2010 International Conference on Biology, Environment and Chemistry
IPCBEE vol.1 (2011) © (2011) IACSIT Press, Singapore

ECOREMEDIATIONS – NATURAL TECHNOLOGIES FOR SUSTAINABLE CITIES

Mojca Kokot Krajnc
Faculty of Arts
University of Maribor
Maribor, Slovenia
mojca.kokot@uni-mb.si

Ana Vovk Korže
Faculty of Arts
University of Maribor
Maribor, Slovenia

Nina Globovnik
Faculty of Arts
University of Maribor
Maribor, Slovenia

***Abstract*—Today, more than half of the population lives in cities. Cities represent a synonym for quality of life, as they are a center of economic, cultural and technological development. Due to mass migration of people in the cities, they are confronted with many environmental and social problems. As a solution to these problems the concept of sustainable cities is developing, where the development is looking to balance the development factors in the environment, society and economy. The paper will address how to increase the environmental component of the city to achieve sustainable development, which is often neglected. In doing so, we believe that the city should be regarded as urban ecosystems, which have certain characteristics of natural ecosystems. To ensure this, it is a very appropriate way to use ecoremediations. Which are natural systems that operate like the nature itself, which has evolved excellent self-cleaning ability through the decade and a balance of all factors in the ecosystem is provided. With the method of analysis, we analyzed which ecoremediational technologies are most suitable for mitigation and elimination of certain environmental problems of cities to provide the role of sustainable cities.**

Keywords- sustainable city, urban environmental problems, ecorememdiation,urban ecosystem, sustainable development

I. INTRODUCTION

With the development of industry a major changes have started in the area. Natural spaces have been replaced with large built-up area, which is one of the main characteristics of cities. With industrialization a population migration to cities is also linked, where they seek better living conditions than those they had in the countryside. The result of this is a high rate of urbanization in Europe and in other parts of the world. Cities in the world occupy only 2% of the Earth's surface and almost half of the total population of the world lives in them. Europe is one of the most urbanized parts of the world, as much as 75% of the population lives in cities. Many reports of the European Union provide that that population will grow in the cities. It is anticipated that in 2020 as much as 80% of the total population of Europe will live in cities. Cities are becoming engines of progress and the driving force behind most of our cultural, intellectual, educational and technological achievements and innovations.

The reports indicate that the urban areas in Europe have expanded in scope between 1990 and 2004, which is five times larger than the territory of the wider area of London [2]. The result is that many cities are faced with many environmental and social problems: overpopulation, poor air quality, litter, crime, etc. Those problems have influence on quality of life in cities. These factors contribute to the destruction of urban and sub-urban habitats and ecosystem functions are reduced, what is the opposite of sustainable development of the city. In Sustainable cities there is a need to look for a balance between all urban components and one way is to look at the city as the urban ecosystem, which has certain characteristics of natural ecosystems, where certain balance and stability between all elements takes place [10]. In most cities today the size and scope of energy and material inputs is too high. These inputs cannot be built into the natural cycle, that causes pollution and with that urban life is losing its quality.

II. ENVITOMENTAL PROBLEMS OF CITIES IN EUROPE

Cities are complex spatial phenomena and heavily modified anthropogenic ecosystem with additional energy inputs. In the economic and social terms, cities are centers of economic and cultural development and therefore they represent for the majority of people a better quality of life. Excessive migration to cities rise substantially nonequilibrium energy flows, which increases the amount of waste, resulting in a number of environmental problems faced by many cities. The most common environmental problems, many cities have [2]:

- high demand for land because of growing population,
- the spread of land development on the edge of the cities and this is losing forests and fields,
- increased energy consumption,
- increase in greenhouse gas emissions,

- the creation of large amounts of waste and waste water,
- pollution of natural resources (mainly air, water and soil),
- reduced and slowed flow of groundwater,
- problems with noise,
- deterioration of the old sites,
- decline of industrial areas in the city and
- a large carbon footprint.

Environmental problems are increasing in many cities by the scope and diversity, thereby also the energy inputs are increasing, but also they are increasingly less built into biological part of the ecosystem, such as sinks. Thus, the flow of energy is becoming more and more one way to waste at the end and reality of that, there are a number of pollutions.

In the past, the burning issue of European cities was in particular, air pollution, which was due to massive use of fossil fuels. In recent years of research, all emissions were reduced; in particular the quantities of SO_2, which was decreased from 1990 to 2007 by 69% as a result of closing some factories and the focus on the use of other energy sources. Nevertheless, air pollution remains a major problem of many European cities, as the amount of particulate matter and ozone showed no improvement between 1990 and 2007. It is also apparent in recent years of slow decline in NOx, which is a result of increased motorization of Europe, since about 36% of all NOx emissions in air is contributed by traffic, which increases from year to year and causes an increased amount of particulate matter in air. Noxious particles are essentially particulate matter and the ozone. According to the European Environment Agency from 1997 about 50% of Europe's urban population is exposed to concentrations of particles that exceed the EU limit. With 61% of urban population is expected to be exposed to ozone values are higher than the EU target values. Most air pollution in Europe has the Benelux countries, northern Italy, Poland and Hungary. While the Finns and Irish have the cleanest air [5].

The big problem in cities is also a noise that is unwanted and harmful outdoor sound. Noise in the natural and living environment is increasing. The level of noise in the area is often directly dependent on population density, which is not really surprising because we know that in Europe more than 75% of the population lives in cities. It is estimated that the noise increases proportionally with increasing urbanization and faster than population growth, as the number of noise sources is increasing faster than the population increases. The negative impact in the city has road, rail and air traffic noise. It is legally permissible daytime noise level of 55 dB and 45 dB at night. World Health Organization estimates that approximately 40% of the population in the EU is exposed to road noise levels which is higher than of 55dB, and that more than 30% of the population is exposed to night-time rates in which of 45 dB. This noise endangers human health. Noise also affects wildlife species. Animals are therefore often migrating from their popular feeding and breeding areas [1].

Some cities are faced with contaminated soil, but this is not a major problem, a major problem of soil in Europe is a use of land due to increasing urbanization. The soil in cities is mainly polluted by heavy metals. Concentrations of heavy metals (Cd, Zn, Pb, Cr, Ni, Hg, Cu) in soils are high in areas where heavy industry once operated. This soil is unsuitable for food processing and other activities. A major problem of soil pollution level is also a great loss of natural soil - the soil, such as open spaces, where they could process the food for the growing population. Namely, because of the increasing urban population, demand for new housing is increased, which results in numerous works of residential and commercial properties. Recent analysis shows that more than 800 000 additional hectares of natural production of land were converted into artificial surfaces for homes, offices, shops, factories and roads, which represent six percent more of urban areas on the continent between 1990 and 2000 [11]. With construction soil is completely demoted and all the functions that are important for living things are broken. Soil and plants growing on it, absorb about 20% of global CO_2 emissions and also help to consolidate the water we drink and the air we breathe, and all this for free. From one hectare of land for up to five tons of animals can survive. Healthy soil reduces the risk of flooding and with counteracting or filtering of potential pollutants protects groundwater supplies [9].

Sixth Environment Action Programme of EAP Thematic Strategy on the urban environment requires a high quality of life, where the level of pollution will not affect on human health and the environment and it will promote sustainability areas [12]. One of the ways is that the cities begin to be regarded as ecosystems - urban ecosystems. Urban ecosystems are marked with different energy flows. In addition to solar energy, in urban ecosystems intake of energy from fossil fuels has greatly increased, which cannot be integrated into biological energy cycle, which increases the unpredictability and fragility. Therefore, the development of urban ecosystem is based on the requirement to maintain ecosystem stability and balance between the individual elements. This can be achieved primarily by increasing the environmental development of cities and to adapt economic and social development. In the vision of the increase in urban environmental development in cities, prof. Jacqueline McGlade, said: “Instead of deterioration of ecosystems, why not start making them? [2]”. A highly effective system how to achieve this is the use of sustainable green technologies, which are known under the word ecoremediations. With this, we will also achieve long-term sustainable development of the entire city.

III. Sustainable cities from Environmental view

As we have seen, the cities both in Europe and in the world face many environmental problems that illustrate the opposite of sustainability in cities. They are supposed to follow sustainable development both in the economic, social and environmental issues and they should ensure a healthy environment to live. The first milestone in the sustainable development of cities can be called Aalborg document, which some European countries signed in 1994 in the Danish

city of Aalborg. The main objective of this document is to develop cities by the principles of urban sustainability. According to the Brundtland Commission is "Sustainable Development is the development that meets the needs of present generations without compromising the ability of future generations to meet their needs " [13].

The basic objective of sustainable development is therefore to exploit the earth's goods to the extent that we actually need and would comply with the non-regenerative resources rationally and economically, so the next generations will be able to use them. For cities, this idea represents an approach in urban areas which contributed to the high quality of life and social well-being of citizens by providing an environment in which the level of contamination does not adversely affect human health.

In the view of the sustainability of cities in the Aalborg document, first targets for economically handling of natural resources in urban areas have been set, as well as maximize conservation of natural quality capital of cities, which include climate, soil, water and forests [11], which represent a healthy life in the city, while providing a balanced ecosystems which constitute safety in the cities against natural disasters and a number of diseases.

The development of sustainable cities is to be held in a steady growth in the representation of all three main factors, namely the sustainability of economy, ecology and society. These three factors are strongly linked to development of the city and are interacting with each other, so it is important to ensure a balance between all.

Five groups of guidelines for ensuring sustainability in cities have been developed in 1995 by Witting and others [15]:

- Natural materials such as soil, water and air is necessary to protect, as the basis for life;
- Reduce energy consumption to a minimum;
- Ensure of internal circulation of energy and thus to increase recycling and reduce of consumption of new raw materials;
- It is necessary to preserve nature in the city and revitalize the natural areas to increase the percentage of nature, which carries natural ecosystem services;
- Increase the habitat of fauna and flora, thereby increasing the biodiversity.

In our contribution we will focus primarily on environmental development, which is neglected in most cities, which already reflected the impact on social development. Many environmental problems caused by the neglect of environmental development in urban areas, are causing unhealthy living environment and a number of diseases with humans. These factors are currently most affect poorer parts of the population who lack the resources for the solutions [15].

One way of increasing the environmental development and thus the sustainability of the urban is the ecosystem understanding of the city. The city is anthropogenic ecosystem, which has substantially different energy flows as a natural ecosystem. In the urban ecosystem, we must seek a balance between all elements of urban life, as well as between all inputs and outputs. The essence of sustainable cities by this approach is its ability to transfer the changes occurring in the environment. Here we provide a direct link, interdependence and create a new balance between its a-biotic and biotic factors, material energy flow, energy flow and its transformation at different trophic levels [10].

Increase of environmental development in the cities can be achieved by the insertion of natural elements in the city, which the functions of natural ecosystems are taken into account. Entering the natural elements in urban ecosystems has been recently increasing, since the function may identify a particular character of the nature [6]. The primary function is generally still to provide a nice look; on the other hand they are functionally less beneficial to the mitigation of urban interventions. With functional integration of nature we will achieve greater self-cleaning ability of the system and thus alleviate the individual environmental problems or even eliminate some of them, because of this it is necessary to take into account functionality. Recently, showing that for this is the appropriate green technology, known collectively as ecoremediations [3].

IV. ECOREMEDIATIONS FOR SUSTAINABLE CITIES

One way of achieving the sustainability of cities in terms of ecology, is regarding to the ecosystem services provided by natural ecosystems. This is primarily solving environmental problems in cities, as well as increases the quality of life.

This can be achieved by new ways and one of these is the use of green technology called ecoremediations (ERM). This broad concept of understanding of natural systems has been established in Slovenia under the support of the Ministry of Environment and Spatial Planning [3]. ERM mimic natural ecosystems that have developed over millennia special features for cleaning and maintaining stability. The development of science has enabled us that we can accurately examine the natural processes and can now be directly used as a sustainable method to protect and restore the environment. ERM are natural systems that take into account the characteristics of interaction of nature and have a high buffering capacity, efficient self-cleaning ability, have increased biodiversity and they retain water. With these new green technologies the urban ecosystem can come close to a natural compositionally-energy circuit. This affects the ideas of sustainability in cities and higher quality of life in them [14].

Ecoremeditional measures for preventing environmental problems in urban areas, which can increase the ecosystem function of urban ecosystems and their impact on improving life in the city, may be exposed to various ERM measures that prevent specific environmental problems, while enhancing the habitats for diverse plant and animal species. Ecoremediations by itself increase the biodiversity of the area and affect the greater stability and balance of the entire urban system, which is one of the main goals of sustainable development in cities.

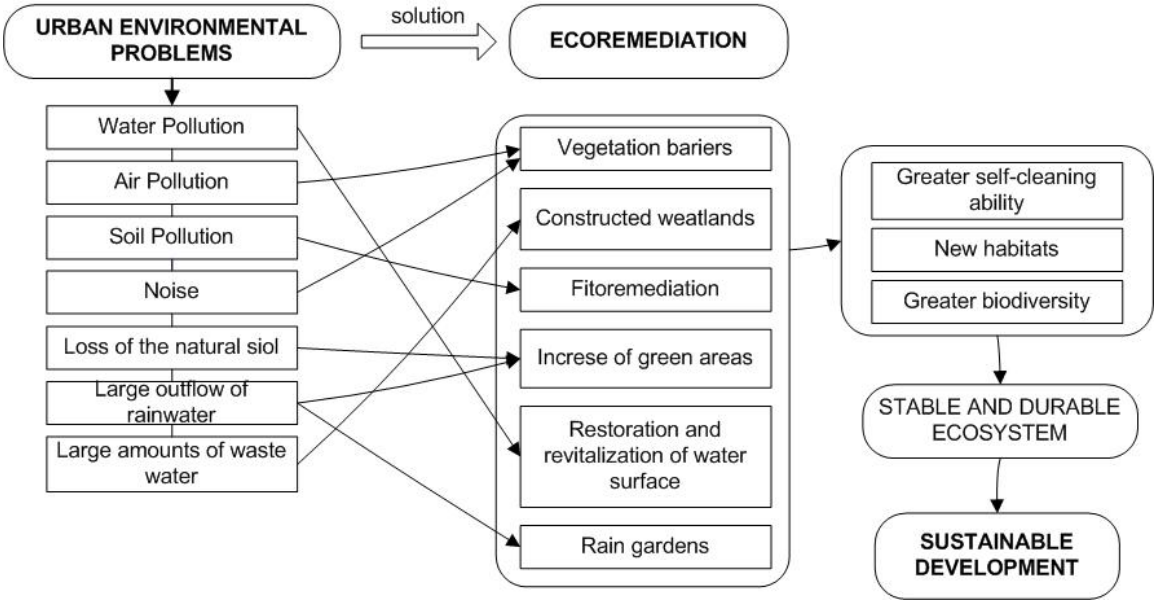

Figure 1. Ecoremediation technologies for the sustainable

V. ECOREMEDIATION TEHNOLOGIES IN THE CITY

With the method of analysis of individual ERM technologies, we found, that in the cities next ERM technologies would be most appropriate.

Revitalization and rehabilitation of running and standing water in the city is reached by plants and with the restoration of the channel, which has all characteristics of the natural channels, and it restore or maintain the structure and function of the aquatic and waterside biotope. The self-cleaning capacity of the stream increases and ensures the sustainable management of the watercourse [7, 14].

Fitoremediations are natural systems that with use of plants clean the soil. They remove pesticides, fertilizers, heavy metals, solvents, oils, explosives from soil. The method is cheap and effective. Product of fitoremediations is biomass, which can be used for different purposes [7, 14].

Constructed wetlands (Figure 2) for waste water from paved surfaces are usually located along the roads and clean the water from the asphalt surfaces. The storm water run-off from the asphalt surface accumulates a bunch of the toxic residues, which are then washed by the rain in sewage and this water is not clean. Wetland replication works as a self-cleaning process in natural wetland ecosystems. With the constructed wetlands we can reach the cleaning of the water flows, which are a flow in groundwater. It consists of the concrete bed, fitted with nets, partition, filter cartridges, tubes and large intermediate space for soli and for plants. Except for the occasional empty baskets, intercepting large pieces of dirty, no maintenance is required. At the small rain water enters through the net in the first partition and is slowly filtered and cleaned by the soil and roots. When there is too much water, water from the first chamber is discharged by two overflow pipes into the outlet works, also equipped with filters. All pipes are perforated, so the water is always filtered through the ground. Cleaning ability is exceptional. Soil in the sink and plant roots with microorganisms are able to filter the water and eliminate pathogenic faecal organisms, nitrogen, phosphorus, copper, lead, zinc and convert them into a harmless form and they also break down chlorinated pesticides and heavy metals [3, 4, 14].

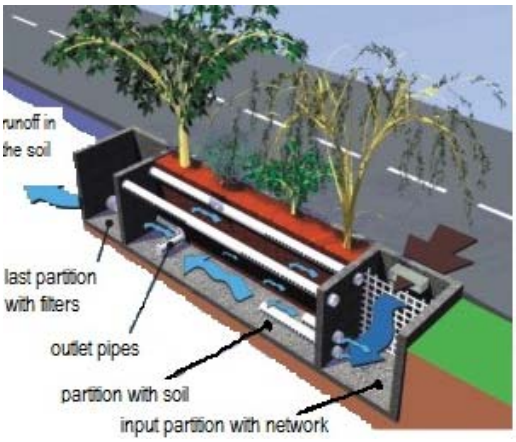

Figure 2. Profil of constructed wetland by road, Simon Tihec

Plant rain gardens are installed in low-lying areas by house, commercial areas, in the middle of parking spaces. In this rain gardens gravel and plants are used, which filter the water, when it runs off through them. So much purified water sinks into the groundwater. Soil absorbs the filtered rain for the fauna and flora. This helps to reduce the pollution of rainwater and increase the water in groundwater by preventing rapid runoff of water from the asphalt surfaces [8, 14].

Green areas in the city have to be increased. These areas through evapotranspiration and shading under the crown

lower the high summer temperatures and increase the humidity. In addition, trees with large leaf surface keep dust and gases, so they clean the air. Also they protect environment against strong winds and dampen noise. Green areas in urban environment strengthen the resilience of flood, drought, and promote healthy biological processes in the behavior of organisms. Due to large-scale green areas in the city the diversity of fauna and flora increases. This diversity affects on the health of the soil and on the absorption capacity of flood water and water filtration. Trees also have an impact on the reducing of carbon dioxide in the air and they reduce the amount of the greenhouse gases in the atmosphere [16].

Because of these effects is essential the integration of the ERM technologies for the pleasant stay in the city. With the use of the ERM technologies, city reduces its carbon footprint, which has a positive effect on climate issues to the local, regional and global space.

The most important benefits of ERM for the sustainable development of cities are: a lot of green spaces in the city can reduce energy costs, it reduces the effect of urban climate and it reduces the need for water. Through these activities we contribute to maintaining and increasing the variety of the habitats in urban areas and allow greater stability in urban ecosystems and less potential for natural disasters. The advantage of these technologies is that they are easy to use and their construction and maintenance are affordable.

VI. CONCLUSION

ERM technologies offer a great potential for achieving the sustainable cities, primarily because of mitigating the environmental problems of cities and even eliminating some of them. The operations of ERM contribute a greater stability and resilience of the entire ecosystem, which ensures high quality of life and safety in the cities. ERM technologies not only affect on social and environmental components of sustainable development, but also on economic component, because their operation is inexpensive. From this perspective are ERM technologies proven for sustainability and appropriate to ensure the sustainable cities.

REFERENCES

[1] About noise, http://www.eea.europa.eu/themes/noise/about-noise.

[2] From urban spaces to urban ecosystems, http://www.eea.europa.eu/signals/articles/urban.

[3] Griesseler Bulc,T., Sajn Slak, A.(2009). Ecorememdiation – a new concept in multifunctional ecosystem tehnologies for environmental protection, Desalination, Vol. 246, 1 – 3, p. 2-10.

[4] Higgins, N.: An analysis of a constructed weatland for treating road runoff in Ireland, http://www.engineersireland.ie/media/engineersireland/community/whitepapers/AN%20ANALYSIS%20OF%20A%20CONSTRUCTED%20WETLAND%20FOR%20TREATING%20ROAD%20RUNOFF%20IN%20IRELAND.pdf.

[5] Indicators, http://www.eea.europa.eu/themes/air/indicators#c7=all&c5=all&c10=&c13=20.

[6] Jones, N. (2008). Approaches to Urban Forestry in the United Kingdom, Ecology, Planing and Management of Urban Forests, Springer.

[7] Kokot, M., Vovk Korže, A., Globovnik, N., (2010). Development of protected areas because of biodiversity with ecoremediations, ICEST 2010, Research publishing.

[8] Rain gardens, http://www.uri.edu/ce/healthylandscapes/raingarden.htm.

[9] Soil — The forgotten resource, http://www.eea.europa.eu/signals/articles/soil.

[10] Špes, M. 2009. A town as an ecosystem. Dela, letnik št. 31, str. 5 - 20.

[11] The European Environment-status and possibilities 2005, http://www.eea.europa.eu/sl/publications/state_of_environment_report_2005_1/SL-summary.pdf.

[12] Vovk Korže, A. (2008). Sustainable Development with Ecoremediations, Ecoremediations - a means to achieve Environmental Goals and Sustainable Development in Slovenia , Katar, Ljubljana, str. 17 – 33.

[13] Vovk Korže, A. (2008). Wiev on the indicators – finger for measures of sistainable development, Dela, št. 29, str. 103 - 118.

[14] Wittig, R. (2008). Principles for Guiding Eco-city Development, Ecology, Planing and Management of Urban Forests, Springer, p. 24 – 29.

[15] Vrhovšek, D., Vovk Korže, A. (2009). Ekoremediations. Faculty of Arts, ERM, University of Maribor, Limnos, Maribor.

[16] Zitković, M., (2008): Managing green space for urban biodiversity, http://www.countdown2010.net/2010/wp-content/uploads/FS7Greenspace_small.PDF.