XXIII INTERNATIONAL ECO-CONFERENCE® 2019
XIII ENVIRONMENTAL PROTECTION OF URBAN AND SUBURBAN SETTLEMENTS

25th–27th SEPTEMBER 2019
NOVI SAD, SERBIA

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THE ECOLOGICAL MOVEMENT OF THE CITY OF NOVI SAD: AN IMPORTANT DECISION OF ITS PROGRAMME COUNCIL

Since 1995, the Ecological Movement of the City of Novi Sad organizes „Eco-Conference® on Environmental Protection of Urban and Suburban Areas", with international participation.

Twelve biennial conferences have been held so far (in 1995, 1997, 1999, 2001, 2003, 2005, 2007, 2009, 2011, 2013, 2015 and 2017). Their programs included the following environmental topics:

Session 1: Environmental spheres: a) air, b) water, c) soil, d) biosphere
Session 2: Technical and technological aspects of environmental protection
Session 3: Sociological, health, cultural, educational and recreational aspects of environmental protection
Session 4: Economic aspects of environmental protection
Session 5: Legal aspects of environmental protection
Session 6: Ecological system projecting (informatics and computer applications in the field of integrated protection)
Session 7: Sustainable development of urban and suburban settlements–ecological aspects

Conference participants have commended the scientific and organizational levels of the conferences. Conference evaluations have indicated that some aspects are missing in the conference program. In addition, since a team of conference organizers was completed, each even year between the conferences started to be viewed as an unnecessary lag in activity.

Eco-Conference® on Safe Food

With the above deliberations in mind, a decision was made that the Ecological Movement of the City of Novi Sad should embark on another project – the organization of Eco-Conferences® on Safe Food. These Conferences were planned to take place in each even year. Preparations for the first Eco-Conferences® on safe food started after the successful completion of the Eco-Conference® '99.

So far ten Eco-Conferences® have been held (in 2000, 2002, 2004, 2006, 2008, 2010, 2012, 2014, 2016 and 2018.) focusing this general theme.

Theme of the Eco-Conference®

By organizing the Eco-Conference® on Safe Food, the organizer wishes to cover all factors that affect the quality of human living. Exchange of opinions and practical experiences should help in identifying and resolving the various problems associated with the production of safe food.

Since 2007 Eco-Conference gained five times in a row, a sponsorship from UN and their sectorial organizations (UNESCO and UN-FAO) and became purely scientific Conference.

Objectives of the Eco-Conference®

– To acquaint participants with current problems in the production of safe food.

– To make realistic assessments of the causes of ecological imbalance in the conventional agricultural production and the impact of various pollution sources on the current agricultural production.

– Based on an exchange of opinions and available research data, to make long-term strategic programs of developing an industrialized, controlled, integral, alternative and sustainable agriculture capable of supplying sufficient quantities of quality food, free of negative side effects on human health and the environment.

Basic Topics of the Eco-Conference®

Basic topics should cover all relevant aspects of the production of safe food. When defining the basic topics, the intention was itemize the segments of the

production of safe food as well as the related factors that may affect or that already have already been identified as detrimental for food safety and quality.

The topics include ecological factors of safe food production, correct choice of seed (genetic) material, status and preparation of soil as the basic substrate for the production of food and feed, use of fertilizers and pesticides in integrated plant protection, use of biologicals, food processing technology, economic aspects, marketing and packaging of safe food.

To paraphrase, the envisaged topics cover the production of safe food on the whole, individual aspects of the production and their mutual relations, and impact on food quality and safety.

Sessions of the Eco-Conference®

1. Climate and production of safe food.
2. Soil and water as the basis of agricultural production.
3. Genetics, genetic resources, breeding and genetic engineering in the function of producing safe food.

4. Fertilizers and fertilization practice in the function of producing safe food.
5. Integrated pest management and use of biologicals.
6. Agricultural production in view of sustainable development
7. Production of field and vegetable crops.
8. Production of fruits and grapes.
9. Livestock husbandry form the aspect of safe food production.
10. Processing of agricultural products in the framework of safe food production.
11. Economic aspects and marketing as segments of the production of safe food.
12. Food storage, transportation and packaging.
13. Nutritional food value and quality nutrition.
14. Legal aspects of protecting brand names of safe food.
15. Ecological models and software in production of safe food.

Attempts will be made to make the above conference program permanent. In this way will the conference become recognizable in form, topics and quality, which should help it find its place among similar conferences on organized elsewhere in the world.

By alternately organizing conferences on environmental protection of urban and suburban areas in odd years and conferences on safe food in even years, the Ecological Movement of the City of Novi Sad is completing its contribution to a higher quality of living of the population. Already in the 19th century, Novi Sad was a regional centre of social progress and broad-mindedness. Today, owing first of all to its being a university centre, Novi Sad is in the vanguard of ecological thought in this part of Europe.

It is our duty to work on the furtherance of the ecological programs of action and, by doing so, to make our contribution to the protection of the natural environment and spiritual heritage with the ultimate goal of helping the population attain e higher level of consciousness and a higher quality of living.

Director of the Ecological Movement
of Novi Sad
Nikola Aleksic

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ECO-CONFERENCE® 2019
ECOLOGICAL MOVEMENT OF NOVI SAD

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MICROBIOLOGICAL PURIFICATION OF WASTEWATER

Abstract

Water plays a vital role in the biosphere as a component of all living beings, participates in photosynthesis, a basic life process on the planet, and represents the environment to a large number of living beings. In water ecosystems, pollutants come from two sources, both natural and anthropogenic. The main anthropogenic sources of pollutants are municipal wastewater, industrial wastewater, and water from agriculture. Microbiological degradation of organic pollutants is the only possibility of their removal from water. In this paper, the possibilities of purification of wastewater are considered, with special emphasis on the role of microorganisms in the process.

Key words: *water, pollutants, wastewater, microbiological purification*

INTRODUCTION

Soil, water and air are equally important components of the environment, which enable the maintenance of life on the planet.

The soil is a thin and very active living layer that covers the lithosphere. It is not an inert substrate, which serves only the planting of plants, but it represents one of the spheres where there is a condensation, that is, the compactness of life. Russian scientist Vernadsky considered the soil like the territory of the largest geochemical energy, a very important laboratory of chemical and biochemical processes that take place in it. Modern ecology considers soil as a biogenic substance, which creates an independent layer on the surface of the earth – a pedosphere, and plays a key role in the life of the land biogeocenoses and the biosphere of the entire planet, allowing the development of global biogeochemical cycles of the circulation of matter and the flow of energy, that lie at the basis of maintaining life on the planet (Đukić et al., 2007; Brankovic et al., 2012; Šarčević-Todosijević et al., 2016, 2017a, 2018a, 2019; Popović et al., 2019).

Water is used in everyday life for the preparation of food, hygiene needs, in the industry, but it is not only a matter used in various fields of human activity.

Water plays a vital role in the biosphere as one of the components of all biological systems, that is, living organisms. In addition to carbon dioxide from the atmosphere, the molecule of water is the basic substrate for the process of photosynthesis, in which occurs the primary production of organic matter, which lies in the basis of the food chain of all the organisms of the planet. Also, as one of the greatest riches of each country, water occupies as much as three quarters of the planet (Dukić, 1984), and represents the environment to a large number of systematic groups of living organisms, from microorganisms to mammals (Clifford, 1991; Bouchard, 2004).

In addition to the abiotic components, for the preservation of ecosystems, it is equally important and completely equal and its biotic component, that is, the living communities of all organisms, whose overall diversity on the level of the biosphere is biodiversity. Without biodiversity, there are no biogeochemical cycles and oxygen production, no ecosystem functioning, no photosynthesis, nor decomposition of organic matter. Preserved biodiversity contributes to climate regulation, reduces the effect of greenhouse gases, maintains the quality of air and water. In the framework of the implementation of measures of protection and conservation of natural values, it is necessary to include, first of all, the preservation of biodiversity, that is, ecosystem, genetic and species diversity as the main components (Popović, 2001; Popović, 2015; Šarčević et al., 2018b).

One of the most important areas of science that can be used in the recultivation of polluted ecosystems and the prevention of environmental pollution is biotechnology, whose potential and possibilities for application for these purposes depend on the biological diversity of organisms, i.e. biodiversity. Biotechnology represents the application of biological systems, that is, living organisms, in the creation of specific products or in the management of appropriate processes, and methods of biotechnology are widely used in the prevention of pollution, as well as recultivation of contaminated ecosystems.

In this paper, the possibilities of biological treatment of contaminated water are considered.

WASTEWATER TREATMENT

Water pollution significantly affects all living organisms of aquatic ecosystems. In aquatic ecosystems, pollutants come from two sources, both natural and anthropogenic. Natural sources of pollution are primarily due to different excessive situations occurring occasionally in certain areas, but they can cause major disturbances in the river ecosystem with bad, often long-term negative consequences for the living organisms in them. Floods cause soil erosion and the introduction into natural waters of various materials, which followed by eutrophication, which changes the physical and chemical composition of water, often with long-term consequences.

The basic anthropogenic sources of pollutants that come to the rivers are communal wastewater, industrial wastewater, waters from agriculture, as well as atmospheric waters that drain soil and roads. All these waters introduce different, often very dangerous pollutants into the river ecosystem. Especially adversely affect industrial wastewater as they can block the biogeochemical cycle of matter circulation at some stage or cause other disorders in the ecosystem. Communal wastewater, discharged into the river without prior purification, significantly reduces the capacity for natural autopurification and poses a threat to the cenobionts. These waters contain inorganic and biodegradable and other organic matter, dissolved or in the form of suspended and sedimentary matter, as well as microorganisms. The most common organic ingredients, nutrients and metals are: organic carbon, fats and oils, phenols, phthalates, ammonia, nitrite and nitrate nitrogen, organic nitrogen, orthophosphates, polyphosphates, organic phosphates, Al, As, Cd, Cr, Co, Fe, Pb, Zn (Đuković et al., 2000; Milivojevic et al., 2016).

Because of the above, it is extremely important to purify wastewaters from all mentioned sources, and purification can be: mechanical, chemical and biological. The choice of purification method depends on the character of wastewater, the required degree of purity, the economics of individual treatment processes (Đuković et al., 2000; Đukić et al., 2007).

Figure 1. Wastewater treatment plant
(source, http://www.vodovodsu.rs/14-Preciscavanje-otpadnih-voda)

Microbiological degradation of organic pollutants is the only possibility of their removal from water. Biological purification of wastewater is based on the ability of individual microorganisms to use many organic and inorganic substances in wastewater for their own metabolism. Biological water treatments are based on processes in which microorganisms develop and multiply continuously. Biological treatment of polluted waters is based on aerobic and anaerobic degradation of organic matter. During aerobic degradation, organic matter is oxidized to carbon dioxide and various nutrients (N, P and S compounds), assimilates in biomass and passes into other organic compounds (Đuković et al., 2000).

Aerobic wastewater degradation processes take place in open basins (natural or artificial), which represent lagoons – aerobic lakes, where microorganisms are suspended in activated sludge, or by entering biomass of microorganisms through wastewater into the bio-disc process. Microorganisms suspended in activated sludge are: *Pseudomonas*, *Achromobacter*, *Flavobacterium*, *Mycobacterium*, *Nocardia*, nitrifying bacteria (*Nitrobacter* and *Nitrosomonas*), *Sphaerotilus*, *Thiothrix*, *Leucothrix*, *Geotrichum*. Microorganisms immobilized on the carrier in the bio-disc process are: *Achromobacter*, *Flavobacterium*, *Pseudomonas*, *Alcaligenes*, *Sphaerotilus*, *Beggiatoa*, *Nitrosomonas*, *Nitrobacter* and molds (*Fusarium*, *Mucor*, *Penicillium* and *Geotrichum*) and yeasts (Jemcev and Đukić, 2000; Marinković, 2015).

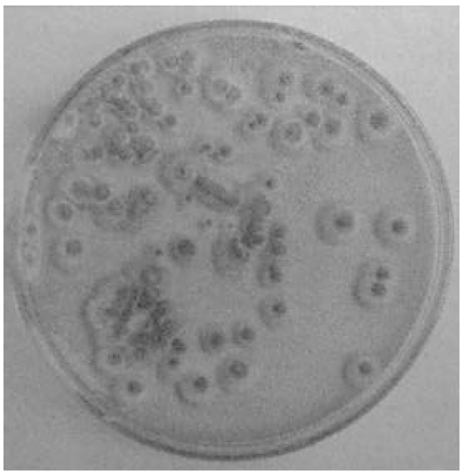

Figure 2. Penicillium sp., isolated from natural ecosystems (Lalević, 2009)

In the anaerobic biological treatment of water, gases are formed: methane, carbon dioxide, hydrogen, sulfur dioxide and nitrogen (Đuković et al., 2000). The process takes place in fermentation reactors, in which the temperature (30–40°C or 50–75°C) and pH (7–8) conditions are controlled. For the purification of highly contaminated wastewater, a process of methane production methanogenesis, which takes place in three phases, is used. The decomposition of organic matter to organic acids, alcohol, ammonia and hydrogen is done by the following taxa of microorganisms: *Bacillus*, *Clostridium, Streptococcus, E. coli, Micrococcus, Proteus, Pseudomonas* and *Streptomyces*. Further transformation to acetate, CO_2 i H_2 is performed by genera *Thermo-*

anaerobium, Desulfovibrio and *Syntrophomonas*. About 70% of methane is formed from acetate, and the rest from CO_2 and H_2, with the participation of methanobacteria (*Methanothrix, Methanosarcina, Methanomicrobium, Methanogenium, Methanospirillum*) (Jemcev and Đukić, 2000; Marinković, 2015).

The initial strains of microorganisms used in these processes are obtained from the natural environment (Figure 2, 3), and later they are selected for the selection of the most active (Đukić et al., 2007).

Figure 3. Bacillus sp., izolated from the ecosystem on nutritious substratum MPA (Živanović et al., 2018)

Chan et al. (2009) emphasize the importance of the integration of aerobic and anaerobic pathways of degradation into a single bioreactor, which improves the overall degradation efficiency. Highly reactive anaerobic-aerobic bioreactors are increasingly used for wastewater with strong chemical oxygen demand. They are especially suitable for the treatment of industrial wastewater due to minimal spatial requirements, low investment costs and reduction of chemical oxygen demand (over 83%) (Chan et al., 2009). Two-stage anaerobic-aerobic treatment is used primarily for the purification of highly concentrated industrial wastewater.

In the elimination of nitrogen compounds by denitrification, the consumption of organic carbon during anaerobic pre-treatment is problematic.

The process of nitrification/denitrification via nitrite, proved to be effective. Carbon consumption is only 60% compared to denitrification via nitrate. The basic parameter for regulating the process is the concentration of free ammonia in the reactor. Concentrations of 1 to 5 mg NH_3/l inhibit the nitration, but not the nitrition. The content of ammonia is controlled by the continuous measurement of NH_4 and the pH of the medium. The inhibition limit of denitrification was at 0.13 mg $HN0_2$ /1 (Abeling and Seyfried, 1992).

Figure 4. Pool for nitrification and denitrification (source, http://www.vodovodsu.rs/14-Preciscavanje-otpadnih-voda)

Azo dyes represent the largest class of colors used today most of the colored textile and leather items are treated with this color. There is ecological concern related to the use of azo dyes due to potential carcinogenic health risks of products of their biological degradation under the influence of microflora of the digestive tract. These dyes may build up in the environment, many wastewater treatment plants, from the industrial processes in which they are used, allow these dyes to pass through the system practically untreated. The initial step in the degradation of these dyes is cleavage of the azo bond, which is impossible to achieve in aerobic conditions, but is easily feasible in anaerobic conditions. The objective of testing Seshadri et al. (1994) was to determine the possibility of using the anaerobic microbiological reactor to achieve this cleavage. Also, the effects of typical process variables, such as hydraulic retention time (HRT), influent dye concentration levels, degree of bed fluidization on removal efficiencies were studied. The results indicate that almost completely separating the azo bond can be easily achieved for each of the investigated dyes under a hydraulic retention time of 12 or 24 h. However, in the course of the process, the by-products are in the form of aromatic amines, so the possibilities for their complete removal are considered (Seshadri et al., 1994).

In wastewater, microorganisms are present in a much larger number than in drinking water. The pathogenic bacteria, present in the water, have no significance in wastewater treatment, but they represent biological pollutants, which must also be removed by disinfection.

According to the Regulations on the Hygienic Correctness of drinking water, water is microbiologically correct if it does not contain pathogenic microorganisms, coliform bacteria and fecal streptococci, intestinal protozoa, helminths and their developmental forms, vibriones and bacteriophages. Water disinfection processes include oxidative processes, such as chlorination, water ozonation, hydrogen peroxide disinfection and non-reagent processes, in which disinfection is performed with UV rays, ultrasound, and heat. Chlorination is the oldest and most common method for water disinfection, active chlorine disintegrates the cell membrane of microorganisms and leads to the death of microbial cells. Ozone (O_3) is active similar to the chlorine and easily decays to atomic oxygen. Atomic oxygen is an extremely strong oxidizing agent that destroys microorganisms (Đukić et al., 2000; Cvijan, 2000; Đuković et al., 2007).

In this regard, it is necessary to mention the possibility of applying a large number of systematic groups of macro- and microorganisms in biological monitoring of the environment, or biomonitoring.

Šarčević-Todosijević et al. (2017b; 2018c) investigated the community of aquatic invertebrates of Banjska river, in which samples of macrozoobenthic organisms were taken seasonally for biological and ecological analysis.

Table 1. The average number of macrozoobenthos individuals in different seasons (Šarčević-Todosijević et al., 2018c).

Animal groups	**Spring**	**Summer**	**Autumn**	**Winter**
Mollusca	/	/	8	17
Oligochaeta	/	111	110	149
Ephemeroptera	608	1088	777	7752
Odonata	18	122	69	33
Plecoptera	13	33	8	100
Coleoptera	182	301	105	51
Diptera	17	66	88	186
Chironomidae	155	2119	4410	2074
Simulidae	7	/	28	913
Trichoptera	187	442	410	517
The average value (ind/m^2)	**148**	**535**	**601**	**1179**

The water quality was estimated based on the presence of indicators of the corresponding levels of saprobity. The wastewater inflow significantly affects on the structure of the macroinvertebrate community, on the basis of which it was concluded that the load with organic matters should be decreased (Šarčević-Todosijević et al., 2017b; 2018c).

CONCLUSION

Water is one of the three equally important components of the environment, involved in basic life processes on Earth. It plays an important role in the structure and function of all biological systems. Like other components of the environment, water is also exposed to intensive loading by inorganic and organic pollutants. The only way to remove organic pollutants is to expose them to the action of microorganisms, which use them in their own metabolism, as a source of food and energy in bonded mineralization to inorganic ingredients. Pathogenic bacteria are not involved in these processes and represent biological environmental pollutants, which must also be removed from the water.

Although many contaminating organic matters in the microbiological treatment of wastewater is successfully disintegrating, it is also necessary to work on the fate of the by-products, which occur during the degradation of certain types of organic matter, in order to allow their complete removal from the treated waters.

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MIKROBIOLOŠKO PREČIŠĆAVANJE OTPADNIH VODA

Apstrakt

Voda ima vitalnu ulogu u biosferi kao gradivna komponenta svih živih bića, učestvuje u fotosintezi, bazičnom životnom procesu na planeti, i predstavlja životnu sredinu velikom broju živih bića. U ekosisteme voda, polutanti dospevaju iz dva izvora, prirodnim i antropogenim putem. Glavni antropogeni izvori polutanata su komunalne otpadne vode, industrijske otpadne vode, vode iz poljoprivrede. Mikrobiološka razgradnja organskih zagađivača, predstavlja jedinu mogućnost njihovog uklananja iz vode. U ovom radu, razmatraju se mogućnosti prečišćavanja otpadnih voda, s posebnim akcentom na ulogu mikroorganizama u procesu.

Ključne reči: *voda, polutanti, otpadne vode, mikrobiološko prečišćavanje*

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