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Ecoremediation

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ECOREMEDIATION

1. Introduction

The surface of the planet Earth is covered by natural and artificial ecosystems. Every ecosystem consists of two components, which are the living space or biotope and the living group or biocenosis. They are inseparably connected with each other, because the substances between the parts of ecosystem continually circulate and the energy decants. The more complex is the structure, the more stabile is the ecosystem and with that its possibilities to adjust to the changes in environment (Vrhovšek, 2004 and others).
Ecosystem is an ecological system where parts of animated and inanimate nature are connected in a functional unit (Lah, 2002).The animated part connects plants, animals and human society, which for their life need the inanimate part, air, water and soil. In such a connected system the substances circulate and the energy decants. Every part of the system impacts the others and every part depends on the functioning of the entire system. Changes in ecosystem can cause internal or external factors.
Structure of ecosystem:
Basic components are:

- inanimate components (water and nourishing substances)
- primary producers (green plants)
- decomposers (microbes and animals that decompose dead organic rest) recycle nourishing substances and energy and
- energy

Vegetation changes of living space and the population movements change biotope and biocenosis in short term, whereas ecosystems is more stabile. Mutual relations in plant and animal communities on one and rations between members of animal and plant communities on the other side and also the relations of them towards animated and inanimate nature; all that unites living space of plants and animals (Geister, 1998).

In Slovenia there is in a short distance an interweave of forests at the mountain areas, seas and littoral regions, wetlands, meadows, karst pastures, karst caves and other ecosystems that enable a symbiosis to very different organisms. Transley based ecosystem as a whole of abiotic and biotic factors (Wilfing, 1993), where processes are active and energy circulates. Due to connection of elements and processes in ecosystems, their function changes, which impacts stability of the entire system.

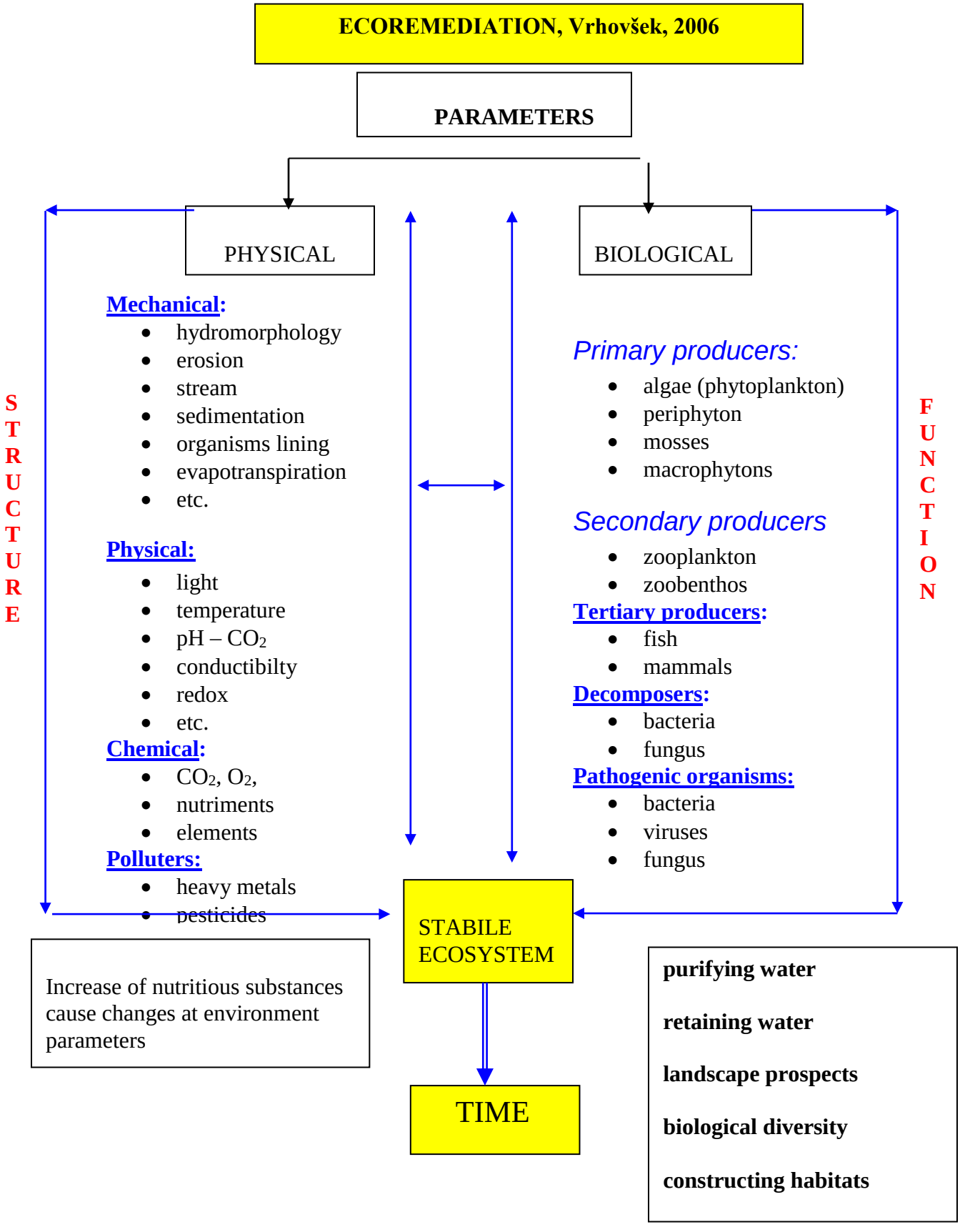
2. Ontogenesis of water as a basis to understand the Ecoremediation

Ecoremediation (ERM) comprises methods of protection or restoration of the environment by means of natural processes existing in ecosystems. The establishment of ERM systems provides sustainable environmental management solutions that contribute to the preservation of biodiversity and pollution reduction, increase the quality of water and soil, and can be applied in protected and sensitive areas. The functions of ERM are based on aquatic, waterside, and wetland ecosystems, and are characterized by high retention capacity, flooding prevention, and reduction of specific physical, chemical, and toxic pollution. This chapter reviews the operational performance of ERM in Slovenia, including constructed wetlands for sewage, landfill leachate, industrial wastewater, drinking water, highway runoff, ponds/wetlands, vegetated drainage ditches for agricultural runoff, landfill restoration, and river revitalization. A further aim of the ERM concept is to promote the idea of unifying different kinds of ‘‘green technologies’’ that are based on nature’s self-cleaning mechanisms, enhanced by the latest scientific developments, in the search for sustainable solutions that do not rely on the passive role of nature, but look to nature in building sustainable models through an understanding of human–environmental relations (Griessler Bulc, Šajn Slak 2009).

As it is written in the millennium ecosystems estimation, published in 2005, human actions have brought the planet Earth to the edge of mass extinction of species and keep threatening our survival. Based on current estimations the loss stages due to human activities are hundred to thousand much higher than in natural conditions. The millennium estimation emphasises that ecosystem services enable human life and conclude that the future of the mankind depends on healthy ecosystems (Draft report on stopping diversity loss until 2010). Knowing ecosystems, their processes and functions is needed for a successful environment protection.

In the paper on lakes development dr. Vrhovšek (1983) explained the formation and dying of lakes – the ontogenesis of lakes. Eutrophication or enriching water by anorganic and organic substances is one of the main problems at managing water sources. The biggest problem and at the same time the cause for fast eutrophication is the flow and the increasing accumulation of nourishing substances in a water environment. The main symptom of this phenomenon is shown in constant productivity increase of plant and animal organism. Decay of greater amounts of organic material consumes much oxygen and therefore the lower lake levels can often be without it.

Picture 1: Function and structure of ecosystems define ecoremediation



From Picture 1 we can see that all factors, shown in the scheme and many others are reciprocally connected with each other. Every change of abiotic (physical) factors impacts the structure and function of biotic (animated) factors and vice versa. If the structure and function of organisms changes the abiotic factors change as well.

3. Traditional usage of natural processes

In history of human and nature symbiosis and due to lack of technical help, the human being had to observe nature changes very carefully, learn from them and use them on his behalf. Retaining water was used cleverly as the drinking water source for watering of animals and plants. Selfcleaning capacities were already known as far back as to old Egyptians, as they drank water only between plants. Mayas as well had their own sewage system led to the swamps, where it got cleaned.

In the past people have arranged their own water system with retaining rainwater, using it for watering of animals, washing linen, extinguishing fire, sometimes even as the source of drinking water. They named it bud, pond or puddle. On a clay bud foundation there have soon grown plants, different animals and microorganisms have come, who purifyed water and at the same time represented an ecosystem with a great biodiversity.

Natural ecosystems have in their ontogenesis developed many remediation systems that enable them to maintain a dynamic diversity. So at some segments or regions particular processes develop in order to help the ecosystem to survive through daily and yearly changes as well as those of hundred and thousand of years.

Some ecosystems, especially land ecosystems are more stabile and these kinds of changes are shown through in long term. But if we look at water ecosystems, we can see that these changes are very quick; along the entire water stream as well as time changes. Many of these changes cause particular catastrophical situations, e.g. flood and drought; others are consequences of basic hydromorphic characteristics of water body.

Basic purpose of ERM usage is multipurpose and conatural water streams, lakes and wetlands managing, which will enable an integral development of particular areas and contribute to the symbiosis of human being and nature and mitigate natural rigours of the weather. Therefore ERM are economically and ecologically, but most of all in a long term, amongst the most successful ways of environment protection. This has been recognized by people in the past, when they have managed water systems to retain water successfully and use it in many ways.

Riverine swamp vegetation enables retaining and aerating water, retaining bigger parts and is a suitable habitat for numerous organisms.

Pool	Rapids
	
Gravel deposit	Swamp vegetation
	

Picture 2. Natural processes (foto:by author).

4. Ecoremediations in the lives of people

With increasing development and knowledge about natural processes, ecology and relations in ecosystems we have discovered some not researched potentials in nature. They are very efficient for protection and renewal of already degraded and threatened areas. The concept of ecoremediations (ERM) refers to usage of lasting systems and processes for sanitation and protection of environment. Ecoremediation technologies include principles of puffer capacities of nature, phytoremediation (phytostabilisation, phytoextraction, phytostimulation, phytodegradation, phytotransformation, phytovolatization…) and bioremediation for sanitation of environment pollution. Conatural (green) approaches increase biodiversity and with that return ecosystem's balance. Ecoremediation methods have the potential for decreasing, preventing and abolishing natural catastrophes (flood, drought, landslides, non points pollution sources (agriculture, transport) and unmarked pollution sources (communal, industrial sewage). High efficiency can be reached by protection of living space, especially water sources, brooks, rivers, lakes, underground water and seas. Basic ecoremediation functions are high puffer capacity, selfcleaning capacity, increasing biotic diversity and retaining water. Using ecoremediations (phytoremediations, puffer areas and constructed wetlands) we can revitalize degraded areas (stone pits, roadsides), eliminate excessive nutrients content and purifying sewage water. Additional ERM value is also bringing revival of

degraded areas. With renewed environment its value returns and it can be use for developing other activities. Using ERM we protect habitat important areas against pollution and enable a conatural development. With nature we can also decrease impacts of natural disasters. Ecoremediations are being constantly implemented by nature; therefore it is important to know natural law and systems for their correct usage. Ecoremediations use natural processes in natural and partly artificial water ecosystems to assure better water sources usage, to eliminate harmful pollution impacts and to preserve biological diversity. Ecosystems have a big puffer capacity and can retain, reform or neutralize many organic and anorganic pollutants using natural processes. They are biotechnological methods that use natural and conatural processes and systems (ecosystems) for protection, sanitations of environment, purifying and preservation of water.

4.1 Preventive role of ecoremediation

At every intervention to the environment ecoremediations need to be compared, considered and implemented as the preventive measures for environment protection.

Repairing damages done in environment is much more expensive and unreliable in comparison to preventing degradation. Therefore we emphasize education, because ERM enable understanding of nature activities, processes in nature and their monitoring (e.g. water purifying, retaining heavy metals in soil, noise mitigation). Great importance also lays on informing, notifying and lifelong learning. Preventive meaning of ERM is exceptional, because it includes different aim groups, from children to elderly, different profession profiles and government and non-government institutions. Very important preventive role is lays also in countryside preservation and carrying out Common agricultural policy.

4.2 Sanative role of ecoremediations

Due to needs of using verified procedures at sanitation of environmental damages that often originate from inconsideration of natural frames, ERM is also used for sanitation of damages.

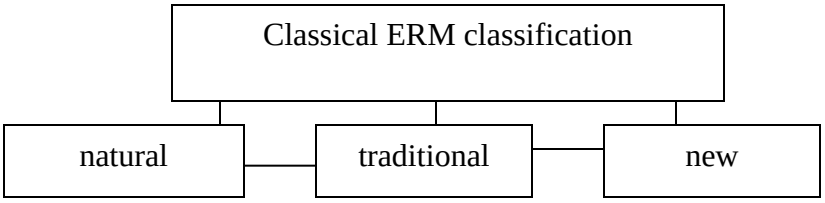
Using ecoremediation technologies we can decrease and abolish consequences of natural rigours of the weather (flood, drought, landslides etc.) and non points pollution (agriculture, tourism, traffic, industry, dumping grounds and dispersed settlements). With relatively low expenses we can achieve big results at protection of living space, water sources, brooks, rivers, lakes, underground waters and seas. Basic functions of ecoremediations are big puffer, selfcleaning and habitat capacities. These should be used at water sources protection, soil and sediments pollution and at mitigating impacts of climate changes (Kokot, M., Vovk Korže, A., Globovnik, N., 2010).

Importance of ecosystematical approach is shown on picture 8, where you can see a strong connection between inanimate and animated part of environment, which defines the structure and function and defines system stability.
Most of the technical means of river remediation are also suitable for the estuary area, but it must be improving the appropriate methods to combine the characteristics of the estuary landform, environment, climate and biological. The river remediation technology including river inline repair and outside line repair (Li, Du, Zou, Li, 2011).

5. Classification of Ecoremediation

I. Classical ERM classification:

With this classification there are joint forms at natural ERM that are in nature in the forms of pools, waterfalls and meanders. Amongst old forms are buds that have been used by people for many purposes, amongst new forms there are constructed wetlands, ecoremediation ditches, wind barriers and puffer areas that are used for natural environment protection. Incorrect interventions are being sanitated with revitalizations and renaturations, phytoremediations (for purifying of polluted soil), with methods for conditioning drinking water and with that sanitating already degraded forms of natural environment components.

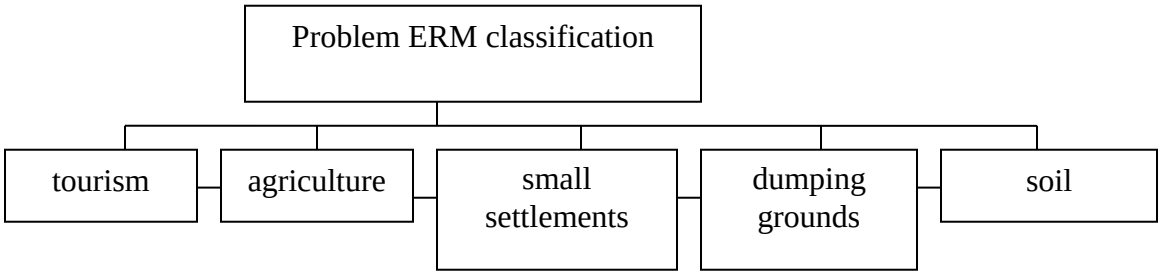


Today we classify ERM based on the problem that they solve due to its complexity and inter-sectorial part

II. Problem ERM classification

ERM for balancing water quantities (measures against floods, prevention/reduction of drought consequences),
ERM for saving polluted water due to agriculture, tourism, industry etc. ERM for saving unmarked water pollution: preventing/decreasing pollution from agriculture (underground water, food)
ERM for preventin/decreasng pollution from dispersed settlements,
ERM for protection of drinking sources and conditioning drinking water,
ERM for protection of protected areas (water protected areas, nature protected areas and others),
ERM for protection underground water and stagnant water (lakes),

ERM for renewal of degraded water streams, gravel, clay pits, stone pits,
ERM for purifying and recycling water from,
ERM for purifying specific polluters (bioremediation, microremediation),
ERM for purifying contaminated soil (from lakes, industry, agriculture),
ERM for renewal of degraded landscape areas,
ERM for sanitation of dumping grounds and black dumping grounds,
ERM for reducing highway pollution,
ERM for increasing selfcleaning environment capacities (preventive and sanative),
ERM for increasing or preserving biological diversity (rare, endangered, protected species and habitats),
ERM for usage of renewed energy sources (wooden biomass for energy purposes),
ERM for managing and maintaining ERM systems (e.g. constructed wetlands)



With classification of ERM for protection of environmental components we wish to show ERM forms that are specific for protection of particular environment components:

III. Environmental ERM classification

ERM for water ecosystems:
ERM drainage ditches,
conaturally regulated water streams,
puddles, pools and buds,
conditioned water springs,
wetlands and swamps,
Littoral riverine zone and waterside area,
ecologically acceptable stream,
side branches
millraces,
bays,
pools,
meanders,
waterfalls and rapids,
dams,
thresholds,

gravel deposits,
retainers and dry retainers.

ERM for air (dust, stench, noise, wind):

boundary lines,
barriers against wind, dust and noise.

ERM for preventing erosions and landslides:

vegetation planting on erosional areas,
correct shrubbery and trees clearing,
planting riversides.

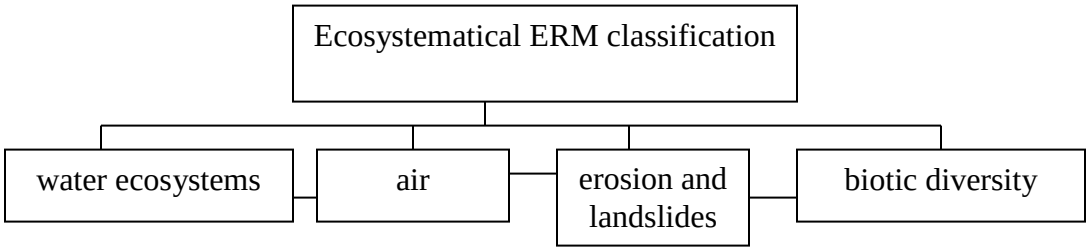
ERM for protection and renewal of land ecosystems:

vegetation zones,
constructed wetlads in combination with deposits (limnotop),
water and waterside plants,
substitution ecosystems,
ERM melioration ditches,
vegetation zones,
systems for reducing and preventing erosion.

ERM for protection of biodiversity:

boundary lines,
puddles, pools,
vegetation zone (mitigative zone),
water and waterside plants,
wetlands and swamps,
ERM as substitutional ecosystems,
constructed wetlands as multipurpose ecosystems,
conatural swamps for non points pollution.

With classifying ERM for protection of environmental components we wish to show ERM forms that are specific for protection of particular environment components:



There is an increasing need to define possible ERM in selected activities, where at the same time many environmental components need to be taken into account. Classification of ERM due to activities is:

IV. Sectorial ERM classification

ERM in agriculture:
ERM melioration ditches,
boundary lines,
ERM of water streams and stagnant water,
retaining water,
constructed wetlands for households,
constructed wetlands for agriculture,
constructed wetlands for conditioning drinking water source,
ERM for purifying soil,
vegetation zones,
wind barriers,
ERM for preservation of wetlands,
Planting resistant sorts of cultured plants,
ERM for managing entire farm for healthy living.

ERM in industry:
constructed wetlands for purifying and recycling water,
constructed wetlands for purifying soil,
ERM for integral environmental saving of factories.

ERM for tourism:
constructed wetlands for tourist farms, hotels, restaurants, autocamps,
recreation areas (golf courses, swimming pools),
stagnant waters as multipurpose area,
ERM in protected areas and parks.

ERM for health care:
planting etheric plants (aromatherapy),
planting herbs and ERM for protection of plantations,
bioproduction ,
reducing poisonous substances in food chain (melioration ditches, protection of water sources, conditioning drinking water)
bioremediations.

ERM for small settlements and individual houses:
constructed wetlands for households,
ERM landscaping,
swimming water dowsing.

ERM for cities:
ERM for green city systems,
renaturation of city water streams,
sanitation of city stagnant waters.

ERM for education and research-development activity:

- grounded learning on problems in the environment, using field and laboratory methods,
- participation of young people at environmental problems
- andragogic education,
- educating specialized users (farmers, tourist workers, nature protectors)
- diplomas, doctor's diplomas, specializations
- research-development activities (universities, faculties, research institutes),
- international projects for education and Research and Technology Development in Slovenia.

ERM for promotion on environment:

presence of media,

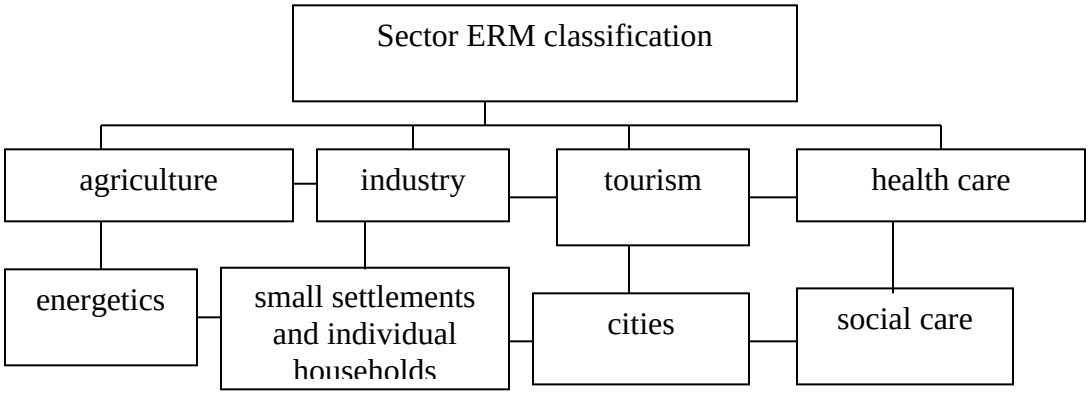
publicity,

inclusion of public into decision-making on environment.

ERM for help at employment.

ERM as economical category.

For scientific development of new ERM, cowork at applications and implementation of international and national projects is needed, as well as incorporating ERM into education and the way people live with an emphasis on practical research work at educational institutions and transfer ERM results into all spheres of society. It is urgent to develop conatural way of thinking that will directly impact social, economical and of course psychological development of Slovenia.



In Slovenia's Development Strategy (2005) it is defined that ERM is used as way of conatural landscaping. In every activity there are possibilities to introduce conatural ways of environment protection for those areas where it is necessary. Mostly in protected areas (Natura 2000) ERM is the most suitable way of activating local potentials for harmonised regional development.

6. Use of Ecoremediation in practice

ERM are more and more used as systems not only for protection and renewal of environment but also as the way of living – symbiosis of human being with nature. People recognize all the benefits of ERM as multipurpose, long duration, applicability, social views, economical views, but above all the fact that many problems that we have caused ourselves, can be solved only using ERM – ecosystematical technologies.

The most important environmental viewpoint of ERM usage is their multipurposefulness. In addition to all the listed capacities of retaining water, selfcleanig characteristics and preservation of biotic diversity there are other locally and globally important reasons. These are for example preserving waste energy value, making biomass, using CO_2, learning and educational objects and finally; only these kind of systems can be used in certain areas. Multipurposefulness is shown and can be a great help at decreasing climate changes, lack of energy and preservation of rare and endangered species. In practice all these ecosystem characteristics can be adjusted according to needs and consequences of needs.

Slovenia ha san exceptional advantage in Europe in the field of environment. Due to its specific industrial development in the past fortunately we have not polluted the environment entirely (that was the case in many industrial developed countries). Nevertheless you can feel more and more globalization impacts as well in Slovenia. There is a dilemma whether we should repeat mistakes of European countries or suggest an alternative way, which is the integral conatural development with maximal incorporation of local and regional potentials. Because of exceptionally favourable position the main wealth in Slovenia is in biotic diversity and water ecosystems that can be connected successfully with green economy.
According to resolution of Minister Janez Podobnik on 24th February 2006 ecoremediations are included in all strategic documents in Slovenia. For this purpose we have completed environmental legislative documents with the objective to incorporate ecoremediations officially as well in Slovenian regulations and to achieve required environmental objectives.
Based on 18th article of Law on Slovenian Government on 14th March 2006 the resolution of Minister Janez Podobnik on creating working group for planning ecoremediation policy in the Republic of Slovenia (annex) was passed on. With this resolution we are obliged to activate ecoremediations a well in legislation as in practice and education.
Ecosystematical approach as the base of ecoremediatios is recognized as a suitable approach to manage natural sources and environment. Traditionally measures of managing were pointed at certain usage (agriculture, energetics, tourism) with defining

regimes for every one of them. Ecosystematical managing means that flora, fauna and human society depend on each other and are connected with physical environment, which creates the ecosystem.
Sector approaches cause conflicts between users, therefore systematical approach is needed and that has already been stressed at the United Nations conference on environment and development in 1992 in Rio de Janeiro.
As an integral ecosystematical approach the concept of integral water, river basin, river mouth, sea and coastal areas management is used.
European frame water directive (EU Water Framework Directive, 2006/60 EC) has accepted the ecosystematical approach as the origin for lasting water sources usage.
Ecosystematical managing (Ecosystem – Based Management) is designed as the adaptable process that is based on learning with introducing scientific methods to processes of management (GPA, 2006).
Integral water sources management (IWMR) has got the central meaning for preparing many programmes and initiatives when the land waters became restricted factor for human activities (GPA, 2006).
Ecosystematical managing carries the motion:

FROM	TO
individual species	ecosystem
small areas	big areas
short term perspectives	long term perspectives
independence of human being from ecosystem	human being as the part of ecosystem
separation of management and research	adjustments of management
searching for benefits of ecosystem	preserving production potential

(Sheman, Duda 1999).

Theory as well as practice have shown that local population can under professional guidance build many ERM themselves and can maintain them as too. At work their knowledge can be used, but also heavily employed workers can work, especially at maintenance. Depending on sort of ERM, as well some other products can be gained, for example energents (biomass, biodiesel, etheric oils, building material etc.) or tourist sightseeing can be offered for certain places that would enrich tourist offer.
ERM are without a question important because of its long term efficiency, because environment protection and its renewal becomes the structural part of local population. With right upbringing it can be preserved for later regardless of education.

In Slovenia around 37% of area is protected under NATURA 2000 and if we count to it as well all the other protected regions like water retention area, water protected, nature protected and other areas, the percentage of Slovenias land under special conditions is near 50 %.

Especially in areas where nature protection impacts and their adjustments to the conditions are more important, ERM are usually the only way for these activities.

Protection of endangered and rare plants and animals sorts is possible only with ecosystematical technologies, because only with them we can achieve or create the environment where they will live or survive. With these technologies we can select the most suitable combination of ecological factors for every sort, group of animals or for the entire habitat, for example the repopulation of otter in Goričko region, some sorts of fish, crayfish etc.

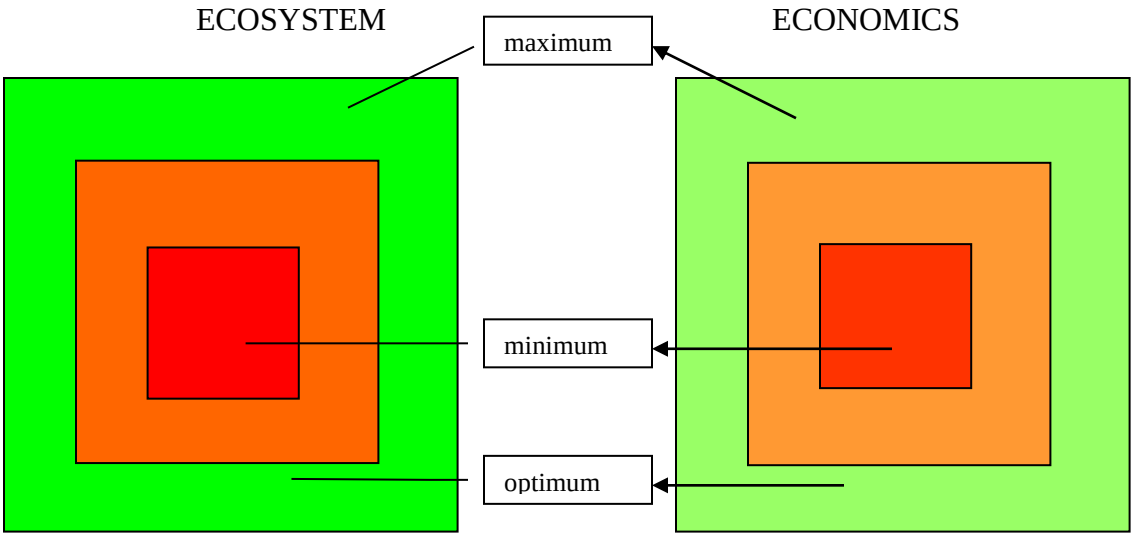
7. Education for Ecoremediation

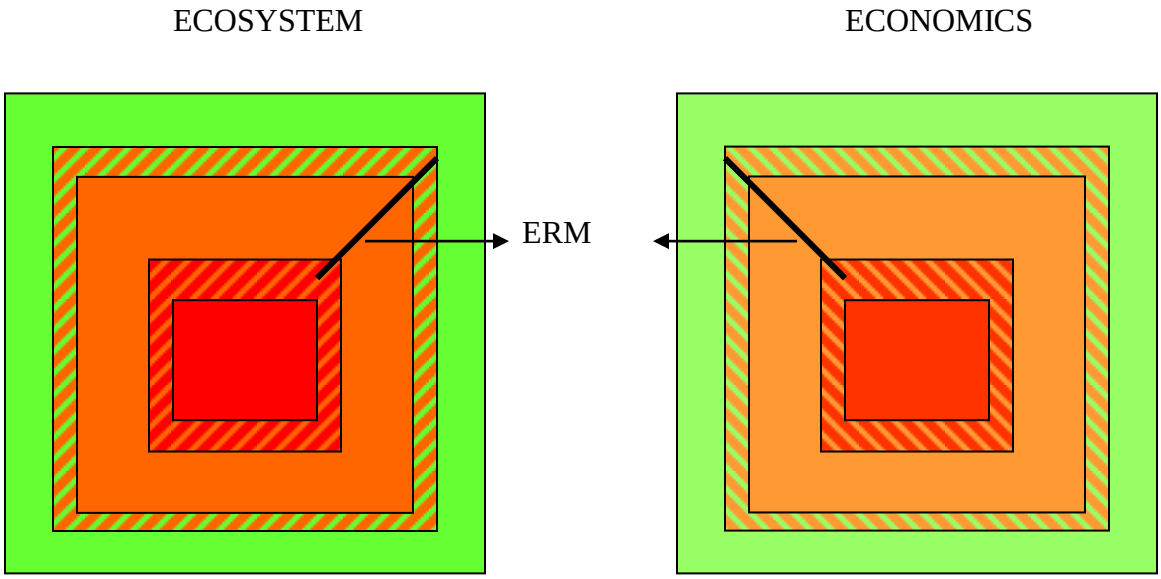
For environment protection education is essential. Knowing nature activities, its legislation and understand processes that on in the environment (natural and social) is substantial for environment preservation and protection. We wish there was no need to talk about over and over again about sanitation ways of degraded environment. But still we have some areas in Slovenia that will need to be sanitated. Science and behaviour development enable usage of conatural approaches to environment protection and as the most integral conatural approach ecoremediations are being more and more recognized. Ecoremediations are not just the conatural approach for sanitation of degrade environment, but as well the way of thinking that is based on knowing how the nature works, relation to the environment in the past and introducing new possibilities of environment protection, which enables science development.
In small municipality in Slovenia, new teaching polygons for ecoremediations and permaculture are offered. Visitors are offered the possibility to achieve something new, invited to help to sustain and preserve the nature in its beauty and learn how to do something on their own. Practical knowledge is gained through experiential work and inquiry based learning which is guided and assessed if necessary. With the variety of environmental topics that exist in the polygons, teachers can cover many of the topics from their school curricula and do not have to the lectures. Knowledge gained through practical experiences is more solid, supports learners' practical experiences and skills and is of great value for the transfer and everyday use (Vovk Korže, Kokot, Globovnik, 2011).

8. Tollerance borders of ecosystem and humanbeing

Every ecosystem has its own optimal conditions where it is in a kind of dynamic balance. Of course it has a lower and upper tolerance limit that is defined by the constitution and function of ecosystem. Every change as for natural as well as human impacts on upper or

lower tolerance limit can destroy ecological balance and ecosystem changes or is degraded in another dynamic balance or ecosystem with different structure and function.
Using ERM it is possible to mitigate the consequences that originate from the ecosystem and so to reduce the differences at tolerance limit of ecosystem as well as economical calculation of human impact.
Scheme shows tolerance limits of ecosystem as well as tolerance of economical impacts Changes at one as well as at another must range limits of orange colour (optimum).





As it is shown in scheme, the tolerance can be changed with ERM to a certain limit by not destroying ecological balance. With right measures it can also be increased, e.g.: increase water retention, selfcleaning capacity and biodiversity or protect endangered species and habitats. On the other side with these kinds of measures we can enable bigger economical usage of the one that interferes with ecosystem.

9. The need to an integral approach

On the web site of Ministry of the Environment and Spatial Planning there are many appeals about lack of water (drought) influencing social and economical sectors and threatening usage of natural water sources. Further it is put out that from the side of developmental needs it is important to reestablish policy and suitable programmes of water management aiming to assure enough water quantities for usage that includes suitable technologies for rational water usage as well as measures for loss reduction. For increased water disposability of suitable quality water, the essential importance is on protection and renewal of ecosystems like rivers, wetlands, forests and soils that using natural way of capturing, filtering, nourishing and supplying water.

The main purpose is multipurpose and conatural managing with water streams, lakes, wetlands, which contributes to symbiosis of human being and nature and mitigates natural disasters, if they happen. Because of that ecoremediations are economically, ecologically and in long term one of the most successful ways of environment protection nowadays.

We forecast that in next decades the landscape changes will increase due to the growth f population, globalization, industrialization and efforts to demolish poverty and famine. Because of that it is urgent to introduce environmental approaches with the right integration between elements already connected to each other. (Water and ecosystem managing, p. 7).

Not connecting existing knowledge as well as administrative institutions reflects in limited expectations of different expert groups and represents intellectual heritage from the times of French philosopher Descartes from the 17th century. Physics understand most of all physical phenomena, chemists chemical phenomena, biologists biological phenomena. Because the views of these different groups differ a lot, they have big problems communicating, also with policy makers, so it is hard to reach a unified understanding of dilemmas concerning human environment.

10. Conclusion

Water, food and raw material that assure the survival of human kind originate from natural environment that surrounds human settlements. These sources can not be exploited without changing the landscape (digging wells, drain water into canals, constructing reservoirs, contracting natural vegetation for cultivation of land, contracting forests for wood, drainings, levelling of ground) and these kind of changes are a disturbance for those ecosystems. Because there was need to grow more food for growing population, people used fertilizers at first, but later herbicides as well. These impacts had Harmful side effects for the environment (eutrophication, water pollution, water retainance, soil and water salting). Some of the side effects can be avoided; the others are difficult to abolish (Water and ecosystem managing, p. 6).

In the ontogenesis of ecosystems the ones have developed, which are adapted to the most unpleasant factors. In there live organisms that can not be found anywhere else. These conditions are nowadays made by men with his activities that often mean a deviation from nature.

Ecosystems have a big puffer capacity and can with natural processes retain, treat or neutralize many organic and anorganic pollutants. Ecoremediation use natural processes in natural and partly artificial ecosystems to ensure better usage of water sources, for elimination of harmful pollution impacts and preservation of biotic diversity.

Renewal of devaluated ecosystems using ecoremediations means besides more stabile natural systems as well better state of natural elements in living environment, which improves human's and other living creatures' lives. Above all they offer big educational and pedagogical possibility, which is perhaps more important than technical effect. Natural sources are already exploited and because they are limited we are obliged to protect and repair them as long as it is possible.

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