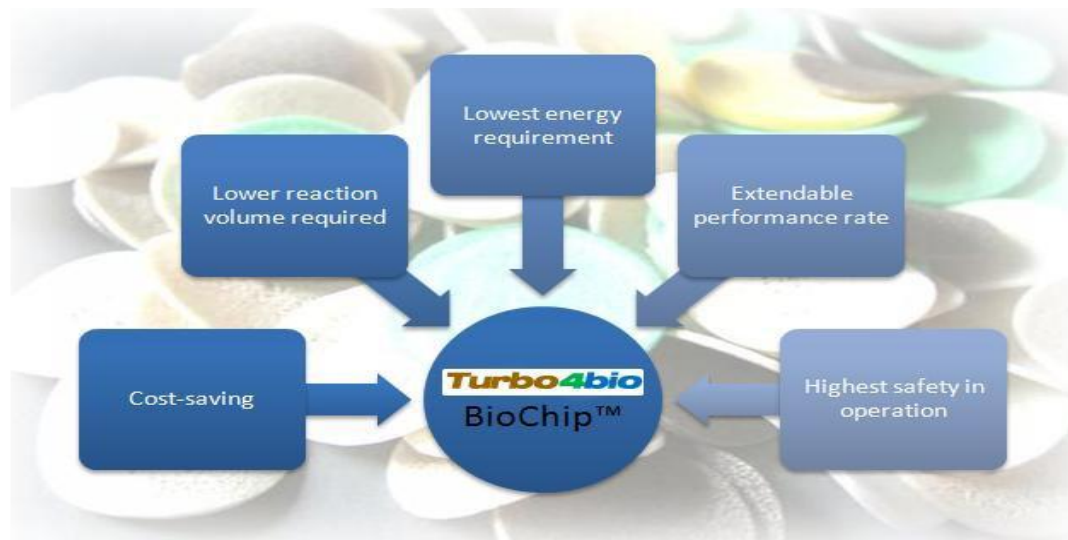
SN	Parameter	Units	Conventional Activated Sludge	MBR	MBBR	SBR	ORGANICA FCR	Turbo4bio
1	Biomass Concentration	mg/l	2,000 – 3, 000	6,000 – 12,000	5,000 – 8,000	2,000 – 3,000	8,000 – 12,000	12,000 – 25,000
2	Typical Effective SRT	Days	3 – 12	8 – 15	8 – 15	3 – 12	40 – 45	40 – 45
3	Aeration Factor (a)	NA	0.5 – 0.6	0.3 – 0.5	0.7	0.5 – 0.6	0.85 – 0.9	0.85 – 0.9
4	Aeration Type	NA	Fine Bubble	Fine Bubble	Coarse bubble	Fine bubble	Fine bubble	Fine bubble
5	Solids Phase Separation	NA	Clarifier	Membrane	Retaining Screen, followed by clarifier	Settle and decant	Clarifier or Disc filter	Clarifier w/tube settler
6	Typical HRT	Hours	8 – 24	5 – 12	4 – 12	10 – 28	4 – 12	4 – 6
7	Typical Sludge Production	kgTS/ kgBOD removed	1.0 – 1.2	0.8 – 1.0	0.8 – 1.0	1.0 – 1.2	0.5 – 0.9	0.1 – 0.2
8	Energy Demand	kwh/m ³ treated	0.35 – 1.6	0.9 – 2.8	0.7 – 2.4	0.6 – 1.8	0.15 – 1.2	0.4 – 0.9
9	Land Requirement	M ² /m ³ capacity	0.35 – 2	0.6 – 1.4	0.6 – 1.4	0.5 – 1.5	0.12 – 0.4	0.12 – 0.4
10	Minimum Site Buffer Zone Requirement	Distance from facility (Nearest public structure)	250 m	250 m	250 m	250 m	10m - 25m	10m

SUMMARY OF TURBO4BIO PROCESS



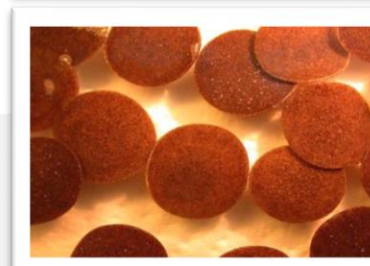
1. Advanced (IFAS +MBBR)System
2. Works on IFAS Process
3. Invented by Aachen University of technology and started in commercial Operation around 20 years ago.
4. Awarded UK patent 2002, USA patent 2009 and European patent 2013
5. Maximum capacity constructed or under construction is 500,000 m³/day
6. Uses less air which results to lower power consumption (30%-50% Energy Savings, No use of Chemicals) and lower OPEX
7. Saves on space and this results to lower CAPEX
8. Approved by Shell UK, KBR USA, Iraqi Ministry of Planning, Saudi Ministry of Defense / Saudi Ministry of Health , Water District of Davao - Philippine , UAE Municipality.
9. Up to 99% less sludge
10. Significant energy reduction: 0.4 - 0.9 kWh /m³ depending on plant size
11. OPEX below competition: 0.1 \$ /m³ total depending on plant size & requirements
12. CAPEX below 550 - 1150 \$/m³ total depending on plant requirements
13. Elimination of odors
14. Sustainable Technology for new plants, Retrofit and Upgrades of WWTP

TODAY'S REVOLUTION IN WASTEWATER TREATMENT



TURBO4BIO BioChip® MBBR BIO-MEDIA

This unique BioFilm Media provided from us is self cleaning with highest protected effective surface ratio, best possible stable removal performance within smallest footprints, low running costs & highly competitive. The T4b-biofilm carrier chips are produced from a material and with a procedure that, provided properly stored and used, ensures a minimum clogging free aging time of >10 years. T4b bio Chip's are used in new or retrofitting & upgrading needing industrial or municipal STP's, be it in a MBBR or IFAS lay-out & as biological treatment for aquaculture systems or fish farms. This attached growth Biofilm Media is made of virgin proprietary polyethylene. Packed in 1.5 m³ Super Bags.



TURBO4BIO BIOCHIP® MBBR BIO-MEDIA





COD

- Aerobic
- Anaerobic



NH₄-N

- Nitrification



NO₃-N

- Denitrification

	T4b-3000-01
Media Dimensions	22x1mm
Effective Surface Area	>4000 m ² /m ³
Number of BioChip/ m ³	1.000,000
Weight per m ³	170 kg
Material	Proprietary Mix Polyethylene based
Color /Form	White / Round, Parabolic, Hollow body
Density	~ 0.95 kg/l @ 23°C
Filling In Reactor	5-55%
Ecological effect	Harmless to the environment
Transport	Non hazardous good

High efficient degradation, minimum required volume, lowest energy requirement and highest performance data. The Turbo4bio BioChip™ beats the pants of all conventional carriers. The tremendous approved efficiency rates compared to other conventional carrier are guaranteed in highest COD- and also N- degradation results.

HIGH-PERFORMANCE MBBR CARRIER MEDIA FOR BIOFILMS



MAJOR BENEFITS AT A GLANCE

First of all, it has to be pointed out that Turbo4bio's staff has more than 20 years of profound experience with nearly each type of MBBR carrier media available on the global market. The different shortcomings of these carriers had been taken into consideration when the T4b BioChip was developed.

In the following, the major benefits of the T4b-BioChip are explained more in detail.

Constant Removal Rates = High Process Stability:

Due to the fact that the optimally thin biofilms on the T4b BioChip are controlled in their thickness by the aforementioned self-cleaning effect due to shear forces, the removal performance is maintained at a highly constant level (no decrease in performance caused by thick biofilms as with "conventional" tubular carriers). Especially for the end-customer and authorities, the stability of the biological treatment process is a highly important criterion in order to not exceed the required effluent parameters at any time.

No clogging: biofilm is only inside the pores



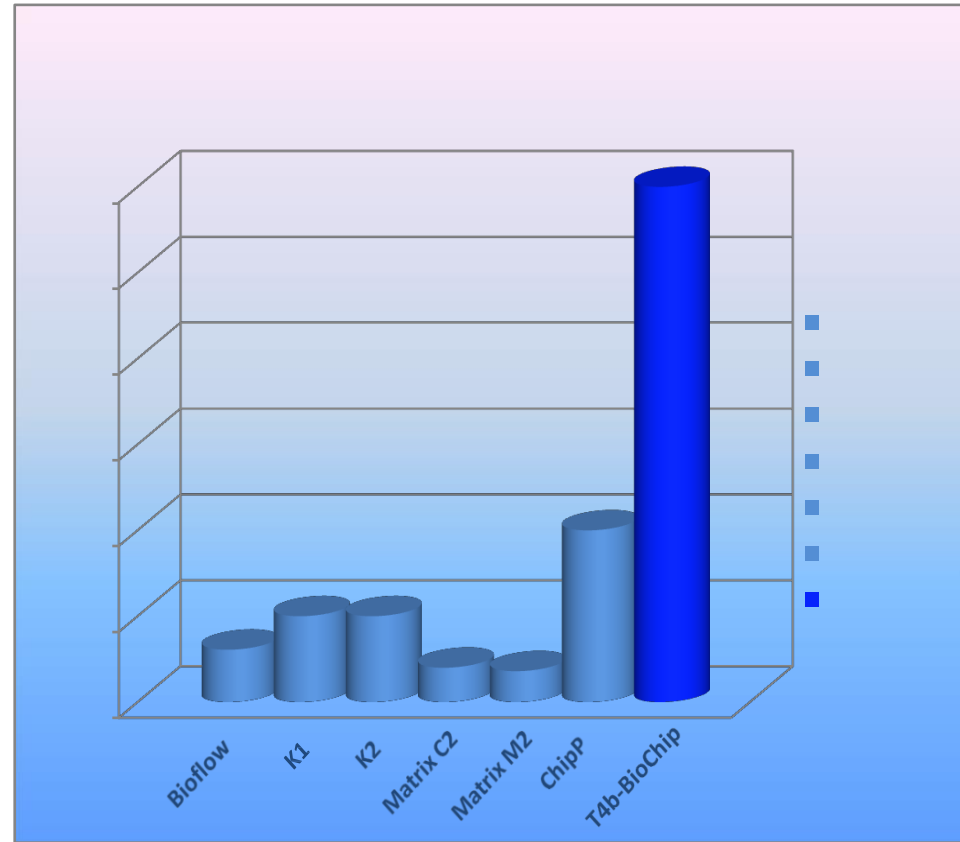
Smaller footprint of the reaction tanks = savings in construction expenses:

The high biodegradation performance of the T4b BioChip carrier allows for using less carrier volume than with "conventional" carriers since there is less T4b BioChip volume required for providing the similar protected active surface area. This fact is highly beneficial for customers as they can save money due to smaller tank volumes and it is a crucial feature when there is only limited space available when building a new WWTP.

FAVORABLE PRICE - SURFACE AREA RATIO:



The **TURBO4BIO** BioChip offers a price-to-surface area ratio which is more favorable than many other carrier types. In order to properly evaluate offers for carrier media, it is required to compare prices of different media not per m^3 but per m^2 provided by any type of carrier media, since each media has a different m^2/m^3 ratio. For this reason, it needs to be taken into account that the protected active surface area (in m^2/m^3) and not solely the volume (in m^3) of carrier media which is crucial for the removal performance.



Comparison of the protected active surface areas of different types of MBBR carrier media

REFERENCE LIST FOR EXECUTED PROJECTS



Plants using the patented Hans Turbo4bio-Shaft Technology (2000-2017) in cubic meter [m³/day]

YEAR	DESCRIPTION	CAPACITY m3/day
2000	USAID Lebanon, BSCHOTFEEN	350
2002	USAID Lebanon, MYMES VILLAGE	500
2002	USAID Lebanon, MYMES VILLAGE	1,000
2002	USAID Lebanon, KFEER VILLAGE	3,500
2002	USAID Lebanon, YANTA VILLAGE	1,000
2002	USAID Lebanon, YANTA VILLAGE	2,000
2002	USAID Lebanon, AKKAR VILLAGE	1,000
2002	USAID Lebanon, JOBIA VILLAGE	7,000
2002	USAID Lebanon, DER ALAHMER	3,500
2002	USAID Lebanon, KFER FILA	3,500
2002	USAID Lebanon, JEBIAH VILLAGE	7,000

REFERENCE LIST FOR EXECUTED PROJECTS



2005	Ministry of Public Work, HUTTEEN, KUWAIT	9,000
2005	Ministry of Public Work, SHOHADDA, KUWAIT	9,000
2009	City of Wayne, WAYNE NEBRASKA, USA	500
2009	RIC, DUBAI U.A.E.	140
2009	Water Masters, Jeddah Saudi Arabia	100
2010	Sharjah Municipality, Sharjah UAE	140
2010	Residential complex, Jeddah, Saudi Arabia	60
2012	Governate of Najaf, An-Kufa STP, Iraq	50,000
2013	City Star Cristal Lagoon, Sharm al-Sheikh, Sinai, Egypt	3,000
2013	KKMC at Hafar Al-Batin, MOD, KSA	14,000

REFERENCE LIST FOR EXECUTED PROJECTS



2014	Barwa Housing STP, Doha, Qatar	600
2014	Suez Thermal Power Plant, BAPETCO, Egypt	100
2014	KAEC offices complex, KAEC- Jeddah, KSA	1,000
2014	Jizan Economic City Labor Housing STP, Aramco, KSA	400
2015	Hacienda Bay-Palm Hills resort, North Coast, Egypt	500
2015	Porto Sharm luxe resort, Sharm al-Sheikh, Egypt	1,000
2015	King Fahad Hospital, Jizan-Jeddah, Saudi Arabia	3,000
2016	Hacienda Bay-Palm Hills resort- Ext., North Coast, Egypt	500
2016	Porto October, 6 th October City, Egypt	2,000
2016	Davao City Water District, Philippines	100
2016	Porto October, 6 th October City-Ext., Egypt	1,800
2017	Maradi Hospital, Niger	300
2017	Isfahan, Iran (under construction, final stage)	12,000

REFERENCE LIST FOR EXECUTED PROJECTS



Orders Under Execution 2019/2020:

2019	AL SADEG Area AL BASRA Iraq	28,000 m3/day
2019	AL Basra City, Iraq	31,500 m3/day
2019	Al Muthania, Iraq	50,000 m3/day
2019	Al Najaf, Al Mishgaab, Iraq	50,000 m3/day
2019	Hospital for Cancer Karbal Containerized type, Iraq	300 m3/day
2019	Nasma Dubai UAE , Containerized	1,500 m3/day
2019	Metito, Egypt, classified site, Iraq	3,000 m3/day
2019	Najaf, Imam Al Shrine, Iraq	6,000 m3/day
2020	AL Qurna , Basra Governate, Iraq	100,000 m3/day
2020	AL KUT, Wasset Governate , Iraq	60,000 m3/day

Total contracts value (Under Execution): Euro 180,800,000

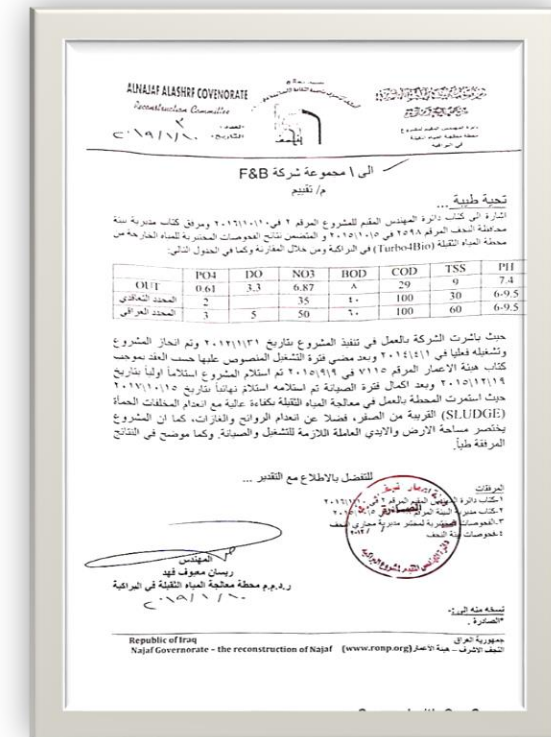
RECOMMENDATIONS



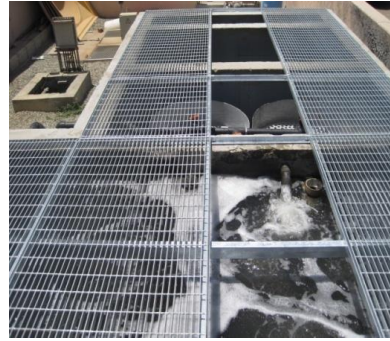
Khatib & Alami - Turbo4Bio Approval



Summary of Operation Kufa Plant 50,000 m³/day



CONTAINER HDPE CONCRETE STEEL MODULAR



THE TURBO4BIO APPLICATIONS



- MUNICIPAL : New Construction, Retrofits, **Upgrades**
- SATELLITE PLANTS: Private Developments, Hospitals, Schools, Small rural cities, Hotels & Resorts, Golf Courses, Rest Stops, Parks
-
- COMMERCIAL: Shopping Centers, Office Buildings, Restaurants ,University, villages.
- RECLAMATION: Irrigation, Stream Augmentation, Aquifer Recharge, Sewer Mining
- **TURBO4BIO** continues to penetrate these markets worldwide & towards industrial market as the Food, Beverage & Paper segments or any organic wastewater application