Green Walls as an Approach in Grey Water Treatment

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Abstract. Grey water contributes significantly to waste water parameters such as biochemical oxygen demand (BOD), chemical oxygen demand (COD), total suspended solids (TSS), total phosphorus (Ptotal), total nitrogen (Ntotal), ammonium, boron, metals, salts, surfactants, synthetic chemicals, oils and greases, xenobiotic substances and microorganisms. Concentration of these pollutants and the water quality highlights the importance of treatment process in grey water systems. Treatment technologies operating under low energy and maintenance are usually preferred, since they are more cost effective for users. Treatment technologies based on natural processes represent an example of such technology including vegetated wall. Main aim of this paper is to introduce the proposal of vegetated wall managing grey water and brief characteristic of proposed system. Is expected that prepared experiment will establish the purifying ability and the potential of green wall application as an efficient treatment technology.

1. Introduction
Grey water as a type of in-building waste water is nowadays recognized as a substantial alternative source of water. The requirements for functional and safe reuse of grey water, stems in quantity and quality of water, both directly dependent on user behaviour. According to different usage habits, grey water contributes wide range of pollution concentration, therefore in accordance to environmental aspects and user health, it is necessary to ensure appropriate treatment before further utilization. The treatment technologies must be well designed to handle variations in pollution concentration contained in grey water and to produce effluent of an appropriate, safe quality water [1]. Numbers of treatment technologies have been developed, ranging from simple, low-cost devices that supply grey water directly for application, to highly complex and costly advanced treatment processes incorporating sedimentation tanks, bioreactors, filters, pumps and disinfections units [2,3]. However, system operating under low energy and maintenance are usually preferred [4], since they are more cost effective for user. Treatment technologies based on natural processes represent an example of such technology. This technology could be considered as an environmentally acceptable ecological treatment, which could be affordable with low capital and maintenance requirements and contribute to sustainability [5]. Green walls also known as living walls are considered as a self-sustaining vertical gardens, with significant potential to manage water. Some of the green walls are currently watered with recycled grey water however vegetated walls used as a treatment technology could be considered as a new topic. Vegetated walls can use blank spaces of building walls and facades and except to visual aspect, undertake the function of waste water treatment plant technology. Therefore, it is proposed to develop an efficient and sustainable system reusing grey water based on constructed wetland principles as an approach in grey water management.
2. Vegetated "green" wall design
The proposed system will operate as a bio filtration system and will provide treatment mostly through physical (straining, sedimentation) and biological (plant and microbial assimilation, other microbial processes) processes as water percolates vertically down through the filter media. It is expected that the upper layers will be less saturated and experience more aerobic conditions as the bottom layers according to gravity flow of water in wall. Important in design of grey water managing wall is also to realize some of critical aspects influencing the system function as plant selection, hydraulic retention time of filter media, periodicity of grey water inflow (user habits) and influent pollutant concentration. However primary was necessary to connect the vision of constructed wetland and vegetated wall merging and determine the principles and processes in wall.

2.1. Constructed wetland into green wall
As mentioned before, the vegetated walls can undertake the constructed wetland treatment ability, and transform it onto smaller area, however with comparable treatment efficiency. For design of the wall have been purposed the vertical flow system of constructed wetland. In these systems is wastewater fed on the whole surface area through a distribution system and passes the filter media in mostly vertical path [6]. The dosing of wastewater is performed intermittently, therefore the filter media goes through saturated and unsaturated phases, along with different phases of aerobic and anaerobic conditions. The filter media acts as a filter for removing solids, a fixed surface upon which bacteria can attach and a base for the vegetation. The top layer is planted and the vegetation is allowed to develop deep, wide roots, which permeate the filter media. The vegetation transfers a small amount of oxygen to the root zone so that aerobic bacteria can colonize the area and degrade organics. However, the primary role of vegetation is to maintain permeability in the filter and provide habitat for microorganisms. Nutrients and organic material are absorbed and degraded by the dense microbial populations. By forcing the organisms into a starvation phase between dosing phases, excessive biomass growth can be decreased and porosity increased [7]. According to previous researches, more than 90% removal of BOD5, COD and TSS can be achieved with vertical flow wetlands. As the constructed wetlands age, the rate of organic removal increases. Total nitrogen and phosphorus removal in constructed wetland systems can be as high as 98–99%, respectively [8].

2.2. Constructed wetland into green wall
First idea of vegetated wall treating grey water was based on "do it yourself approach", hence the design of the wall consisted of simple plastic bottles serving as a plant pots, attached to wood pallets, Figure 1.

![Figure 1. 1st Idea of wall construction based on “do it yourself approach”](image-url)
The vertical flow of grey water in bottles is ensured with interconnection of each bottle, therefore each one serve as a small wetland with identical layers layout. It is expected that this model will help exploring a novel module of vegetated wall treating grey water.

2.3. Plant selection

Nowadays a range of plants is used for vegetated walls, however there is difference between plants selection for aesthetical purpose, or for waste water treatment. Important is to select plant tolerate for water-logged conditions but also a high nutrient environment and elevated salinity [9]. Current selection included 4evergreen species (Table 1).

| Figure | Name | Basics |
|---|---|---|
| | Cotoneaster dammeri | • fast growing evergreen low shrub  
• height 40-50 cm  
• average, dry or moisture soil |
| | Blechnum spicant | • deer fern/ hard fern and evergreen  
• height 50 cm  
• average or moist soil |
| | Carex oshimensis | • evergreen arching grassy foliage  
• height 15-20 cm  
• average or moist soil |
| | Ophiopogon planiscapus | • evergreen perennials forming clumps  
• height 20-30 cm  
• permeable and moist soil |

2.4. Filter media

Filter media commonly used in centralised wastewater (CW) are sands and gravels but the adsorption capacity of these materials can vary greatly or diminish in long term [10]. In the scope of modular vegetated walls is usually as a growing media used lightweight substrate with granular material in order to improve water retention [11]. In accordance to selected plant’s needs, the filter media compound was selected from 3 layers: gravel at the bottom, coarse sand and washed sand mixed with sawdust assuming the role of carbon source. Important issue is to determine the hydraulic retention time of selected plants and filter media, therefore can be established the approximate time necessary for grey water to pass through all layers. The hydraulic retention time will be determined according to purposed experiment in laboratory conditions.

2.5. Pollutant concentration

The vegetated wall will be tested in laboratories conditions, where real samples of grey water will be used. Grey water will be discharged from installed devices mostly consisting from sinks, shower and washing machine. This enable to test different variations of pollution rate, hence determine the purification ability of both light and dark grey water.

3. Conclusions

Main aim of this paper was to introduce the proposal of vegetated wall managing grey water and brief characteristic of proposed system. Is expected that prepared experiment will establish
the purifying ability of selected plants and filter media, therefore the potential of this application in real conditions.

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