Conceptual design for municipal sewage processing using the «ISBS» Technology at the Local Wastewater Treatment Plant

CONTENTS

E-mail : slatpro14@gmail.com; Mobile : +972-50-5825681 ; http://sverit-bg.com/

INTRODUCTION

The **«ISBS»** Biotechnology [*Integrated Spatially-conjugated Bacterial Sequence technology*] is a combination of the design-and-engineering solutions and the biological models, predicated on the biological principles and microorganism's patterns of activity, in other terms bioengineering modeling implemented in the «**MCBR**» [*Modular-type Composite (Combined) Biological Reactor*].

«**MCBR**» - [*Modular-type Composite (Combined) Biological Reactor*] is the set of technological subsystems, that provide a three-dimensional-ordered, multi-stage biological treatment process of sewage.

From the design and engineering standpoint, the «**MCBR**» is a compartmented bioreactor with a combination of sequentially located and operably linked various bio-clusters [in other terms the spatiotemporal bio-modules **«TOP»**].

The biological process of wastewater treatment is carried out in a flow-through mode, a multiple-section bubbling reactor («**MCBR**»), without biomass sedimentation zones and recyclization of active biomass.

The number of bio-modules and their combination, as well as the number of reactor segments [sections], are custom-designed, following the pollutant's concentration and a hydraulic load of inflowing sewage. By a continuous biological treatment process of sewage, and following the amount of oxygen supplied into the bioreactor the two indicated above parameters are modified taking into consideration a decrease in organic pollution concentration.

The sewage hydraulic residence time (**HRT**) in the sections of the bioreactor is differentiated also, taking into account the oxidation rate of biodegradable pollutants, and taking into consideration the concentration of active biomass immobilized on multi-tier inert surface, [**D.M.I.S.**] or [**A.M.I.S.**].

The effective and foolproof biological wastewater treatment process («**ISBS**») is performed using the spatiotemporal bio-modules «**TOP**» - [*Three-dimensional-Ordered Packages*].

The "*Dynamic Multi-tier Inert Surface*" - [**D.M.I.S.**] or "Anoxic Multi-tier Inert Surface" - [**A.M.I.S.**] is the multilevel (polymolecular and multifilament) inert surface designed for hydrobionts immobilization. Using the multilevel inert medium assembled within a specific bioreactor's space the oxidation-reduction chains of a morphologically and metabolically diverse bacterial community (a spatially symbiotic metabolism) are formed.

Patented Dynamic and Anoxic Multi-Tier Inert Surface [**D.M.I.S.**] & [**A.M.I.S.**] promotes a bacteria immobilization onto the three-dimensional-ordered filamentous assembly. The Multi-tier Inert Surface filled by the immobilized symbiotic bacteria is the key element of the patented "*Three-dimensional-Ordered Packages*" - «**TOP**».

The complete biochemical sewage treatment using the «**ISBS**» Technology including nitrification, denitrification, and aerobic biomass stabilization is realized strictly following the generic composition of the hydrobionts fixed onto Multitiered Inert Surface.

The necessary conditions for the existence of the fixed biological forms, that assimilate organic and non-organic contamination without biologically active biomass "***cumulative gain***", are created in the bio-module «**TOP**» using the regulated effects on the ambient medium.

The «**ISBS**» Biotechnology performs multi-stage sewage processing without biologically active biomass *"cumulative gain"* and without surplus biological sludge yield. Consequently, no need for the supplementary solid-liquid phase separation process, and slurries dewatering equipment after biological sewage processing.

Thus, the biological water treatment **«ISBS»** process, implemented in the bioreactor «**MCBR**» is the combination of bioengineering modelling, simulating a self-purification process occurring in the natural basins, specifically in the rivers but with a more intensive treatment process rate.

1. CONCEPTUAL FRAMEWORK OF THE «ISBS» BIOTECHNOLOGY

1.1 BIOLOGICAL PROCESS DESCRIPTION

The **«ISBS» Technology** [*Integrated spatially-conjugated bacterial sequence technology*] for biological wastewater purification is ***a three-dimensional-ordered biological process*** with a set of technological

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subunits, subsystems, and equipment assembled in the correct order and provides a ***multi-stage*** sewage treatment process.

The main principle of the «ISBS» - Technology is the generation in the **Modular-type Composite Biological Reactor** («**MCBR**») of the spatially-conjugated sequences of bacterial colonies using the subunits, containing the three-dimensional-ordered filamentous assemblies and embedded air dispersal systems.

The above-noted spatially-conjugated sequences of different types of microorganisms are integrated into «MCBR» through the use of composite multi-clusters, containing a multi-tier, multifilament, properly-aerated inert surface.

The associations of different immobilized bacteria and the colonies of ″higher-order″ predators (*Protozoa*) are sequentially distributed in time and space (spatiotemporal distribution, spatiotemporal clustering).

A key element of the «ISBS» process is a **continuous formation** within the biological reactor the **flexible self-adaptive symbiotic associations** of the different **immobilized microorganisms and the free-floating "higher-order" predators' colonies** (Protozoa). These microorganisms are **sequentially distributed** and **operably linked in time and space** (spatiotemporal distribution, spatiotemporal clustering), and through this process, the "**trophic cascade effect"** (*from top to down and from down to top*) is created.

Through a process of continuous biological sewage treatment, organic pollution's concentration exponentially decreases. The **optimum conditions of the ambient medium** in the reactor's bio-modules **changes also correspond to certain species of microorganisms**. Within the **spatially-linked bio-modules («TOP»)** one relevant bacterial symbiotic association and predators' trophic chain (subsequence) is being replaced with another operably linked, trophic subsequence.

The **spatial symbiotic successions of reduction-oxidation processes** are formed due to bacterial activity which is supported under conditions of **steady-state growth** (so-termed *plateauing, established bacterial culture*) and depending on **deoxygenation constant**, as well as **diffusion coefficient** and **availability of nutrients** for **exoenzymes**.

The symbiotic associations of the free-floating and immobilized on the multi-tier (multifilament) inert surfaces micro-organisms, and the colonies of free-floating *Protozoa* are integrated into the reactor's bulk using the **spatiotemporal aerated and non-aerated bio-modules «TOP»** ("*Three-dimensional-Ordered Packages*"), also referred to as **the self-contained bio-modules**.

The spatiotemporal trophic cascade effect is formed using the composite spatiotemporal multi-clusters (bio-modules), predominantly including the immobilized bacterial colonies and free-floating microorganisms, and incorporated ″higher-order″ predators' colonies (Protozoa).

These spatially-conjugated multi-clusters with the microorganisms' symbiotic associations provide a step-by-step, multi-stage sewage purification process.

The integrated spatially-conjugated bacterial sequence comprises mainly the microorganisms fixed onto the **Dynamic Multi-tier Inert Surface** [**D.M.I.S.**] **and Anoxic Multi-tier Inert Surface** [**A.M.I.S.**]**,** and much lesser comprised of the bacterial colonies suspended in reactor's liquid medium. The **symbiotic associations of the free-floating and immobilized on the multi-tier (multifilament) inert surfaces microorganisms**, and the colonies of free-floating *Protozoa* are integrated into the reactor's bulk using the **aerated and non-aerated spatiotemporal bio-modules «TOP»** ("*Three-dimensional-Ordered Package*").

Biodegradation of organic pollution, as well as biological oxidation of organic and inorganic nitrogen, is carried out by the suspended and immobilized onto the multi-tier (*multifilament*) inert surface bacteria.

The definite biomass concentration and specific species composition of the **bacterial colonies immobilized on the** [**D.M.I.S.**] & [**A.M.I.S.**] **are limited by the environmental parameters, like a nitrate-nitrogen and dissolved oxygen as the electron acceptors, and by the organic and non-organic nutrients**. These parameters are the controlled variables, both separately for each bio-module «**TOP**» and the «**MCBR**» generally, as a multi-modular system (*an assemblage of the composite technological units*).

Consequently, the **biologically active biomass concentration and species composition of bacterial colonies** in ″**MCBR**″ can vary within wide limits, by the environment formed within the specified boundaries of these **spatiotemporal bio-modules** ″**TOP**″.

Balanced, **self-regulating, and steady-state process** of growth and degradation of the free-floating and fixed bacterial colonies is ensured by the creation of optimal conditions for their vital activity in the bioreactor.

By such an «**ISBS**» process structure in the «**MCBR**», the active **biomass concentration can rise to five up to seven times as compared with traditional aeration tanks**. This makes it possible to double the productivity of the biological treatment process and **cut in half the sewage Hydraulic Retention Time**.

NOTE:

*One of the main specific characteristics of "**ISBS**" Technology is the application of the multi-level dynamic inert bio-carrier fixed in a separate bio module.*

*In contrast to other types of bio-carriers used, for example, in the "IFAS" or "MBBR" processes, the biofilter [**D.M.I.S.**] has a particular elasticity and flexibility, but to a certain extent, it is limited in freedom of movement in space. The biofilter [**D.M.I.S.**] is integrally fixed in the definite places of every bio module, and its structural components cannot come in contact with each other, randomly and chaotically under the action of air sparging or water medium mixing in the "**MCBR**". A swinging in space of the bio-filters individual structural components is devoid of a chaotic trajectory of movement (a collision-free path motion pattern, without crossing or touching each other).*

*Affected by the action of air sparging or water medium mixing, the systematic chaotical impacts with each other and physical contacts of the biofilter particular parts destroy a biofilm on the bio-carrier, operating in a suspended state (for example, by the design of the "**IFAS**" or "**MBBR**" processes).*

As a consequence, it leads to a partial biomass loss and spatially-inhomogeneous biofilm growth, and onwards to carrying out eroded and clipped active biomass from the bioreactor. This ravages and destabilizing effect causing biofilm erosion is typical for most types of biofilters operating in suspension. Such negative effects make it difficult to monitor the biomass effective dose in the bioreactor.

*In contrast to this, in addition to the very good adhesion characteristics of the biofilter [**D.M.I.S.**], the proposed design of the dynamic components of the biofilter does not lead to biofilm erosion (shearing and washing away) because of random encounters of bio-carrier parts. The biofilm on the biofilter develops more homogeneously, in a sustained fashion, and harmoniously. Such biofilm is more resistant to stress caused by periodic environmental drift or recurrent fluctuations of the peak loads.*

*The next essential characteristic of the "**ISBS**" Technology and bioreactor design is the spatial compartmentalization of the biological process onto many sequentially located subunits (sub-elements) in the longitudinal direction of treating water movement, taking into account the hydraulic speeds and air sparging effects, as well as an application of the special bio module units, towards this goal.*

Taking into account the periodic fluctuations of environmental media, this biological treatment process construction, using the self-adjusting bio-modules and the spatial compartmentalization of the reactor's bulk onto a certain number of specific sections (compartments) optimizes the capability of biomass adaptation and metabolism efficiency ratio in each sub-division, and also simplifies the purification process operational capabilities.

Such a constructive composition of the biological purification process - that using the framed design of autonomous sub-elements, and with the simultaneous bioreactor space sequentially divided onto a certain number of ecological niches (compartments) - promotes dynamic self-regulating growth and maintaining of stable biofilm on the inert carrier. As well, this arrangement compensates for the stress effects on biomass during a sudden change in environmental conditions.

*The "**MCBR**" multi-stage design absorbs the sharp fluctuations of the environment, as well as protects a biochemical treatment process against short-circuiting (kinetic slip) in the different bioreactor zones, and allows for a much smoother and balanced water treatment process.*

In conditions of periodic fluctuations of environment, in each subdivision, a cultivated adaptive capacity of the attached biomass also simplifies the possibilities of the bioprocess operational adjusting, and as a result, leads to a more flexible and smoother biochemical process of oxidation of contaminants.

At the same time, regulation of the biofilm life-sustaining activity is simplified due to the use of only two main limiting factors - the maintaining of certain organic and inorganic nutrients concentrations, and the

E-mail : slatpro14@gmail.com; Mobile : +972-50-5825681 ; http://sverit-bg.com/

maintaining of the necessary concentration of dissolved oxygen or nitrate-nitrogen correlation, as the electron acceptor for oxidative or nitrate respiration.

These preferential process features are important for the treatment of high-strength wastes, as well as when it is necessary to maintain a high dose of biomass concentration in the bioreactor. During normal operation of the «**ISBS**» process using the Bio-Modules «**TOP**», thanks to a properly adjusted process complete mineralization of suspended organic sludge take place in the bioreactor. In the purified effluents the quantity of biological sludge (calculated on the dried basis) is reduced by 150 ÷ 300-fold as compared with other existing traditional technologies. Consequently, the additional equipment for **sedimentation or recyclization** of **surplus biologically active biomass as** well as equipment for sludge digesting, dewatering, and transportation practically is not needed.

It should be noted:

The «**ISBS**» biotechnology creates conditions, practically for full mineralization of all organic matters including the aerobic stabilization of suspended bacterial cells formed by biofilm erosion and also by cell spalling.

Multistage «**ISBS**» biological process prevents the biomass's excessive generation and yield. The wastewater flows through a set of the bio-modules «**TOP**» in flow-through mode simulating the self-purification processes in natural waters such as rivers.

The main experimental proof of the absence of biomass "*cumulative gain*" in the biological treatment process is the testing of water for the presence of phosphorus. In the case of biological wastewater treatment without surplus biomass yield the **total phosphorus quantity in purified water** effluent should be the same as in wastewater influent.

In practice, one of the significant pieces of evidence of such a process in the «MCBR» is that the influent concentration of phosphorus is equal to the phosphorus concentration in purified water (activated sludge effluent). This suggests that there is no "cumulative gain" and surplus biomass yield and, therefore, there is no accumulation of phosphorus in any biological way.

At the traditional sewage facilities (e.g., the sewage oxidation ponds, Activated Sludge facilities, SBR, MBR, MBBR, etc.) the yield of surplus biological sludge, depending on impurity composition and sewage pollution load is on average between 1.5% and 5% of total daily sewage flow[1]. In other words, such biological purification process resulting in permanent "cumulative gain" of surplus biological sludge requires its withdrawal from circulation and additional treatment.

Note:

The **«ISBS»** Technology permit to avoid the problems coming out of the significant season's fluctuations of hydraulic and pollution load while in the operation of a sewage treatment plant.

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[1] *Sludge Treatment Costs. The sludge treatment expenditures comprise approximately 50% of the total operating expenses of a WWTP and are the major concern of WWTP management. Over the past few decades, sludge treatment costs have risen substantially in most countries, due to:*

- *Tighter regulation policies regarding the quality of sludge reused for agriculture.*
- *The global increase in fuel prices of transportation.*
- *The closing or reduction of many landfill sites to minimize GHG emissions and seepage into the ground.*

In many countries, a sludge is trucked to remote landfill locations hundreds and even thousands of miles away in order to dispose of it legally. Each truckload of sludge in fact contains 80% water and only 20% solids.

In Europe, sludge originating from one country is sometimes transported and dumped in a different country, resulting in costs of sludge treatment and disposal that can reach €200 ~ €400 ($250 ~ $500) per ton! This explains why major efforts to find efficient solutions for the increasing and increasingly costly sludge problem are being sought. These costs are expected to rise even more due to more stringent regulations aimed at curbing environmental damage and the dangerous effects of untreated recycled sludge on human health when used for agriculture.

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The significant season fluctuations of hydraulic and pollution load have no impact on the quality of the treatment process, as in case of decline or complete water failure, the biological treatment system maintains its functionality for a long period.
In case of a decline of sewage feed or complete water failure is disconnected in series some sections of the bioreactor (in proportion to the reduced amount of water supplied), as well as turning off a certain number of blowers.
After any case of disconnecting one of the bioreactor sections (planned or unplanned), there is no need for loading the new biomass portion and re-configure the operation parameters of the blowers and air control ball valves. The bacterial strains adapted to the specific environment of each bio-module are well-preserved on the inert carrier (spores, cysts, capsules, etc.).
After the renewal of water and air supply into the sections of the bioreactor, the microorganisms restore their vital activity practically within 6~8 hours.
After the bioreactor sections fill with wastewater, the treatment process parameters reach design capacity production in a few hours.

1.2. MAJOR ADVANTAGES OF THE «ISBS» TECHNOLOGY

- Fully automatic biological process
- Foolproof system
- Stand-alone system
- No Major Maintenance Anticipated
- No Chemicals Required
- No Membranes requiring maintenance, cleaning up, or renewal
- No electromechanical devices in the Bioreactor

MAJOR ADVANTAGES OF THE MODULAR-TYPE COMBINED BIOLOGICAL REACTOR

1. **«ISBS»** Technology is applicable for sewage with different concentrations of contamination (domestic, industrial, and agricultural sewage), and also for purification of small volumes, for example from 50 m^3/day up to averages volumes (1,000 m^3/day) as well as big volumes (from 20,000 m^3/day and above);
2. The surplus biological sludge production is 100 ~ 300 times less compared to other existing technologies;
3. The additional systems for settling and recirculation of surplus activated sludge are not needed;
4. No treatment and utilization of surplus activated sludge required;
5. The residence time of wastewater treatment considerably shortens;
6. The systems for restoring initial properties of multilayer inert carrier and extra nutrition of bacteria are not needed;
7. Nitrification, Denitrification, and Aerobic biomass stabilization are performed in the bio-module **«TOP»**, which eliminates supplemental wastewater treatment systems;
8. Foolproof and robust system;
9. Operational safety;
10. Full automated;
11. Resistant to the dancing of effluents;

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12. High process stability and reliability;
13. Functional simplicity & Longevity;
14. Absence of the objectionable odor;
15. Low average energy costs per m³ of treated wastewater;
16. Not large construction footprint;

2. DESCRIPTION OF THE WASTEWATER TREATMENT BIOLOGICAL PROCESS

The core principles of designing the biological purification process following the «ISBS» - Biotechnology are:

- **a)** The biological process of wastewater treatment is carried out in a flow-through, aerated «**MCBR**» - [*Modular-type Composite (Combined) Biological Reactor*] without biomass recirculation into the initial stage of the treatment process.
- **b)** The main principle of the **«ISBS»** Technology is the generation of a *spatially-conjugated sequence* of the bacterial colonies in a *Combined Biological Reactor*, by applying *the subunits containing a three-dimensional-ordered filamentous assembly and built-in air dispersal system*. Biodegradation of organic pollution, as well as biological oxidation of organic and inorganic nitrogen, is carried out by biomass suspended and fixed on an inert carrier.
- **c)** The «**MCBR**» is a concrete or metal basin divided into several technological parts. The bio-modules «**TOP**» are placed in each part of «**MCBR**». The Aerated bio-modules «**TOP**» are filled with the fixed multilayer, three-dimensional-ordered inert bio-filter [**D.M.I.S.**] and with the built-in, purpose-designed diffusers.
- **d)** The biological wastewater treatment process in the «**MCBR**» is performed using the bio-modules **«TOP»**. The number of Three-dimensional-Ordered Packages is determined by technological parameters of influent wastewater and purified water quality.
- **e)** The «**MCBR**» is divided into the aerobic and anoxia zones, depending on the composition and concentration of pollutants in wastewater. The ratio between the number of the aerobic and anoxia zones varies also depending on wastewater composition and concentration of pollutants. Nitrification and Denitrification (**N/D** - ammonia oxidation process and nitrate reduction process) are performed as a part of the «**ISBS**» process. **N/D** is performed using **Three-D Original Packages** with bio-filter [**D.M.I.S.**], preliminary seeded by specific bacterial culture.
- **f)** The multilayer, three-dimensional-ordered inert bio-filter [**D.M.I.S.**] promotes to immobilization of the bacterial cells. The entire area of the filamentary structure of [**D.M.I.S.**] is filled with attached bacterial colonies.
- **g)** To form the microorganism's certain species diversity, the physical and mechanical properties of [**D.M.I.S.**] (*volume density, fabric bulk, surface density, as well as the geometric characteristics and thus an area for bacterial immobilization*) can be changed in each separate bio-module **«TOP»**.
- **h)** The aquatic environment, as well as the bacterial number and bacterial species on [**D.M.I.S.**], vary in each «**TOP**» bio-module subject to an oxidation rate and controlled air supply.

Modus operandi of the «ISBS» - Process

The process of wastewater treatment is performed in the following way and contains the following main components and mechanisms by the requirements of **"ISBS"-Technology**:

2.1. Sewage water from various welfare facilities through a series of intermediate drain shafts flows to the base-pumping station of **LWTP**.

2.2. The next stage of the treatment process is: **before the sewage inflows to the equalization basin, it is critical to screen wastewater through the Mechanical/Primary Treatment system**. Wastewater is supplied to the equalization basin using the submerged feed pumps (operation mode: operating/ stand-by).

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2.3. The **Mechanical/Primary Treatment** system is the sequentially installed automatic screening units with bar spacing maximum size **ø 6 mm** and **wedge wire screen 1~2 mm** arranged in a line, and the sand removal systems (combined or separate units) for removal of particles above **200µm**;

2.4. Equalization tank and **Influent Feed Pumps** for raw wastewater:

The influent feed pumps are the submerged-type pumps with operation mode: operating/ stand-by installed in an Equalization tank. The feed pumps supply wastewater into «**MCBR**» **continuously or in the "Plug-flow" format**;

2.5. The raw wastewater flow meters are installed before the equalization tank and before «**MCBR**».

2.6. The «**MCBR**» [*Modular-type Combined Biological Reactor*] is a concrete or metal basin compartmented into several technological parts. The «**MCBR**» is divided into the aerobic and anoxia zones, depending on the composition and concentration of pollutants in wastewater. The ratio between the number of the aerobic and anoxia zones varies also depending on wastewater composition and concentration of pollutants. The bio-modules «**TOP**» are placed in each part of «**MCBR**».

The bio-modules «**TOP**» are filled with the fixed multilayer, three-dimensional-ordered inert bio-filter [**D.M.I.S.**] and with the built-in, purpose-designed diffusers.

Nitrification and Denitrification (**N/D** - ammonia oxidation process and nitrate reduction process) are performed as a part of the «**ISBS» process**. N/D is performed using "*Three-D Original Packages"* with [**D.M.I.S.**], preliminary seeded by specific bacterial culture.

2.7. The multilayer, three-dimensional-ordered inert dynamic bio-filter [**D.M.I.S.**] promotes to immobilization of the bacterial cells. The entire area of the filamentary structure of **M.I.C.** is filled with attached bacterial colonies.

To form the microorganism's certain species diversity, the physical and mechanical properties of [**D.M.I.S.**] (volume density, fabric bulk, surface density, as well as the geometric characteristics and thus an area for bacterial immobilization) can be changed in each separate bio-module «**TOP**».

2.8 Bio-filter [**D.M.I.S.**] is designed for:

- Providing sufficient oxygen access to bacteria cells;
- Providing minimal conditions for bacteria survival;
- Protecting bacteria cells from "**shock impact**";
- Ensuring sufficient surface contact between water boundary and dissolved oxygen and Multilayer Inert Surface;
- Preventing clogging the working **Dynamic Multilayer Inert Surfaces**.

The definite biomass concentration and specific species composition of the bacterial colonies immobilized on the bio-filter [**D.M.I.S.**] are limited by environmental parameters such as dissolved oxygen and nutrients, which are the controlled variables, both separately for each bio-module «**TOP**» and «**MCBR**» as a multi-modular system (combined technological units).

Consequently, a biomass concentration in the «**MCBR**» and species composition of the bacterial colonies can vary in a wide range, following the environment formed within the specified boundaries of these **spatiotemporal bio-modules**.

2.9. The environment (quality and quantity of organic and inorganic pollutants in the water) varies in each «**TOP**» bio-module too, by the controllable variations of air and pollutants supplied into the «**MCBR**», as well as by the oxidation rate of the polluting agents, and a biomass concentration and species composition of the bacterial colonies.

2.10. Each bio-module «**TOP**» (Three-dimensional-Ordered Package) is equipped with a purpose-designed, build-in, controllable aeration system (fine bubbles air diffusers).

2.11. Air demand for bio-module "**TOP**" is regulated (automatically or manually) by air valves located on the main distribution air manifold. Checking and adjustment of the supplied air are carried out mainly during the process of growing and adaptation of the specific bacterial cultures which correspond to the tasks and stages of the purification process. After adaptation of the bacterial cultures to the environment the controlled air valves hold steady.

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2.12. There are no electromechanical devices in the «**MCBR**» sections. A sparging by air and mixing are carried out using **the integral diffusers and thanks to the special dispersing construction of the multilayer inert bio carrier**.

2.13. Processing water from section to section flows by gravity. In the bioreactor water flows in a sinuous line, namely - flows through the upper and down windows located in the reactor's partition walls.

2.14. Nitrification and Denitrification processes (**N/D**) are performed as parts of the «**ISBS**» process, by the adjustment of supply oxygen quantity and by the biofilm thickness on the bio-filter surface.

2.15. The air blowers for the treatment process are located in the service room. The blower operating mode: operating/ standby.

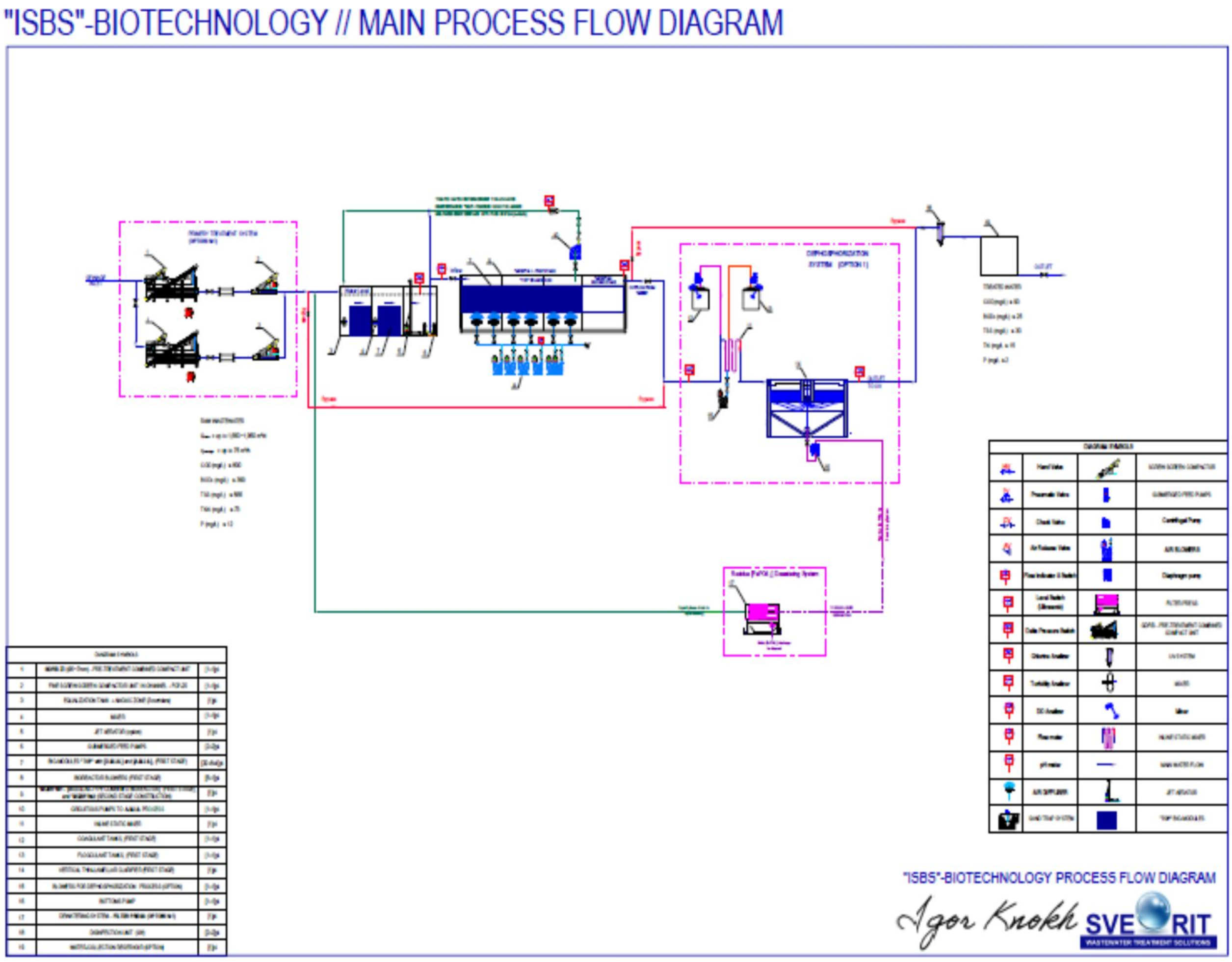
2.16. The main control panel for automatic operation of the **LWTP** (operation of blowers, pumps, Mechanical/Primary Treatment, etc.) is located in the service room too.

2.17. The Reserve diesel generator is located on the site of **LWTP**. The effective wastewater treatment process depends on the continuous air supply which is necessary for providing sufficient oxygen access to bacteria cells and for maintaining the minimal conditions for bacteria survival.

2.18. **HRT** - Total Hydraulic Retention Time (time of sewage processing) depends on the inflow water-specific characteristics and purified water quality requirements.

Complete **biological wastewater treatment** including nitrification, denitrification, and aerobic biomass stabilization is realized strictly following the generic composition of hydrobionts fixed onto **Multilayer Inert Surface**.

3. LWTP PROCESS FLOW DIAGRAM



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4. TECHNICAL DATA

Municipal sewage from a residential area

Table 1 (Influent)

CHARACTERISTIC*	unit	Data
Temperature	ºC	-5 ºC ~ 20 ºC
COD	mg/L	**≤ 840**
BOD_5	mg/L	**≤** 420
TSS	mg/L	**≤** 300
NH_4^+ Ammonia [N- NH_4],	mg/L	**≤ 55**
(TKN)	mg/L	**≤ 75**
pH		6 ÷ 8
P TOTAL ($P_2O_5^-$)	mg/L	**≤ 12**

Table 2 **EFFLUENT** QUALITY REQUIREMENT (Outlet)

CHARACTERISTICS	Unit	Data
Temperature	ºC	----
COD	mg/L	50 ≤
BOD_5	mg/L	5 ≤
TSS	mg/L	5 ≤
NH_4^+ Ammonia [N- NH_4],	mg/L	0.5 ≤
TOTAL. (TN)	mg/L	15 ≤
P-PO_4	mg/L	2 ≤

***The list of pollutants that are banned if they are found in wastewater in large quantities:**
Poisons and toxins dyes, solvents and chemical aerosols, acids and alkalies, other chemicals, such as photographic developer, fixing fluid, etc.

**No less than 80% of the systematic samples of purified effluent water have to meet the requirements set forth above (Table 1, 2) and provided that organic and hydraulic load comply with the technical data and Terms of Reference for the design of the Project as specified (the maximum deviation not more than 10% of the target value of Project).

****Acceptable range of the measurement's inaccuracy. The maximum and minimal deviations of the measured characteristics (COD, BOD_5, TSS, NH_4^+, and TN) should be excluded from the statistically significant characteristics in 80% of the relevant measurement samples of purified effluent water.*