PROPOSED PROJECT FOR THE BIOLOGICAL PURIFICATION OF WASTEWATER USING PLANT SPECIES

PROIECT PROPUS PENTRU PURIFICAREA BIOLOGICĂ A APELOR UZATE PRIN INTERMEDIUL PLANTELOR

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Abstract. *The establishment of artificial wetlands is an ecological alternative to the conventional water treatment systems and reduces the anthropogenic impact on the environment. In this context a project consisting in a succession of cells filled with gravel and planted with different vegetal species having a purifying role is proposed for the Suceava's University campus. Beside water cleaning, the artificial wetland has many other functions: increasing biodiversity, recreational, esthetical, and educational.*
Key words: wastewaters, biological purification, biodiversity

Rezumat. *Una dintre soluţiile care se pot adopta pentru diminuarea impactului antropic asupra mediului este aceea de epurare a apelor uzate prin crearea de zone umede artificiale. În acest context se propune un proiect de amenajare a unor celule (bazine) plantate cu diferite specii vegetale cu rolul de a epura apele uzate provenite din viitorul campus Moara al Universităţii „Ştefan cel Mare", Suceava; se evidenţiază multifuncţionalitatea proiectului care are şi valenţe estetice, recreative, de ameliorare a biodiversităţii şi educative.*
Cuvinte cheie: ape uzate, purificare biologică, biodiversitate

INTRODUCTION

Nowadays, the anthropogenic pressure is more and more powerful and one of the fundamental demands of sustainable development is to diminish this pressure. The creation of artificial wetlands is one of the ways to succeed in this attempt, solution that is already used in certain countries around the world [1, 3, 7].

There are two types of artificial wetlands: with open flow using water ponds and canals, very similar to the natural wetlands, or artificial cells with subsurface flow. In both cases hydrophilic or aquatic plants are planted; these plants are enhancing the removal of pollutants from the wastewater by consuming a part of them as nutrients (especially the nitrogen and the phosphorus), but metals also, which are adsorbed and deposited in their biomass [2, 4]. In the same time, the plants pump air into their root system and so creating conditions for maintaining populations of aerobic bacteria which are decomposing organic substances from the wastewater.

Starting with this idea, the creation of a multifunctional green zone is proposed for the purification of the wastewaters resulting from the Moara campus of the „Ştefan cel Mare" University of Suceava.

MATERIAL AND METHODS

The solution adopted for the proposed project is the one comprising artificial cells with subsurface flow which are planted with a variety of carefully chosen plants for cleaning the wastewaters from the university campus. In the same time the plants must be able of living in these water-saturated conditions.

The project realisation **consists in** the succession of following phases:

- the execution of the three different cells by mechanical soil excavation to the maximum depth of 2,5 meters
- the water insulation of the cells with geomembranes or clay to prevent the contamination of soil or phreatic layer by the polluted water
- the implantation of porous pipes system which ensure the adduction and circulation of sewage water from a cell to another
- filling the cells with different sorts of gravel, placing the roughest elements on the base
- planting the different chosen species with their own soil or in perforated pots; right after planting the plants must be provided with the necessary water flow. The water reaches the three types purifying cells after passing through a usual septic tank.
- the last phase consist in the disposal of a control box in order to allow the monitoring of the water level

The criteria for the selection of the species planted in the cells were their ecological demands; consequently, due to their purifying qualities, for the type 1 cells, hygrophytes, hydrophytes and mesohygrophytes species were chosen. In the same time, for the type 2 cells, mesophytes, mesohygrophytes and hygrophytes species were chosen for their purifying capacity but also for their aesthetic values. In the 3 type cells, trees and bushes are planted to accomplish the purification process by evapotranspiration.

RESULTS AND DISCUSSIONS

The Moara university campus capacity will be of about 2500 resident equivalent units (meaning persons living in the campus 24 hours per day). It have been taken into account that for every resident equivalent unit results 150 l wastewater a day which requires for purification an artificial wet zone of 2,5 square meters; thus, for purifying the full amount of wastewater, a total area of 6000 m^2 artificial wetland was projected, considering some periods like holidays or exam sessions while the campus attendance is diminished. The depurative surface is formed of the three types of cells already mentioned placed as follows: in centre the type 1 cell, surrounded by the type 2 cell and peripherical the type 3 cell (figure 1). The wastewater is conducted in summer from the septic tank towards the type 1 cell then goes over the type 2 and 3 cells (figure 1); beyond the growing season when the plants can't carry on their filtrating capacity, the wastewaters are oriented along an alternative way, through a green house (one of the several green houses belonging to the university botanical garden) placed near the purifying wet zone (figure 1). Among other species in this green house the Nil salad (*Pistia stratiotes* L) and water hyacinth (*Eichornia crassipes* Mart. Solms.) are grew for their extraordinary capacity to filtrate polluted waters [2].

The hygrophytes, hydrophytes and mesohygrophytes species which can be planted in type 1 cell are: *Alchemilla vulgaris* L., *Calamagrostis pseudophragmites* (Haller fil.), *Caltha palustris* L., *Comarum palustre* L. *Epilobium hirsutum* L., *Epilobium parviflorum* Schreber, *Equisetum fluviatile* L., *Equisetum palustre* L., *Equisetum telmateia* Ehrh., *Filipendula ulmaria* (L.) Maxim, *Hippuris vulgaris* L., *Lathyrus pratensis* L., *Lychnis flos-cuculi* L., *Lycopus europaeus* L., *Lysimachia nummularia* L., *Lysimachia vulgaris* L., *Lythrum salicaria* L., *Mentha aquatica* L., *Mentha longifolia* (L.) Hudson, *Pedicularis palustris* L., *Phragmites australis* (Cav.) Steudel, *Polygonum bistorta* L., *Polygonum hydropiper* L., *Polygonum lapathifolium* L., *Potentilla anserina* L., *Ranunculus repens* L., *Ranunculus sardous* Crantz, *Ranunculus sceleratus* L., *Saponaria officinalis* L., *Stellaria palustris* Retz., *Thelypteris palustris* Schott, *Typha angustifolia* L., *Typha latifolia* L., *Typha minima* Funck in Hoppe, *Veronica anagallis-aquatica* L., *Veronica beccabunga* L.

These species will be placed in the compartments of the purifying cell (figure 1) according to the taxonomic classification, for educational purposes, every species being provided with an informative panel. The access to the compartments of this cell is ensured trough 2 meters width wood walking alleys (figure 1). The total area of this cell will be 20% of the 6000 m^2 - the extent of the entire aggregate. The depth of the type 1 cell will be 1,20 m.

The type 2 cell can be planted with the following mesophytes, mesohygrophytes and hygrophytes species: *Acorus calamus* L., *Agrostis stolonifera* L., *Arundo donax* L., *Bolboschoenus maritimus* (L.) Palla, *Briza media* L., *Calla palustris* L., *Calystegia sepium* (L.) R.Br., *Carex acutiformis* Ehrh., *Carex hirta* L., *Carex riparia* Curtis, *Carex tomentosa* L., *Carex vulpina* L., *Cirsium oleraceum* (L.) Scop., *Deschampsia cespitosa* (L.) Beauv., *Eleocharis palustris* (L.) Roemer et Schultes, *Eriophorum latifolium* Hoppe, *Geranium palustre* L., *Geranium pratense* L., *Glyceria maxima* (Hartmen) Holmberg., *Glyceria notata* Chevall.; *Hemerocallis lilioasphodelus* L., *Heracleum sphondylium* L., *Inula helenium* L., *Iris pseudacorus* L., *Iris sibirica* L., *Juncus effusus* L., *Juncus inflexus* L., *Menyanthes trifoliata* L., *Myosotis scorpioides* L., *Petasites hybridus* (L.) P. Gaertner, B. Meyer et Scherb., *Poa palustris* L., *Scirpus sylvaticus* L., *Solanum dulcamara* L., *Stachys palustris* L., *Telekia speciosa* (Schreber) Baumg., *Trollius europaeus* L., *Valeriana officinalis* Kreyer. These vegetal species will be disposed according to the romantic landscape style. The type 2 cells area will represent about 50% of the total area and their depth will be 1,70 m.

The type 3 cells will be set with trees and bushes for accomplishing the purifying process by returning in the air the water vapours; there are chosen species with very intense evapotranspiration process like: *Salix alba* L., *Salix fragilis* L., *Salix purpurea* L. , *Salix viminalis* L., *Alnus glutinosa* (L.) Gaertner., *Alnus incana* (L.) Moench., *Tamarix ramosissima* Ledeb., *Corylus avellana* L., *Frangula alnus* Miller, *Myricaria germanica* (L.) Desv., *Padus avium* Miller, *Ribes nigrum* L. The total area of this type cell will reach about 30% and the depth of 2-2,5m.

If the wastewater volume exceeds the filtrating capacity of the three cell types and is not entirely consumed by them, the water excess will be conducted to a forth type cell represented by an artificial pond where hydrophilic species will be planted to fulfil the same purifying role as the other plant species of the complex. The following species can be used: *Alisma plantago-aquatica* L., *Butomus umbelatus* L., *Ceratophyllum submersum* L., *Elodea canadensis* Michx., *Hydrocharis morsus-ranae* L., *Nuphar lutea* (L.) Sm., *Nymphaea alba* L., *Nymphoides peltata* (S.G.Gmelin), *Polygonum amphibium* L., *Potamogeton natans* L., *Ranunculus aquatilis* Schrank; *Ranunculus trichophyllus* Chaix; *Sagittaria sagittifolia* L.; *Stratiotes aloides* L., *Utricularia vulgaris* L.

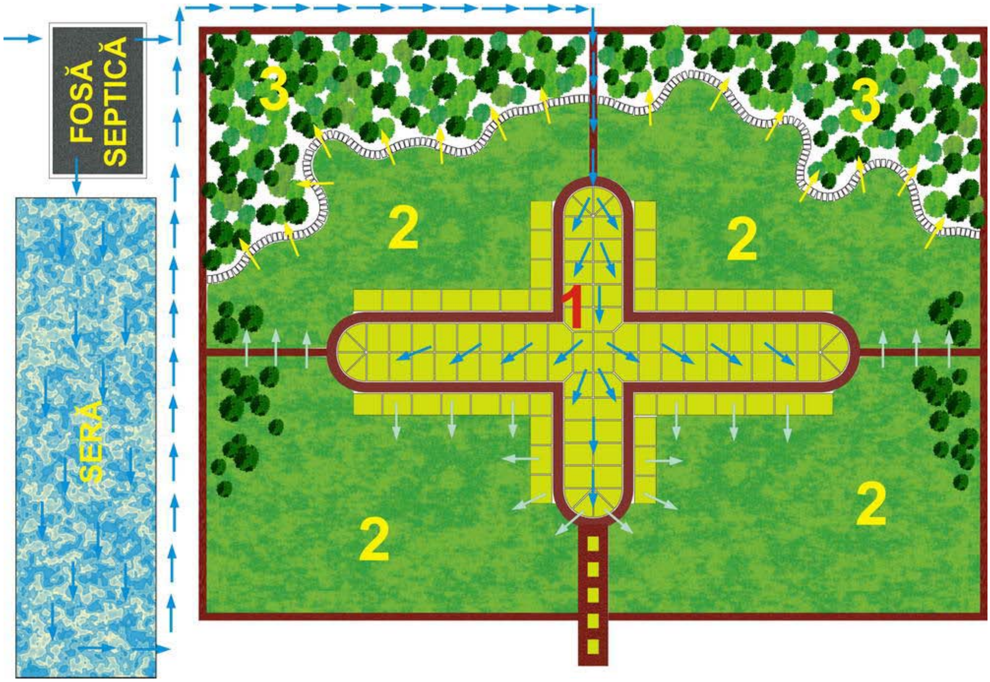
The water lies in the septic tank for 2 - 2,5 days and then for about 4-4,5 days in each purifying cell type [5]. The alternative adopted with subsurface flow avoids the bad odour and the mosquitoes.

In time, numerous animal species (insects, amphibians, reptiles, micromammals) will naturally colonise the artificially created cells, finding appropriate food and shelter conditions. Gradually, humid ecosystems will form, characterised by a high biodiversity, useful in the same time for the educational process.

This kind of artificial wetlands using natural processes and phenomenon for water purification have a lot of advantages comparing with the conventional sewage treatment facilities: efficiency, important economical advantages, not need sophisticated technology and use no machine or chemicals, no electricity consumption, easy maintenance, odourless and beautiful to look and be around, last longer (3-4 time longer than normal wastewater treatment systems), the trees and bushes biomass can be used (compost, osier etc.), increase biodiversity, useful in educational process.

Regarding the filtration efficiency, this vegetal complex reduces with 90-95% the CBO_5, with 90-95% the solid suspensions, with 40-80% the total nitrogen, with 30-60% phosphorous and with more than 98% harmful bacteria [6].

An important amount of money is saved because the investment’s initial cost is up to 50% lower [6], and the operational and maintenance costs are only 5-10% comparing with a normal wastewater treatment system. The maintenance stuff is formed only by the gardeners, the same ones in charge with the botanical garden and the other green areas of the university campus.



Legend:
1 – Cell with purifying vegetation
2 – Cell with purifying and ornamental vegetation
3 – Cell with trees and shrubs with a role in completing the cleaning process

Fig. 1. The filtrating cells location and the wastewater circuit routing

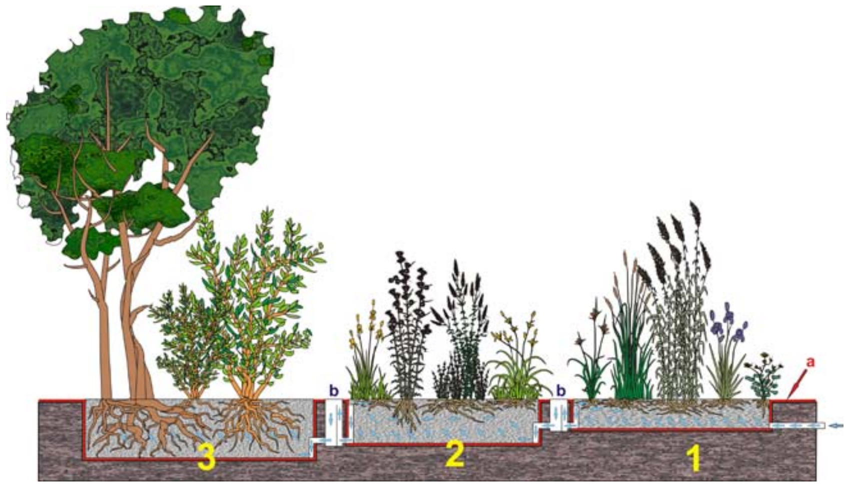


Fig. 2. Cross section through the three type cells for wastewater purification (a – hydro isolation, b – control box for the cell's water level)

The maintenance consist in the periodical checking of water level in the control boxes, the gravel changing or cleansing (after 15-20 years if it porosity diminishes) and comprises too the biannual analysis of the water in different points of the water circuit (exit of septic tank, exit type 1 cell, exit type 2 cell).

This built ecosystem with high biodiversity will be a part of the botanical garden open to the public and useful for the university students in the same time. With a minimum of effort and investment, educational routes can be designed with visual signs along, each of them illustrating various aspects of the newly created ecosystems.

CONCLUSIONS

The proposed project represents an ecological alternative to the conventional wastewater treatment systems and it is a new solution never used in this form until now in our country. So, the sewage waters from the University "Stefan cel Mare" campus reach first the septic tank, after which it is fed into several filtrating cells (ground holes) filled with a diverse range of plants with a gravel base. The plants maintain a population of aerobic bacteria and take up and transform the wastewater.

The design work consisted in planning the proper elements for the specific local conditions: the purifying cell location, the wastewater circuit routing, the filling material, the location and species selection, the alleys design, the insurance of water purification beyond growing season, for assigning the optimum performance and minimum cost functions to this artificially multipurpose created wetlands.

The multiples advantages of the project speak for it self and recommend the multiplication of this ecological solution in other locations too, for public institutions, residential districts, singular habitations, towns or villages.

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