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ADVANTAGES AND LIMITATIONS OF IMPLEMENTATION OF "GREEN SOLUTIONS" IN THE TREATMENT OF WASTE EMULSION AND OILY WATER FROM THE INDUSTRIAL SYSTEMS

Abstract
According to the OECD forecast, it is expected that almost half the world’s population will have problems with water before year 2030, which shall lead to an increased demand for water, which might surpass the “offer” by even 40 percent. However, according to the many analyses, the real problem is not in the real lack of water but in recognizing the true value of water, efficient allocation and planning. Therefore, nowadays, the basic goal of bio-engineering measures and actions imposes the conservation of “healthy” water by the decrease or elimination of the existing pollution, without putting more pressure on the environment, with the integral approach in the sense of synergic activity of scientists from various fields. In this paper, we consider the use of "green solutions" in the treatment of waste emulsions and oily water in order to reduce the amount of hazardous waste and pressure on water resources, while providing multiple benefits, as in both the environmental and economic sense.

Key words*: waste emulsions, oily water, bio-engineering*

Emulsion and water soluble agents for metal processing

Emulsion and water soluble agents for metal processing are used in various industrial branches dealing with processing of different metals, for lubrication, primary cooling and rinsing of sawdust. The basic categorization of emulsion fluids is made according to the content of mineral oil, i.e. synthetic components, in the following way:

- Products with more than 60% of mineral oil,
- Products with less than 60% of mineral oil,
- Products based on synthetic raw materials (with no mineral oil),
- Products based on soluble salts and alcohol (with no mineral oil).

A common negative characteristic of all emulsions is a limited service life due to bacterial degradation.

Aerobic bacteria (in the presence of oxygen) and anaerobic bacteria (in the absence of oxygen) grow in the emulsion, and the types of microorganisms that live in the emulsions during their use are determined by the pH value. Efficient protection from the action of microorganisms can be achieved by the use of protective agents, as well as through a regular control of essential parameters: concentration, pH value, oil separation, foam, degree and type of contamination, corrosivity, etc. On waste classification, waste emulsions are treated together with waste oil and oily water, although in relation to them waste emulsions contain a high percentage of water.

Procedures for treatment of waste emulsions and oily water

Unlike waste oils, waste emulsions and oily waters are characterized by a high water content. Practically, waste emulsions can be treated as waste waters. Therefore, in our work, we will consider biologically acceptable procedures for the elimination of pollutants aiming at their safe discharge into the recipient or their reuse, within a framework acceptable for the environment.

Conditionally, we can divide the treatment processes into three main categories:

- Primary treatment (extraction of mechanical impurities, suspended and colloidally dispersed particles that can be efficiently eliminated through sedimentary processes)
- Secondary treatment (extraction of non-sedimentable colloidal particles and dissolved organic pollutants - biological processes)
- Sludge treatment processes

The paper is focused on the implementation of "green solutions", i.e. biologically and environmentally acceptable treatment processes.

The primary treatment is based on physical properties of treated waste waters and the action of physical forces. The process begins with the elimination of rough materials (e.g. chips) - floating and suspended. The accumulated material (as well as sedimented material) can be further processed along with waste sludge.

Biological treatment is based on the activity of complex elements of the microflora, which during its life cycle, through various mechanisms, adopts organic and a smaller part of inorganic pollutants, using them as "energy substances" for the maintenance of its life cycle activities.

Deodorization of waste emulsions

Bacteriological contamination, due to various metabolic products of microorganisms, results in the occurrence of unpleasant odours of waste emulsions. Practically, deodorization may be carried out as a pre-treatment or within the primary treatment. For the elimination of organoleptic active organic substances, the most frequently used methods are:

1. Filtration of contaminated water through a layer of granular activated carbon
2. Filtration with the addition of powdered activated carbon

Certainly, unpleasant odours can be eliminated by treatment with certain chemicals, but we will here discuss only *enviromental friendly* procedures.

Table 1: Mechanisms for the elimination of effluents

Physical	Chemical	Biological
sedimentation	precipitation	metabolism of bacteria
filtration	adsorption (chemisorption)	metabolism of plants
adsorption (physisorption)	hydrolysis reaction	absorption by plants
volatilisation	oxidation reaction	natural extinction

In the field of treatment of waste emulsions and oily waters it is possible to apply various solutions, i.e. the schemes according to which the process will be implemented will depend on:

- Character of pollution
- Required purification level
- Effectiveness of particular procedures
- Available time and space, etc.

Eco-remediation (biotechnologies) Eco-remediation, as a biotechnology, primarily implies biological and environmentally friendly technologies for the reduction of pollution, which use various microorganisms, green plants and trees for elimination, transfer, stabilization and decomposition of environmental pollutants (*in situ, in vivo* and *in vitro*).

Bio-remediation implies a set of various methods that use certain microorganisms for the purpose of decomposition and elimination of different pollutants and harmful substances, primarily of organic origin. A large amount of research has been conducted recently referring to the environmental role of the large population of non-pathogenic microorganisms, primarily bacteria, in accordance with their identified capability of decomposing various contaminants of organic and inorganic origin, in all parts of the environment - water, soil and air. Numerous microorganisms, primarily bacteria, thus acquire their new environmental role. It has been found that certain heterotrophic bacteria are capable of decomposing various synthetic substances, pesticides, mineral fertilizers and other harmful substances, such as *Pseudomonas* whose dioxygenases can decompose several hundred different components, including PAH. The former results of both laboratory and field research confirm that practically there are no petroleum substrates or petroleum industry by-products that cannot be decomposed by microorganisms ex situ or in situ.

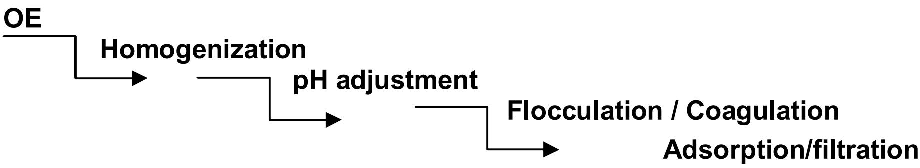
What is of significance is that the biggest success is achieved through the use of autochthonous microorganisms (from the very spot of pollution, i.e. from the very pollutant), in terms of facilitating the bio-remediation process by the use of already adapted or partially adapted microorganisms.

The equation of microbiological mineralization of organic substance:

$$C_cH_hO_oN_nP_pS_sCl_{cl} \rightarrow cCO_2 + h/2\ H_2O + nNH_4^+ + pHPO_4^{2-} + sSO_4^{2-} + clCl^- + \text{Energy}$$

As the aim of bio-remediation of waste emulsions and oily waters, in combination with subsequent phytoremediation, it is possible to obtain a high purification level, and thus use the same water as sanitary or technical water.

The scheme of the waste emulsions bio-remediation process can be presented in a simplified form in the following way:



Phytoremediation (*Phyto* Gr. → plant, herbali; *Remedium* Lat. → medicine, agent, reestablishment of natural balance) as a term, is used for several different methods in which plants are used for the elimination, stabilization or control of hazardous waste. Fundamental and applied research has explicitly shown that selected plant species have a capability to eliminate, decompose, metabolize or immobilize a wide range of contaminants.

In industrial ecology, the term phytoremediation is widely spread, but in the literature we find a number of names, such as *Wastewater Gardens* or *Living Machines*. However, the basic principles are similar: a system designed to facilitate the natural process of waste water purification, renewal of lakes, streams or swamps, treatment of sewage waters or, which is more questionable, locations with toxic waste.

Processes in plants, conditioned by the presence of pollutants in the observed environment, indicate high potential of purification through plants. Plants that possess such potential are called phytoremediators.

Mechanisms of phytoremediation and types of phytoremediation techniques

Table 2: Different phytoremediation mechanisms according to GHOSHU and SINGHU

Process	**Mechanism**	**Contaminants**
Phytofiltration	Rhizosphere accumulation	Organic and inorganic
Phytostabilization	Formation of complexes	Inorganic
Phytoextraction	Hyper-accumulation	Inorganic
Phytovolatilization	Volatilization by leaves	Organic and inorganic

When selecting a phytoremediation technique, certain environmental factors should be considered, e.g. the influence on interspecies relationships. Numerous studies have found that certain microorganisms, similar to plants, are capable of decomposing or mineralizing petroleum derivatives in the process of the so-called „biological combustion", thus providing multiple benefits, such as formation of humified material.

Rhizosphere biodegradation represents microbiological decomposition of organic pollutants, which is facilitated by the root systems of higher plants, since the root systems themselves secrete and provide enzymes and organic substances (polysaccharides, amino acids, organic and fatty acids, growth factors), which stimulate growth and reproduction of microorganisms and enable them to decompose pollutants by their activity. On the other hand, the root system (micro-rhizosphere may be up to 200,000 times longer than the root) increases the active surface for decomposition of pollutants and, in general, contributes to the creation of optimal conditions for the action of microorganisms.

The advantages of this method include *in situ* conditions for decomposition of polluting organic compounds, which contributes to considerable saving of financial resources on remediation of pollution, while the main disadvantage is the fact that this process takes a lot of time. This type of phytoremediation is particularly successful for decomposition of organic compounds originating from petroleum and derivatives, as well as for compounds of BTEX complexes (benzene, toluene, ethylbenzene and xylene), pesticides, etc.

In the process of water phytoremediation, rhizosphere has the leading role due to the association of the plant root and microorganisms. Numerous investigations have shown that species from genus Salix and genus Populus are most efficient in phytoremediation due to the high potential of transpiration and plasticity of the root system. For instance, the mechanism of trichloroethylene degradation by Populus sp. to trichloroethanol, chlorinated acetate and finally CO_2 has been studied.

The adoption efficacy of the root system is also influenced by the availability of nutrients and pH value of the water environment, while at the same time the presence of roots stimulates microbiological activities through the number of microorganisms (not through the number of their species). When various substances enter the root, they are decomposed by peroxidases, nitoreductases, phosphatases or esterases, and then enter the plant metabolism. For the efficacy of phytoremediation it is necessary to be familiar with the interactions between the enzymes secreted by plants into the rhizosphere during their growth and enzymes of microorganisms that can decompose or deactivate defensive components from root exudates. And the very net effects of these interactions - simulation and regulation of the root system on the growth and variety of microorganisms influence the diversity of microorganisms on the root surface. There is a direct analogy between root exudates, pollution and allelopathic chemicals.

What is important is that the overall system must be observed in a holistic manner, i.e. bacteria, fungi and plants should be observed as a unique ecosystem that, being such, responds to stress, in our case the pollutants in water environment, rather than each separate element. Namely, microorganisms live in association with a particular type of plants or inhabit a particular rhizosphere. In the case of bacteria decomposing PCB, it has been discovered that plant roots secrete phenolic compounds both in the presence and in the absence of contaminants. In that manner an ecological niche is formed for more than 17 species of bacteria that degrade phenols in the rhizosphere of mulberry. Adding of terpenes (orange peel, eucalyptus leaf, pine needles, mint plant) stimulates PCB decomposition. Bacteria induced in this manner can decompose PCB when inoculated in polluted water environment or sludge.

The metabolism of pollution in a plant, i.e. a general scheme of the plant metabolism of xenobiotics can be presented in the broadest manner as a process of oxydo-reduction, glycosylation or conjugation with glutathione, through the transport into the central vacuole and/or cell wall. Metabolic pathways of the following groups of organic pollution have been studied relatively well so far:

- chlorinated hydrocarbons (willow and poplar)
- explosives and other ammunition (TNT- trinitrotoluene) (*Cyperus*, *Phaseolus*, *Medicago*, *Allium*, all in non-sterile conditions, aquatic species, *Triticum aestivum* in sterile culture)
- BHT (antioxidants based on benzotriazole) (fungus of white root from live plant)
- PCB and PAH (surfactants, polychlorinated biphenyls and polycyclic hydro-carbons) (*Solanum nigrum*),
- cyanides (willow)

So, the basic mechanisms in phytoremediation are the adoption and metabolism of pollutants by plants. The features of molecules of polluting compounds such as solubility, hydrophobicity and polarity, determine the degree of success of this biotechnology. Practically, plants through their metabolism, after the absorption of contaminants, change the form of organic molecules (pesticides, industrial chemicals, etc.) from toxic to non-toxic, i.e. they turn the pollutant into the polymeric form and store it in their tissue. A disadvantage is the possibility of formation of toxic metabolites and intermediate products of metabolism, which must strictly be taken into account when opting for and implementing this method in practice.

Phytovolatilization is suitable for volatile compounds such as benzene, toluene, chlorinated alkanes and alkenes, as well as MTBE. Phytovolatilization is economically most efficient for such molecules since they are most frequently located on large surfaces, but in small concentrations.

For the past years, much research has been conducted on plants decomposing organic compounds originating from the petroleum industry, and most works and practical results have been achieved with woody plants such as poplar and willow. Particularly successful have been experiments of the constructed aquatic systems using willow (*Salix viminalis L*), where the so-called „zero discharge" is of significance. Waste water discharged into a riverbed where willows are planted disappears through evaporation from the surface of soil and plants, and nutrients are incorporated into the biomass of the willow. To make it possible for the willows to constantly adopt nutrients, about 1/3 of the aboveground biomass is cut down each year. This ensures not only the elimination of nutrients and heavy metals, but the willows also remain healthy, and evaporation is additionally achieved as well.

Willows (*Salix ssp.*) are mentioned as quality factors in the process of phytoremediation due to the capability of absorption of petroleum by-products through the microbes inhabiting their root system (the research has shown their decrease of up to 57% at investigated locations, while for ethanol and benzene the decrease is up to 99%), and they have also proven to be an excellent vegetation filter for waste waters.

Selection of plant species in phytoremediation - The selection of species to be used in phytoremediation is a critical step that determines the success of phytoremediation. The knowledge of species, their overall ecology, as well as physiology and characteristics of their tissues and organs, i.e. the anatomy and morphology, is thus of vital importance. The selection of plant species in phytoremediation is mainly performed on the basis of empirical research, particularly field experiments, since we still do not possess sufficient knowledge of plant characteristics in terms of phytoremediators. The US Environmental Protection Agency (EPA) possesses a database of phytoremediators, but this does not mean that certain species not included in this database are not suitable for phytoremediation in specific cases. The selection of species depends on the identification of climate-adapted species, and it is optimal to use those having an economic significance as well.

When creating an experimental plot it is necessary to establish a monitoring plan, aiming at monitoring the following parameters for further application of the selected species in phytoremediation:

- the degree of survival of planted plants;
- dynamics of height and diameter growth;
- health of plants;
- effects of the applied care measures;
- effects of phytoremediation;
- costs of establishment, care and protection.

The main factors influencing the selection of certain species are ecological conditions considered to be favorable for the natural growth of a species, while at the same time they may be unfavorable for another, so that any discussion referring to financial reliability must be in the context of particular species or types of mixtures. Certain xenobiotics are toxic for plants, and on the selection it must be taken into account whether and to what extent particular plants have a specific degree of tolerance to them, so that they could be used in phytoremediation. The success of phytoremediation frequently depends on whether mycorrhizae are present. The most significant factor for water soluble components is high dilution when they reach the atmosphere. The use of phytoremediation under our climate conditions has positive and scientific confirmation in *in situ* and *ex situ* projects. *In situ* application is more frequent.

The use of plants in constructed aquatic systems - they are designed to use natural purification processes, which normally occur in natural swamps and marshes, as well as in controlled conditions. These systems can be used with a higher level of control, the selection of vegetation, mediums, and the advantages over natural swamps are: the possibility to select the location, size, control of water flow and retention time. Contaminants originating from emulsion waste waters are eliminated by physical, chemical and biological processes. Vegetation in constructed aquatic systems provides a base (root, stem, leaf) to which microorganisms decomposing organic matter can attach. Microorganisms can use plant exudates, and plants can use the products of organic matter decomposition. Such a community of microorganisms or periphyton is responsible for decomposition of up to 95% of the present pollution.

The purification process occurs when the effluent passes through the constructed system medium and through the rhizosphere, where the remaining suspended substances naturally sediment or are further filtered through the medium. The narrow zone around the root hairs is aerobic (due to the release of oxygen by the root), which ensures facilitated and more complete decomposition of organic substances by the use of microorganisms. While plants obtain the needed quantity of energy through the photosynthesis process, by the conversion of CO_2 into organic substances, microorganisms present in the sediment/medium obtain the energy needed for the maintenance of metabolism through the oxidation of organic substances. During this oxidation the final acceptor is oxygen (it is reduced to H_2O), and the organic matter is modified to CO_2 as the final product. Due to the lower quantity of available energy, anaerobic organisms are less efficient when it comes to the decomposition of organic substances, in relation to aerobic ones.

Similar to the conventional treatment of waste waters, these systems generally operate at several levels. Waste emulsions from the system go to the primary reservoir where the pre-treatment is performed in the form of gravitational sedimentation. They are then led to the reactor, where they are divided into the oil and water fractions, and agglomerates are then stopped by the filter, while partially purified water is discharged to the layered garden, comprising a cascade pool with vegetation on an impermeable surface, which is covered by a suitable gravel cover of different grain sizes, and specially selected vegetation on the top. Well designed systems are in compliance with American (EPA) and European health standards. The costs are estimated at 5 to 10% of the regular price of maintenance and expenses, and may be projected so as to depend on the weight, thus reducing or eliminating the need for energy.

Ecosystem processors (biological pools) - The main idea of biological pools is very simple - the first part is the sedimentation zone, while the second part, i.e. the regeneration zone, is used for water purification. Chemical agents are completely excluded from the concept.

A biological pool may be a whole with a lake, i.e. the regeneration zone. Another possibility is to have a biological pool that is partially separated from the regeneration zone, and the third option is when the biological pool and the regeneration zone are two completely separated wholes. Through a completely natural and biological purification process, which occurs in the regeneration zone, hygienically clean water can be obtained.

The main idea of this concept is taken from the nature, i.e. by monitoring of the self-purification capacity of water streams. Biological purification processes are basically similar to self-purification processes in natural waters, where the main difference is the fact that biological processes are based on lesser or greater control of growth and development of microflora. Observed in this way, the given processes gravitate to industrial microbiology, and they differ from it for the fact that the processes do not occur in optimal physiological conditions. The concept thus includes cascades, over which, by a natural fall, through overflow channels, relatively purified water is supplied to the regeneration zone. In the regeneration zone, water purification is carried out by various overwater and underwater plants. Carefully selected plants take nutrients from the water, which are released by microorganisms during the process of decomposition of organic and inorganic substances. In addition, for more intensive filtration, a layer of gravel is laid down and it has a role of the filter for additional water purification. Water flows through the overall system by free fall, and by the use of a pump it is supplied from the lowest point to the entry point of the pool, by which a closed circle is formed. The overflow channel creates water flow on the pool surface, which slowly pulls rough impurities such as leaves, branches and other floating particles, from the water surface towards itself, thus always ensuring clean water. By the use of well installed hydraulics (water supply installations), the regeneration zone can also be positioned underground, so that it does not have to be visible. It is ideal if the space for phytoremediation cannot be big.

Biological processes of waste emulsion and oily water purification can be generally divided into aeorobic and anaerobic ones, or their combination. Aerobic purification is considerably more frequent than anaerobic purification, and it is suitable for application with waters having small to medium concentration of organic pollution. In our case, it is suitable to apply the procedure with suspended microflora, particularly:

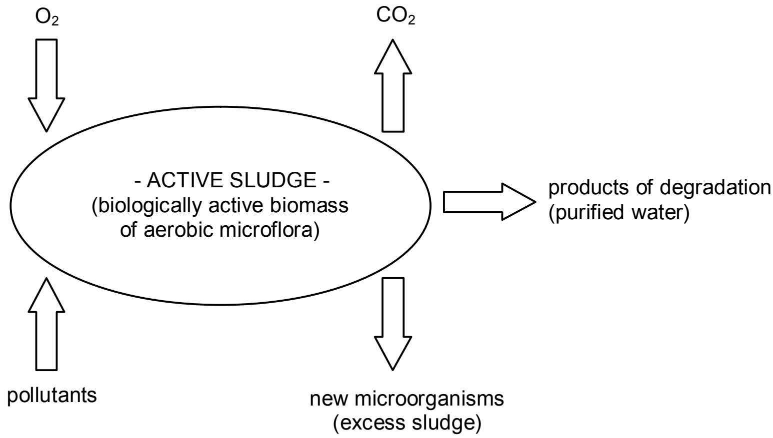
- Procedures with active sludge
- Aerobic aerated lagoons
- Aerobic shallow lakes or pools

Procedures with active sludge - during this process, waste water is introduced into the reactor, in which active carbon is maintained in suspension, and its active microflora ensures simultaneous occurrence of dissimilation (organic substance oxidation), assimilation (synthesis of new microflora cells) and auto-oxidation (endogenous respiration of microflora) (Figure 1).

The most important microorganisms of active sludge are gram negative and nitrification bacteria, protozoa, rotifer, as well as fungi due to the higher tolerance to lower pH values. In practice, there are various technological solutions of active sludge procedures:

- Conventional procedure
- Gradual aeration procedure
- Contact procedure with active sludge

Aerobic aerated lagoons - represent a procedure of aerobic biological purification with suspended microflora, which is close to natural purification processes.
Aerobic shallow lakes or pools - a procedure imitating the self-purification process, with retention of even more than 90 days.

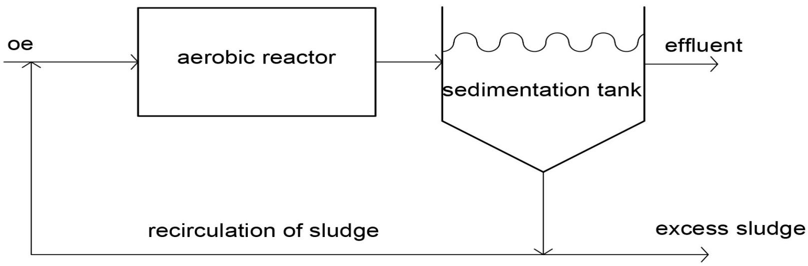


Membrane processes – the former research has shown that membrane systems have a series of advantages in relation to conventional facilities, due to smaller investments, lower exploitation costs and minimum use of chemicals. Many authors consider **reverse osmosis** the future in the technology of procession of variously contaminated waters. Namely, at today's level, through reverse osmosis it is possible to obtain 75-80% of permeate (purified water), while the retentate (remaining water) can be directed to further purification by the use of suitable biotechnology. The scheme below (Figure 2) presents one of the possible structures of combined waste emulsion treatment:

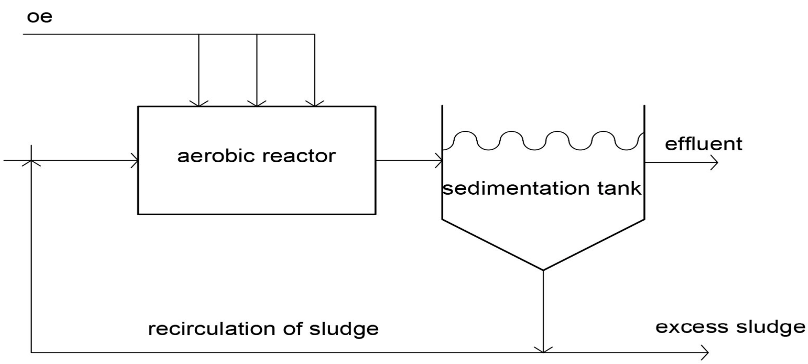
1. Entry of waste emulsion through the cyclone;
2. Reservoir for the disposal of waste emulsions;
3. Mini reservoir for the collection of separated sludge;
4. Mini reservoir for absorbents;
5. Reactor for emulsion splitting;
6. Filter bags;
7. Ecosystem processor;
8. Movable roof structure.

Of course, each system can amend and change the relevant scheme in accordance with its specific needs, and in compliance with the technical as well as temporal and spatial capabilities and limitations.

- **CONVETIONAL PROCEDURE** - (water retention time 4-8 h)



- **GRADUAL AERATION PROCEDURE** -



- CONTACT PROCEDURE WITH THE ACTIVATED SLUDGE -
(reduce the dimensions of the tanks for the same amount -
the consumption of air and the efficiency)

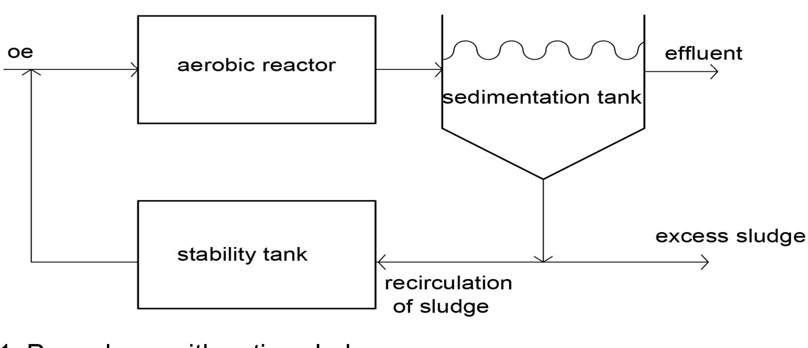


Figure 1: Procedures with active sludge

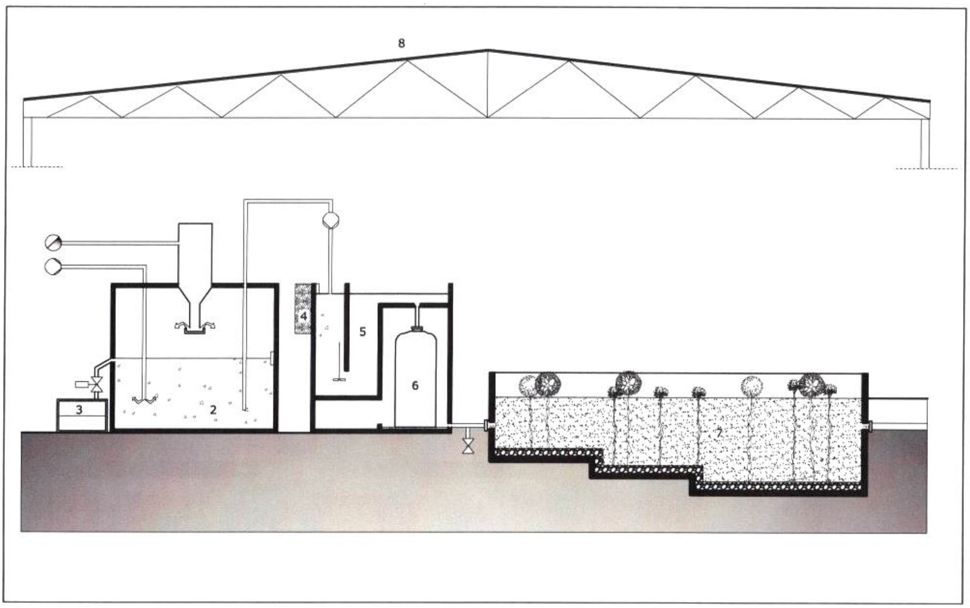


Figure 2. One of the possible structures of combined waste emulsion treatment

Zooremediation - Recent research shows that lower animal organisms, such as shells, can be successfully used in remediation of waters contaminated by various pollutants. Because of ethical principles, animals, as means of ecoremediation, have not had more space so far, but due to incentives and works of some scientific workers, they are gaining importance thanks to precise examples. It is mentioned in literature that some animal species are very efficient remediators of heavy metals, microbiological pollution, hydrocarbon and organic pollutants, especially in aquatic environment. Recent examples include the use of shells (pearl shell) for the elimination of metals and organic substances from water ecosystems aiming at the removal of polychlorinated biphenyls (PCB). Many taxonomic categories of animals most likely possess the characteristics needed for bioremediation processes. The progress of research is also reflected in the introduction of new definitions used in the literature, such as zooextraction, zootransformation, zoostabilization, zoohyper-accumulation, etc., which represent analogy to the terms of phyto-remediation. Aiming at development of zooremediation techniques, it is necessary to introduce standards for evaluation of suitable candidates from the animal world for remediation procedures, for the purpose of final recognition and acknowledgment of the zooremediation concept. This will open new opportunities for future research in this field.

Table 3: Possible treatment of waste emulsions by the use of "green technologies"

Type	Advantages	Disadvantages
Membrane processes - - Ultrafiltration - Reverse osmosis	• Applicable for different types of emulsions, • Easy to use, • No use of chemicals, • Can be easily automated, • No need for special instruments, • Basic concept is easily understandable.	• High price of the membrane, • Membrane sensitivity, • Clogging of membrane pores by some colloidal substances, • Costs of energy are higher than in the case of chemical treatment, and lower than in the case of evaporation, • Secondary oil separation is difficult, • Inefficient treatment of emulsions based on synthetic oils.
Bioremediation	• Applicable for waste emulsions that cannot be treated by ultrafiltration or chemically due to the content of fatty acids or amines. • Possibility of remediation by own consortia of previously selected and adapted zymogenous microorganisms • Use of mobile bioreactors • Acquisition of humified material that has value in use	• Some chemical compounds are not readily biodegradable, • The presence of biocides inhibits microbiological activity, • The speed of biological reactions is low, large volume storage tanks are needed, • Changes in the waste emulsion composition can considerably reduce the treatment effectiveness, • Bacteria should be constantly added. • Limited by the type of pollution that can be remedied, conditions in the environment, and the time needed for its occurrence.
Phytoremediation	• Economical biotechnology, • Natural - *environmental friendly*, • Energy is provided in a natural manner since plants use solar energy on their own, • Creation of biomass, • Aesthetically pleasing.	• Limited application, • For each plant species there are pessimal values of ecological factors, also in terms of plant tolerance to toxic substances, • The period of time needed for the elimination of pollution from the environment is longer than in the case of another method, e.g. mechanical elimination, • Phytoremediation is efficient only with moderately hydrophobic compounds, • Potential hazard of the entry of toxins into the food chain through introduction of herbal tissues with accumulated pollutants into animals and their further distribution through the food chain

Zooremediation	• Research is underway	• Possible formation of toxic metabolites and intermediate products of metabolism Potential danger of the entry of toxins into the food chain and their further distribution through the food chain

Conclusion

There is an increasing number of examples proving that bioremediation, along with phytoremediation, represents the future of "green" technologies. As can be seen from the foregoing, each of the mentioned procedures has certain advantages and limitations, and therefore a multidisciplinary approach is imposed as the most appropriate. Being relatively new, biotechnologies still have many open questions, as well as great opportunities for further research. Since biotechnologies require various knowledge, there is a necessity of synergistic approach of different scientific disciplines directed to solving the same problem.

The results of field tests conducted within „NIS" have shown considerable results achieved in the application of "green" technologies, primarily bioremediation for the treatment of: polluted soil and underground waters, liquid waste pits, deposited liquid waste, all types of "oily waste waters", including those from washing of facilities and pipelines, reservoir and process sediment and sludge, facilities and assemblies for the absorption of petroleum and derivatives, which are permanently, accidentally and incidentally spilled out. In addition, for the needs of factory FAM Kruševac, multi-stage processing of off-balance emulsions (~ 600 m^3) has been successfully carried out by the use of bioremediation.

The most important characteristic of "green solutions" is their environmental acceptability, since these procedures do not generate additional waste and do not create additional pressure on the ambient.

Emulsions and oily waters are classified as hazardous waste pursuant to the law of the Republic of Serbia, along with waste oils. That is unquestionable, but due to such qualification they are practically subject to the same treatment.

The current unrealistically low economic price of water, which underestimates the depth of the crisis the planet is facing when it comes to water, has led to a large scale of unnecessary and inefficient utilization and consumption of water. Although science can and should have a considerable role in dealing with this issue, it is also important to deal with the economic part of the story at the same time, i.e. in a realistic economic framework. Of course, this implies that the price of drinking water should be protected, but any other utilization must have an appropriate price. Agricultural, industrial sectors - everyone must pay much more for water. So, options exist. Whether we will select the right ones is a question for each of us.

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