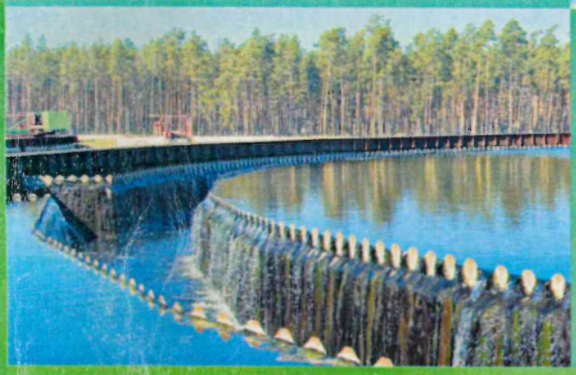
International Water Association

The conference proceedings

Сборник научных трудов

1st Eastern European Regional Young Water Professionals Conference

1я Восточноевропейская региональная конференция молодых ученых и специалистов водного сектора



21-22 | may мая | 2009 | Minsk Минск

Уважаемые участники конференции!

Рациональное использование и охрана водных ресурсов являются одной из наиболее значимых экологических проблем для мирового сообщества. Организация Объединенных Наций провозгласила 2005 - 2015 годы Международным десятилетием действий «Вода для жизни». В рамках этой инициативы проходят различные мероприятия с участием глав государств и правительств, депутатов парламентов и представителей местных властей и общественных организаций.

Тысячи водохранилищ, водохозяйственных и водоохранных сооружений составляют сложную систему, требующую научно обоснованного и эффективного управления. В Республике Беларусь действует ряд нормативных правовых актов (Водный кодекс, законы «О питьевом водоснабжении», «Об охране окружающей среды» и др.), которые гарантируют право гражданина на доступ к чистой воде и устанавливают четкие правила использования водных ресурсов. В области водоснабжения и водоотведения и защиты водных ресурсов реализуется государственная программа «Чистая вода». Она предусматривает совершенствование управления водохозяйственной отраслью, внедрение новых технологий, оздоровление водных источников, строительство очистных сооружений, водозаборов, водопроводов и канализации. Конечно, не все реализовано так, как первоначально планировалось, - жизнь ставит новые задачи. Решить их можно только объединив усилия ученых и специалистов.

Республика Беларусь всячески поддерживает международные инициативы в данной области. Мы рассматриваем Первую Восточноевропейскую региональную конференцию молодых ученых и специалистов водного сектора Международной водной ассоциации как форум для обмена информацией, мнениями и опытом по созданию и реализации региональных и международных программ в водно-экологической сфере.

Надеюсь, что результатом предстоящей дискуссии станет выработка конкретных предложений по решению важнейших водохозяйственных проблем. Желаю участникам конференции эффективной совместной работы!

Председатель Совета Республики
Национального собрания
Республики Беларусь

Б. В. Батура

Dear participants of the conference!

Rational use and effective protection of water resources is one of the most serious environmental problems for the world today. The United Nations Organization proclaimed 2005 - 2015 International Decade for Action «Water for life». Within the framework of this initiative numerous events with the involvement of heads of states and governments, deputies of parliaments and representatives of local authorities and public organisations have already been and will be held.

Thousands of water storage facilities, water economy systems and water security constructions make up a complex system which requires a scientifically grounded and effective management. The Republic of Belarus enjoys a number of regulatory legal acts in this domain (Water Code, laws «On Drinking Water Supply», «On Environmental Protection» etc.). Their provisions guarantee the right of citizens to access to pure water and establish accurate rules of water resources usage. In the field of water supply and water discharge and protection of water resources the national program «Pure Water» is carried out. It presupposes further development of water-management system, introduction of new technologies, sanitation of water resources, construction of treatment facilities, water fences, water pipes and sewerage. Certainly, not all is realised how was originally planned — life puts forward new challenges. And only by uniting efforts of scientists and experts we can solve them.

The Republic of Belarus in every possible way supports international initiatives in the area. We consider the First East European Regional Conference of Young Scientists and Experts of Water Sector by the International Water Association as a forum for interchange of information, opinions and expertise on the development and realisation of regional and international programs in water-ecological sphere. I hope that the discussion we are going to hold will result in particular concrete proposals.

I wish the participants of conference fruitful teamwork!

Mr Boris Batura
Chairman of the Council of the Republic
of the National Assembly of the

Republic of Belarus

Уважаемые коллеги!

Белорусский национальный технический университет (БНТУ), как ведущий технический вуз Республики Беларусь, как базовый технический вуз стран участников Содружества Независимых Государств, признавая особую роль воды в жизни каждого человека и любой страны, вносит свой вклад в деле подготовки специалистов, проведения научных исследований в области рационального использования и защиты водных ресурсов от загрязнения и истощения.

И тот факт, что Первая Восточноевропейская региональная конференция молодых ученых и специалистов водного сектора Международной Водной Ассоциации (IWA) проводится в Беларуси на базе БНТУ, является признанием вклада нашего университета в решение водных проблем.

Надеюсь, что данная конференция придаст новый импульс по обмену идеями и информацией, налаживанию партнерских связей, созданию «кадровых модулей» из специалистов разных стран, разных специальностей, с целью решения актуальных вопросов, связанных с улучшением обеспечения людей чистой водой, наиболее эффективного использования запасов всех видов водных ресурсов.

От имени многотысячного коллектива студентов, преподавателей, научных сотрудников нашего университета желаю участникам Первой Восточно-Европейской региональной конференции молодых ученых и специалистов водного сектора IWA плодотворной работы, а также успехов в повседневной деятельности, направленной на дальнейшее плодотворное сотрудничество между нами, дающее уже сегодня прекрасные результаты, используемые в подготовке кадров, создание новых технологий, аппаратов и конструкций, идущих на решение такой благородной задачи, как обеспечение жителей нашей планеты «здоровой водой».

Успехов Вам, уважаемые коллеги!

Хрусталев Б. М., ректор Белорусского
национального технического университета,
член-корреспондент НАН Беларуси,
Председатель Координационного
Совета технических вузов Республики Беларусь

Esteemed Colleagues!

Recognizing a special and significant role of water resources in the life of human being and any country of the world the Belarussian National Technical University (BNTU) as a leading engineering higher education institution of the Republic of Belarus and basic engineering higher education institution in the member-countries of the Commonwealth of Independent States has been making its contribution to training of highly-qualified specialists, execution of research activity in the field of rational usage and protection of water resources against contamination and depletion.

The right to host the First Eastern Europe regional conference of young scientists and experts of the International Water Association (IWA) water sector in the Republic of Belarus on the basis of the BNTU proves our great contribution to the solution of water problems and we consider it also as a great honour for us.

I would like to express my hope that the Conference shall give a fresh impetus to exchange of ideas and information, establishment of partners' relations, development of personnel modules, that will be composed of experts having various specialities and representing various countries, with the definite objective that is to solve actual matters pertaining to better provision of pure water to people, more efficient usage of reserves of all types of water resources.

On behalf of our University involving thousands of students, lecturers, researchers I would like to wish participants of the First Eastern Europe regional conference of young scientists and experts of the International Water Association (IWA) water sector every success in their activity which is directed on further fruitful cooperation between us that has already given fine results today. And these results are efficiently applied in development of new technologies, equipment and their purpose is to fulfill such noble mission as to provide healthy water to the population of our planet.

Esteemed Colleagues! Once again wish you every success!

Prof. Khroustalev B. M.
Rector of the Belarussian National Technical University,
Corresponding Member of the National Academy of Sciences of Belarus
Chairman of Coordination
Council of Engineering HEIs of the Republic of Belarus

VEL (Vertical flow labyrinth) technology solutions for mankind and nature

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Abstract
Water is very important to every life. Wastewater is the same water which is polluted and nowadays, when it's recourses are getting lower it is very important to save it.
If the villages or small towns are rarely populated and the distance between the living houses is very big, it's very expensive to centralize sewage and build big wastewater treatment systems. The VFL technology with it's very high cleaning efficiency and low maintenance expenses is very suitable for wastewater cleaning up to 10000 P.E. The treated water can be infiltrated into the ground, let into the surface waters without making any harm to the nature. After the tretiary cleaning the water from such system can be reused.

Keywords
VFL technology, wastewater treatment plants (WWTP), ecology.

INTRODUCTION

Water is usually called the blue blood of the planet, treasure of the nature, which is very important to every life. A man can last only ten days without water. Wastewater is the same water but polluted.
Water supply and gathering of the wastewater are like twins that can not exist one without other. But it's very important that the wastewater were not just gathered, but also cleaned, so that they didn't pollute the surface waters, because it's one of the biggest problems all over the world.
Nowadays a lot of specialists come to the point that the elimination of the waste coming out from the man's living with the water by turning it into wastewater is not rational and economical, so they suggest to use vacuum or compressed air instead of the clean water.
By eliminating the contaminants from the wastewater you get clean water. The pollutants can be used for the fuel, fertilizer or any other valuable products.
The reuse of the wastewater for the production of the other products, the reduction of its amount, saving of the water is an actual problem of every present or future user of the water.
A lot of wastewater cleaning methods and technologies have been found and used in the cities' recently. Still the old ones are being improved and the new ones established. But this kind of system that is used for the major cities, does not give desirable results when talking about small towns and villages. That is:

- Very big differences between the inflow wastewater debits;
- Very big concentration differences of the inflow wastewater;
- Very big wastewater concentration;
- Lack of the qualified staff.

The smaller the town, the bigger wastewater debits and wastewater concentration differences are.

The saltatory coefficient of the inflow wastewater in big cities is the proportion between the maximum and average debits, which is 1,5-2, while in small towns and villages it can reach 5. This coefficient in seasonal objects, such as camps, holiday houses, etc. can be even bigger.

The expenses to collect and clean small amounts of the wastewater are very high. That's why it is very important to put the cleaning of the small wastewater amount put in the other category.
The performed research on the wastewater cleaning costs showed that (figure 2.) the expenses of cleaning $1m^3$ of wastewater in small towns are 8-12 times higher than in big cities with over than 1 million people.

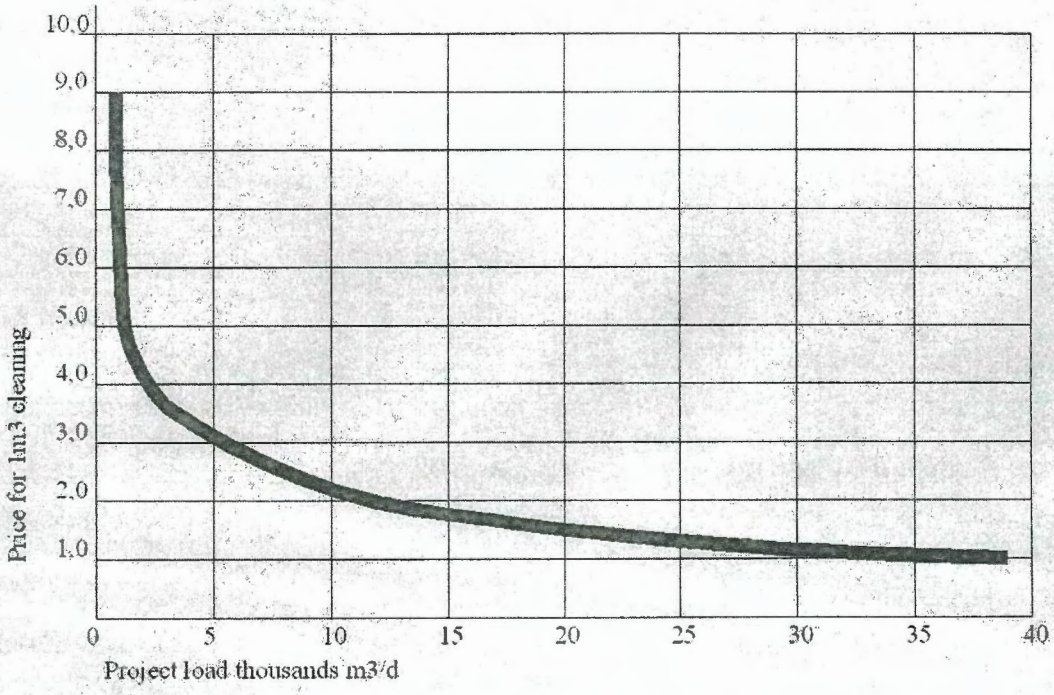


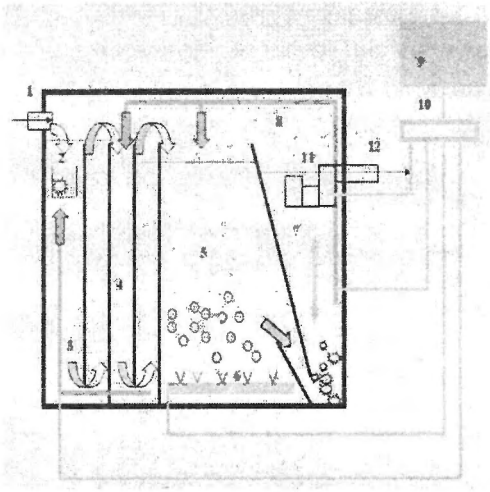
Figure 1. The dependence between the capacity of the wastewater cleaning system and cost.

What makes the installation of the small wastewater treatment systems so expensive? One of the main reasons causing big expenses is rarely populated territory, signally big distance between the living houses, what makes long sewerage.
That shows the necessity of finding new methods to reduce the costs of wastewater cleaning in small regions.

VFL TECHNOLOGY

When it's economically not effective to have centralized sewage system and connect it to the big wastewater treatment systems, it's purposeful to organise either individual cleaning systems (if the distance between the living houses is very big) or one treatment system for the whole complex (villages and small towns). The VFL (Vertical flow labyrinth) technology is specious for it.
The conventional activated sludge process wastewater treatment plants (WWTP) are suitable for major treatment facilities. This system can be used for wastewater cleaning from: residential houses, apartments, small villages, motels, hotels, restaurants, schools, camping sites, hospitals, factories and other objects for up to 10000 P.E.

The treatment technology is based on a continually operated modified activated sludge process. The biological reactor comprises of a non-aerated chamber (anaerobic-anoxic), aerated chamber (oxic), final clarification chamber and an integrated retention chamber.



1. Inlet
2. Inflow basket
3. Airlift No. 1
4. Non-aerated chamber (anaerobic)
5. Aerated chamber (oxic)
6. Tube diffuser
7. Separation chamber
8. Airlift No.2
9. Air pump
10. Air distribution panel
11. Flow regulator
12. Outle

Figure 2. VFL technological scheme

The non-aerated chamber (anaerobic) is divided by a series of overflowed and underflowed baffles into compartments creating a so called „Vertical Flow Labirynth" (VFL). In the separation chamber, a flow regulator is incorporated, which enables the usage of the volume of the integrated retention chamber in all the compartements of the wastewater treatment plant during peak flows and thus against the overloading of the plant.

The wastewater flows through the inlet into the inflow basket, which is situated in the non-aerated chamber (anaerobic). The airlift under the inflow basket creates an internal recirculation within the non-aerated chamber.

The wastewater flows from the anaerobic chamber into the aerated (oxic) chamber trough an overflowed baffle. The diffuser is incorporated in the aerated chamber, which serves for the fine-bubble aeration for the mix of activated sludge and wastewater.

The wastewater-activated sludge mixture flows from the oxic chamber to the separation chamber over the connected gap in the partition wall between the oxic chamber and separation chamber. The other airlift is situated at the bottom of the separation chamber and ensures the recirculation of the settled activated sludge back to the biological reactor.

In the separation chamber a flow regulator is incorporated. The opening of the flow regulator is protected by a protecting screen what ensures that the activated sludge will not flow out with the treated water.

The project load of the activated sludge in the VFL technology – from 0,03 to 0,2 kg BOD_5/kg of dry sludge per day, its' concentration – 5-6 kg/m^3. The activated sludge in the biological reactor is aerobically stabilized and it doesn't need any other cleaning, it doesn't smell and is not toxic, so can be reused in agriculture as fertilizer or using for composting.

The treated water after the biological cleaning can be infiltrated into the ground, let into the surface waters or rainwater sewer without making any harm to ecological system.
In 2007 the VFL technology (wastewater treatment plant AT) was tested in the Prüfinstitut für Abwassertechnik GmbH, Aachen according to EN 12566-3:2006. The testing results were incredible. Apart from required parameters, the VFL technology guarantees the removal of phosphorus and nitrogen without using any chemical reagents.

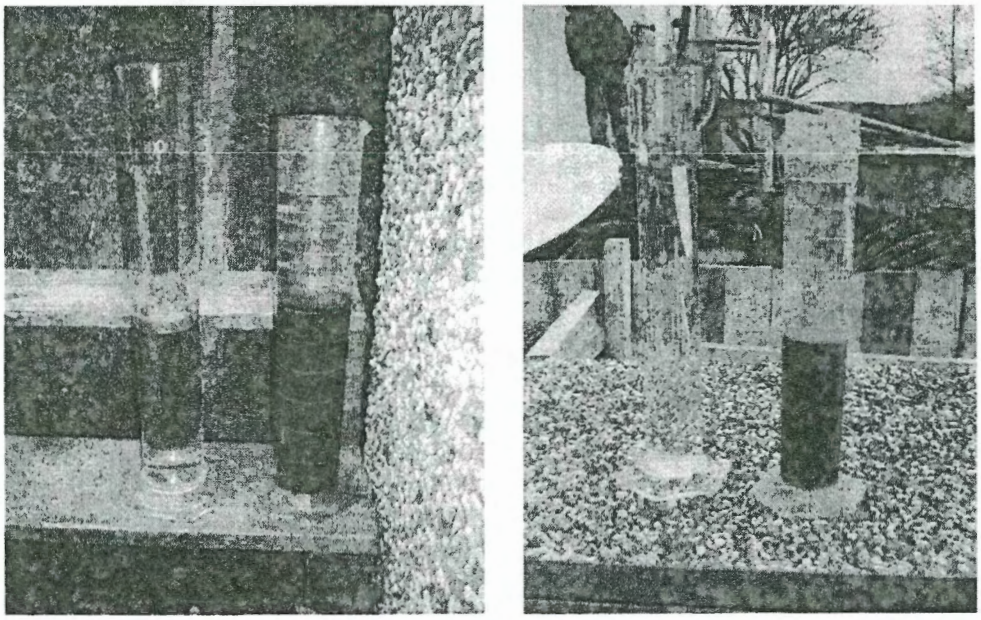


Figure 3. Samples taken from the cleaned water section and the sludge concentration in Aachen laboratory during the testing in 2006 – 2007 year.

Wirkungsgrad BSB_5 [%]	97,2
Wirkungsgrad CSB [%]	88,1
Wirkungsgrad AFS (SS) [%]	94,0
Wirkungsgrad NH_4-N [%] *	96,7
Wirkungsgrad Nges [%] *	61,7
Wirkungsgrad Pges [%]	47,4

* für Temperaturen ≥ 12°C im Bioreaktor

Mit freundlichen Grüßen

PIA GmbH Prüfinstitut für Abwassertechnik Hergenrather Weg 52074 Aachen

Dipl.-Ing. Elmar Lancé

Figure 3. Test results from Prüfinstitut für Abwassertechnik GmbH, Aachen after testing.
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The VFL technology WWTP AT

The wastewater cleaning process in the system is automatic. The air pump is working only 50%, so the electrical consumption is really low. The electrical consumption for the WWTP for individual house (4 P.E.) is only 208 kWh per year.

When evaluating the VFL technology high cleaning efficiency, the removal of nitrogen and phosphorus, the automatic working, very simple assembling and maintenance, very low expenses

and that the system does not need any chemicals for cleaning, its is really suitable for wastewater cleaning up to 10000 P.E.

The VFL technology typical AT wastewater treatment plants up to 250 P.E. are made from polypropylene (PP), compact (doesn't need a lot of place to assemble them) with very low electrical consumption and sludge production). In the table are given the parameters of AT6-AT250 wastewater treatment plants.

Table 1. Parameters of the typical VFL technology wastewater treatment plants

WWTP	Average daily flow (m^3/d)	Population equivalent	Sludge production (m^3/year)	Average el.energy consumption (kWh/year)	Dimensions of the biological reactor	
					Diameter (mm)	Height (mm)
AT-6	0,54	4	1,0	208	1400	1800
AT-8	0,81	6	1,5	270	1400	2200
AT-10	1,20	8	2,0	411	1750	2000
AT-12	1,40	10	2,5	582	1750	2200
AT-15	1,80	12	3,0	782	2050	2200
AT-20	2,70	18	4,5	1564	2050	2700
AT-30	3,80	25	6,3	2689	2300	3000
AT-40	5,30	35	8,8	2359	2850	2700
AT-50	7,50	50	12,5	4254	2950	3000
AT-75	11,30	60	15,0	4380	3300	3000
AT-100	15,00	100	30,0	5840	3500	3000
AT-120	18,00	120	36,0	7300	4000	3000
AT-150	22,50	150	45,0	8760	4500	3000
AT-200	30,00	200	60,0	12045	5000	3000
AT-250	37,50	250	75,0	14600	5300	3000

Advantages of the „VFL" Technology:

- high treatment efficiency with biological nitrogen and phosphorus removal and disinfection;
- not sensitive to peak-flows – due to patented integrated retention chamber and flow control device;
- low investment expenses – because of simple and practical design, low tank volume;
- no smell – aerobic conditions maintained in upper layer of all compartments, even in anaerobic compartments;
- low excess sludge production – only 1 m^3 of excess sludge every year from an individual house (4 P.E.);
- no mechanical mixing in the anaerobic zone – the only mechanical equipment in the system is the air blower;
- low operation costs – electric consumption only 208 kWh / year for an individual house(4 P.E.);
- reuse of treated water – due to the effective „bio clean filter" coupled with the integrated retention chamber and flow control device in the biological react

Treatiary cleaning

Tretiary cleaning is done when the required parameters were not reached after the secondary wastewater treatment. The purpose of the tretiary cleaning – to remove nitrogen (N) and phosphorus (P). Other contaminants can also be reduced in the effluent after this cleaning.

In 2007 year the unique "bio-clean" filter was tested. Using this filter as a tretiary treatment step coupled with disinfection unit, the treated water can be reused. The „bio clean filter" is a slow gravity, vertical flow sand filter with dosing of disinfection agent.

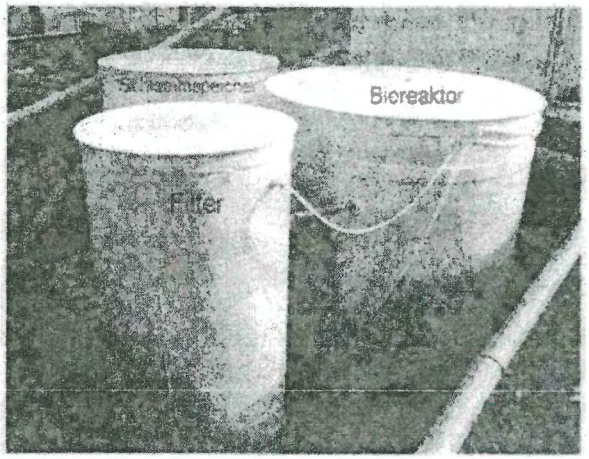

Figure 4. Testing of the bio clean filter in Aachen laboratory

The testing results guaranteed by the Aachen laboratory:

Parameter	Wirkungsgrad	Messwert
BSB_5	98,1 %	5 mg/l
CSB	91,3 %	35 mg/l
TOC	-	30 mg/l
NH_4-N	96 %	1 mg/l
Gesamt-N, N_{ges}	62,4 %	15 mg/l
Gesamt-P, P_{ges}	50 %	3 mg/l
Schwebstoffe, AFS	98,8 %	3 mg/l
Absetzbare Stoffe	-	0 ml/l
Faekalcoliforme	99,9	2 /100 ml

Figure 5. The testing results of the bio clean filter

The "bio-clean" filter can be assembled together with the AT6-AT50 wastewater treatment plants.

THE WASTEWATER TREATMENT PLANTS' VALUATION CRITERIONS

The main criterions that show the technological and economical effectiveness are:

- The comparative price for one person;
- The wastewater treatment efficiency;
- The technical reliability of the wastewater treatment plants (shows the breakdown);
- The technical stability of the treatment processes. It shows if the technology is stable enough during the different seasons;
- The necessity and the difficulty of the maintenance;
- The needed area for the wastewater treatment plants;
- The made influence for the surrounding (smell, noise, insects, sanitary conditions, etc.);
- The needed time for assembling;
- The needed time for start-up works.

The VFL technology WWTP satisfy the above mentioned wastewater treatment plants' valuation criterions and are suitable for small wastewater treatment. Because of the high effluent parameters (BOD_5 – 97,2 %, CSB – 88,1%, SS – 94,0%, NH_4-N – 96,7%, N_{tot} - 61,7%, P_{tot} – 47,4%) water after the treatment can be infiltrated into the ground or let into the surface waters without making any harm to the ecology, nature or mankind.

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