Hospital wastewater refinement using Vetiver plant in tropical regions

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Abstract—Refined wastewater is used for irrigating crops and green space plants. The natural purification method comparing with the other methods is a suitable one, with the help of wetlands having low cost, easy navigation, low technology required and low power consumption. Vetiver is a leading plant in order to refine such wastewater which has unique morphological, physiological, and genetic properties. The purpose of this study was a comparison between hospital wastewater refinement by using Vetiver and typical reed in tropical regions. this study was empirically conducted in outdoor pilot place of Sabzevar university of medical sciences in the warm season of the year (Summer) in 1391. In this study a glass pilot with dimensions of 100*50*60 was made. A mixture of sand, gravel and clay was selected as the soil. In this study subsurface and continuous system were used as irrigation methods. At first, hospital wastewater was stored in a 220 liter tank with a retention time of 4 days to settle, and then entered the pilot through the tank outlet valve with Debbie rate of 0.85 liter per hour. In order to evaluate the efficiency of the plant in hospital wastewater refinement, chemical parameters such as BOD5, TSS, TN, TP and pH were measured based on standards in this method. According to the findings in this study, the removal rate of DOD5, TSS, TN and TP parameters by Vetiver were 88.54, 95.71, 93.93, and 99.80 percent, respectively. According to the unique properties of Vetiver, including its high resistance to adverse environmental conditions and also its optimal efficiency, this plant is recommended to hospital wastewater refinement.

Keywords: hospital wastewater; Vetiver plant; wastewater refinement

I. INTRODUCTION

The consumption of water in different sections of a community leads to the production of wastewater, that its collection and refinement is essential for maintaining people’s health. [1] Wastewater refinement is very important around the world and also costs a lot in different cities and countries, so choosing an appropriate technology considering the climate, economic, and social conditions is a significant issue. [2] From a general view, wastewater is divided into two major groups- municipal and industrial, and the industrial wastewater is more significant due to numerous complexities of quantitative and qualitative characteristics. Hospital wastewater is included in industrial wastewater which due to having various toxic and hazardous substances such as chlorinated organic compounds, heavy metals, cytotoxic compounds, radioactive elements, various detergents and chemical solvents, etc., is of particular significance. [3] Nowadays, the wastewater resulting from the refinement is accounted as a valuable resource of water that could be used for multiple uses (1). There is currently a wide range of natural and mechanical systems for wastewater refinement, each of which having certain advantages and disadvantages. Major problems in mechanical systems that can be pointed to include the high construction cost, high energy...
consumption, the need for efficiency, and sludge refinement and disposal. [4] Experts are therefore particularly interested in considering achieving the appropriate, low-cost methods such as natural refinement [5].

The natural refinement method with wetland, in addition to the low-cost, easy navigation low technology required and also low energy consumption is an appropriate method in comparison to the other refinement methods which is a great help to improve the environment (2). Wetlands are filled with sand to certain uniformity coefficient, and then are covered with various plant species. The vegetation is due to supplying oxygen to the bed, accumulation of microorganisms on the roots, absorption of nutrients from the wastewater and helping to remove suspended solids, [6] thus choosing the suitable plant in bed helps a lot in increasing the system efficiency. One of the plants which is considered by experts in refinement, is Vetiver. This plant due to its special ecological and morphological properties has high tolerance towards climate change, long-term drought, flood, temperature stresses between -14 to 55 degrees centigrade, pH tolerance between 3.3 to 12.5, high resistance to heavy metals, pesticides, etc. [7,8] Another unique property of this plant is long, highly branched and bulky roots that can penetrate into the depth of 2-4 meters in the soil which protects water and soil (8) and since in wetland method, the root of the plant plays the main role in wastewater refinement so according to the root and stem characteristics of Vetiver, it can be widely applied in wastewater refinement. In the study of Kanokporn Bonsong et al. in a research titling refinement of domestic wastewater using Vetiver cultivation technique in floating beds, the removal efficiency of BOD5, TN and TP from domestic wastewater with high concentration by Vetiver floating cultivation system was reported 90.5-91.5, 61-62.5 and 17.8-35.9 percent, respectively [9]. In the study of Hadi Poordar et al, on using the hospital refined wastewater in the green space irrigation by using activated sludge with extended aeration the removal amount of COD, BOD5, suspended solids and Mpn was reported 83.7, 86.4, 78.6, and 99.5, respectively [10]. Also in the study of Rezaee et al under the name of hospital wastewater refinement by aerobic and anaerobic bioreactors, the constant reduction rate of BOD and COD is expressed from 270 to 30, and from 450 to 80 mgr, respectively [11].

Thus, considering the fact that no significant research is yet done on hospital wastewater refinement especially by natural methods, this study was conducted with the purpose of comparing the efficiency of Vetiver and reed in wetland system for hospital.

II. METHODS AND MATERIALS

This study was empirically conducted in outdoor pilot place of Sabzevar university of Medical Sciences in the warm season of the year (Summer) in 1391. The aim was evaluation of hospital wastewater refinement by using Vetiver in tropical regions. The pilot used: in this study a glass pilot with the dimensions of 100*50*60 was made ( figure 1) and due to an increase in accuracy and creating natural conditions, the pilot was exposed to the fresh air, and the reason for choosing the glass pilot was observation of root and stem length during the exploitation. The soil used for the plant growth was a combination of sand (60%), gravel (20%) and clay (20%). An outlet valve was placed at the height of 5 meters from the bottom of the tank and some coarse rubble was dumped on it to avoid clogging.

The method of cultivating the plant: According to the previous studies the proper temperature for planting is 25 degrees centigrade, so the cultivation according to the temperature in the region was done in Spring [12]. In order to a better growth of plants in the bed we used Vetiver buds from the species Vetiveria Zizanioides (It was because the lack of fertility, and therefore is not considered as a weed). The buds were planted at a distance of 25 cm apart from one another, from the soil surface layer. The first irrigation was done by using the municipal wastewater so that the plant gets used to the wastewater conditions. The irrigation method in this study was in the form of sub-surface and continuous system. The prepared wastewater from Mobini Hospital first was stored in a 220-liter tank with a retention time of 4 days to settle, and then entered the pilot through the tank outlet valve with Debbie rate of 0.85 litre per hour.

In order to evaluate the efficiency of this plant in hospital wastewater refinement parameters such as BOD%, TSS, TN, TP and pH was measured based on the standards in the method.

Composite sampling was conducted during 4-hour intervals, from the pilot inputs and outputs.
III. RESULTS

According to conducted experiments on non-refined wastewater incoming to pilot, the characteristics for the non-refined wastewater are as follow:

Table 1- Different parameter values for non-refined wastewater incoming to pilot.

<table>
<thead>
<tr>
<th>Mean</th>
<th>Parameter</th>
</tr>
</thead>
<tbody>
<tr>
<td>mg/l 1090.9</td>
<td>BOD5</td>
</tr>
<tr>
<td>mg/l 610</td>
<td>TSS</td>
</tr>
<tr>
<td>mg/l 5.056</td>
<td>TP</td>
</tr>
<tr>
<td>mg/l 135.478</td>
<td>TN</td>
</tr>
<tr>
<td>6.89</td>
<td>pH</td>
</tr>
</tbody>
</table>

Remove percentage changes of BOD5, TN, TSS and TP by Vetiver is shown on diagrams 1, 2, 3 and 4.

Diagram 1- Comparison of the removal percentage for BOD5 Vetiver pilot

Diagram 2- The comparison for removal percentage of Vetiver pilot TN

Diagram 3- The comparison for removal percentage of Vetiver pilot TSS

Diagram 4 – The comparison of removal percentage of Vetiver pilot TP

Figure 2 shows a good growth for Vetiver. In this figure the plant has many green leaves. According to conducted experiments the average changes of pH in outlet wastewater from pilot were 7.09.
IV. DISCUSSION AND CONCLUSION

Results from this study suggested that the removal efficiency of BOD5 by the plant increases during the time, and this increase in removal efficiency was very significant from the very first week in Vetiver pilot (first week: 42.70% and the twelfth week was 88.54%). In the study of Barakati et al the removal efficiency is also reported higher than the one in reed (8). Some reasons for the higher efficiency in Vetiver pilot rather than reed pilot can be the faster growth and bulky roots in Vetiver which results in a better accumulation of microorganisms and also a better BOD5 removed, as well as numerous leaves in Vetiver rather than reed leads to better and more oxygen transport to roots and stems which has an influence on BOD5 removal.

Nitrogen removal in wetlands is due to microbial activities for nitrification and denitrification and also the plant absorption. The TN removal percentage (diagram 2) is showing Vetiver strength in removing this parameter (Vetiver 94%) and the high efficiency of Vetiver according to figure 1 can be having the green color and the plant absorption, as this plant is of C4 species (Herbaceous plants) and so has the highest photosynthetic efficiency. [13]

TSS removal through a full physical method is conducted by media and roots [14] so we can consider that the reason for the high efficiency in Vetiver is the media genus and the type of aggregation in pilot (diagram3) and the type of root in Vetiver that has a bulky system in roots with thin structures, very fast growth rate and high penetration in deep soil [15]. Also according to the depth of the pilot the root of the plant was not able to penetrate more, so there was a very strong pilot with the root mass in the bottom part of the pilot and this also caused a high efficiency in Vetiver. In the study of Barakati et al the removal percent for Vetiver has been reported 96.5% (8).

Based on the obtained results the amount for TP removal in outlet wastewater from Vetiver pilot was 99.8% (diagram 4). Since the phosphorus removal is conducted based on surface absorption and chemical precipitation processes the reason for the high efficiency in Vetiver could be because of the quality and the type of materials in bed of the pilot and also the unique characteristic of this plant in high efficiency in absorbing the solvent nutrients such as phosphorus (15) in spite of the using of clay as one of the media substances in pilots also results in an increase in phosphorus absorption [16]. According to the results from this results and also considering the particular characteristics of Vetiver, the application of Vetiver system (VS) for wastewater refinement is a new plant-refining technology which has a great potential. VS can also be considered as an economic, natural-green and applicable solution. Also given that Vetiver is able to grow in various climates including dry climates, it can be a proper plant to establish green spaces in these regions, since mature Vetiver has very beautiful light purple flowers (15). Through this way, by using this system in hospital wastewater refinement, we can provide the increase of green spaces in these regions. The unique morphological, physiological, economic and genetic characteristics of this plant, highlights the significance of introducing, recognizing and using this plant more and more inside the country (Iran). Of course the wetland methods with subsurface flows can face problems, in case of lack of the proper commissioning and exploitation, like other methods. In order to avoid these problems on commissioning we must consider cases such as temperature, wastewater composition, moisture content of the bed, and on exploitation side, we must consider cases such as pre-refining, overloading, reaping the wetlands, and purifying the sewer wastewater and obstruction of the pores (12).

Generally, according to the findings of this study, Vetiver has a high efficiency, and using this system in order to municipal and industrial wastewater refinement is recommended.

CONFLICT OF INTEREST: there were no conflict of interest expressed by the authors.

V. REFERENCES


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