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Waste Water Treatment by Phytoremediation Technique

Abstract

The waste water treatment techniques such as Activated sludge process, Adsorption/bio-oxidation process, Advanced oxidation process, Aerated lagoon, Aerobic granular reactor, Aerobic granular sludge technology and Phytoremediation, are practised in different industries worldwide. In this study Phytoremediation method is applied to study the waste water quality parameters removal efficiency of different plants for treating waste water. The main objective of the study is to find the efficiency of removal of different waste water quality parameters from the synthetic waste water generated in the laboratory by different plants such as Hyacinth, Vetiver, Pharagmites austrilus, and Canna Indica. The waste water quality parameters such as Total hardness, Biological oxygen demand, Dissolved oxygen, Total dissolved solids, Lead, Zinc and Copper are taken in the synthetic waste water samples preparation. After experimental studies using Phytoremediation models, the results arrived are as follows: (1) Hyacinth removal efficiency from Total hardness synthetic solution is 69.28% and from total dissolved solids (TDS) synthetic solution is 3.35% and also it is observed that the Dissolved oxygen(DO) and Biological oxygen demand(BOD) reduction from synthetic solutions prepared . (2) Canna Indica removal efficiency from TDS synthetic solution is 2.63% and also it is observed that the DO and BOD demand reduction from synthetic solutions prepared. (3) Vetiver removal efficiency from TDS synthetic solution is 74.92% and also it is observed that the DO and BOD reduction from synthetic solutions prepared. Vetiver removal efficiency from Zinc, Lead and Copper synthetic solutions are 14.43%, 47.61% and 32.07% respectively. Phragmites austrilus removal efficiency from Zinc, Lead and Copper synthetic solutions are 10.67%, 19.07%, and 23.27% respectively. Since the retention time is less in this study it has come less removal efficiency for different plants. It is observed that the phytoremediation technique is very economical and may be implemented to many industries.

Keywords: Phytoremediation, Hyacinth, Vetiver, Pharagmites austrilus and Canna Indica plants

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1. Introduction

Pollution of soil and water by the waste water disposal from different industries is causing major threat to human and animal life. Waste water treatment before disposal is the only remedy for this problem. The treatment of waste water rich in nutrients and other toxic chemicals has mainly been done using conventional waste water treatment systems such as Activated sludge process, Adsorption/bio-oxidation process, Advanced oxidation process, Aerated lagoon, Aerobic granular reactor and Aerobic granular sludge technology. These technologies are very expensive and dependent on electrical energy and skilled personnel [1]. Phytoremediation is one of the biological wastewater treatment methods [2] used for treating waste water. This technique is feasible and sustainable for removal of pollutants from industrial waste water [3].

Phytoremediation technique is applied in constructed wet land system using the Vetiver plant for treating waste water in many developed countries [4]. Vetiver grass is a perennial grass with deep root system with unique morphological characteristics and has high biomass production. It has the ability to resist adverse environmental condition, absorbs and tolerates extreme levels of nutrients [5]. The Vetiver grass is also used for heavy metal removal from contaminated water from industry [6].

The work dealt with the removal of heavy metals from secondary treated waste water using aquatic plants such as Typha latifolia and Pharagmites australus [7]. Water Hyacinth, confined in barriers so that it only covers 10% of the pond, and regularly harvested, can remove sufficient nutrients to avoid excessive phytoplankton growth.[Ref 8]. The pollution of crude oil contaminated water has been a major problem in oil producing communities the use of Hyacinth plant fount to be more effective in removing crude oil in the water bodies [9]. The bucket reactor based wetland systems were adopted for the treatment of pulp and paper mill waste water using Typha angustifolia and Canna Indica [10].

In residential houses grey water started playing its major role due to the increasing population and instead of allowing the grey water in to the drainage as a waste, it can be recycled naturally by using roots of Canna Indica [11]. The main objective of the study is to find the efficiency of removal of different waste water quality parameters from the synthetic waste water generated in the laboratory by different plants such as Hyacinth, Vetiver, Pharagmites austrilus, and Canna Indica. The waste water quality parameters such as Total hardness, Biological oxygen demand, Dissolved oxygen, Total dissolved solids, Lead, Zinc and Copper are taken in the synthetic waste water samples preparation.

2. Materials and Methods

Hyacinth, Vetiver, Phragamites austrilus and Canna Indica plants are taken for the phytoremediation experiment to treat synthetic waste water. In this study, two methods of treatment are tried. The plants such as Hyacinth and Vetiver are allowed to float in the waste water and the plants such as Phyragmites austrilus and Canna Indica are allowed to treat the waste water applied to soil directly. Hyacinth and Phyragmites austrilus plants are collected from Navule Lake in Shivmoga. The Vetiver plants are collected from nursery (B.H. Road Shivomga). The Canna Indica plants were collected from JNNCE College campus itself. The synthetic waste water samples are prepared to represent as industrial waste water and treated using phytoremediation technique.

2.1 Phytoremediation Model Preparations

a. Hyacinth and Vetiver Model

The container of 10 liters capacity is taken with 6 liters of water and the plants Hyacinth and Vetiver allowed to grow for 2 weeks to sustain its growth. After 2 weeks the plants are allowed to grow in synthetic waste water sample for different trials of testing.

b. Phragmites Austrilus and Canna Indica

The container of 10 liters capacity is taken with drainage facility by filling the base with gravel size 10-20 mm up to 8 cm height. The thick sand was filled in the next layer to a height of 6 cm and soil bed 8 cm. The tap water was poured into the containers so that the water column was 5 cm above the soil bed and plants were watered daily and allowed to grow for 2 weeks for sustaining the growth. After 2 weeks the plants are grown in synthetic waste water samples for different trials of testing.

2.2 Preparation of synthetic solutions

The synthetic samples are chosen based on the industrial waste water characteristics such as the industrial waste water may contain Lead, Zinc, Copper, Total hardness, Total dissolved solids (TDS), Biological oxygen demand (BOD), and Dissolved oxygen (DO). The TDS synthetic solution is prepared by mixing two grams of NaCl with two litres of distilled water and stirred thoroughly. The TDS synthetic sample is tested before and after the process of Phytoremediation. The BOD and DO synthetic solutions are prepared by putting vegetable peelings, waste from sinks, fruit peelings, and torn leaves in to the water in the beaker and left for three days. The plant models are allowed to grow in the prepared synthetic samples. The samples from the plant models are collected after particular retention time from the outlet of the models and filtered using the strainer and taken for testing. Similarly, the Lead, Zinc and Copper Synthetic solutions are prepared by dissolving lead acetate, zinc sulphate and copper sulphate salt with six litres of distilled water separately each. The methodology flow chart for the Phytoremediation process carried out in this study is as shown in fig.3.

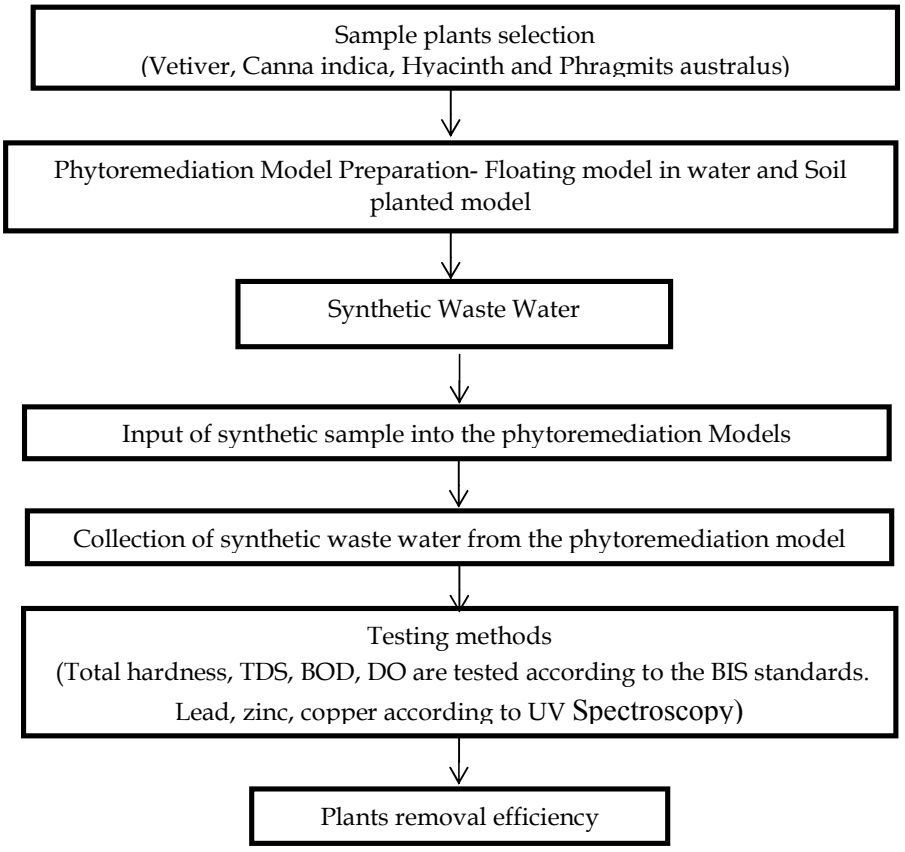

Figure 3: Methodology flow chart for Phytoremediation

3. Sample Collection and Testing Method

The waste water samples are collected from outlet of the phytoremediation models after the allowed retention time using the sample bottles of 1 litre capacity. The sample bottles are properly cleaned before collecting the samples based on the sample collection methods (IS 3025-1 (1987)). Testing of samples are done based on, referring IS 3025-49 (1994) for Zinc, IS 3025-44 (1993) for BOD, IS 3025- 38 (1989) for DO and IS 3025 -21 (2009) for Total hardness, IS 3025 -16 (1984) for TDS, IS 3025-42 (1992) for Copper and IS 3025-47 (1994) for Lead.

4. Results and Discussion

After the arrival of test results, removal efficiency of different plants is analyzed. The analysis of Hyacinth plant for removal of Total hardness, DO, BOD and TDS are as shown in Table 1, Table 2, Table 3 and Table 4 respectively. The analysis of Canna Indica plant for removal of DO, BOD and TDS results are as shown in Table 5, Table 6 and Table 7 respectively. The analysis of Vetiver plant for removal of DO, BOD, TDS, Zinc, Copper and Lead are as shown in Table 8, Table 9, Table 10, Table 11, Table 12 and Table 13 respectively. The analysis of Pharagmites australus plant for removal of Zinc, Copper and Lead are as shown in Table 14, Table 15, Table 16 respectively.

Table 1: Removal efficiency of Hyacinth Plant for Total hardness

Sl. No.	Plant	Retention time	Initial Total hardness in mg/l	Final Total hardness in mg/l	Reduction in Total hardness mg/l	Removal efficiency %
1	Hyacinth	1 day	94	26	68	72.34
2		2 day	94	26	68	72.34
3		3 day	94	25	69	73.40
4		4 day	94	24	70	74.46
5		5 day	94	22	72	76.59
6		6 day	94	22	72	76.59

Table 2: Removal efficiency of Hyacinth Plant for DO

Sl. No	Plant	Retention time	Initial DO in mg/l	Final DO in mg/l	Reduction in DO mg/l	Removal efficiency %
1	Hyacinth	1 day	8.287	5.328	2.959	35.71
2		2 day	8.287	5.299	2.988	36.05
3		3 day	8.287	5.285	3.002	36.22
4		4 day	8.287	5.180	3.107	37.49
5		5 day	8.287	5.101	3.186	38.44
6		6 day	8.287	5.100	3.187	38.45

Table 3: Removal efficiency of Hyacinth Plant for BOD

Sl. No	Plant	Retention time	Initial BOD in mg/l	Final BOD in mg/l	Reduction in BOD mg/l	Removal efficiency %
1	Hyacinth	1 day	2.486	1.701	0.785	31.41
2		2 day	2.486	1.692	0.794	31.93
3		3 day	2.486	1.678	0.808	32.50
4		4 day	2.486	1.652	0.834	33.54
5		5 day	2.486	1.621	0.865	34.79
6		6 day	2.486	1.615	0.871	35.04

Table 4: Removal efficiency of Hyacinth Plant for TDS

Sl. No	Plant	Retention time	Initial TDS in mg/l	Final TDS in mg/l	Reduction in TDS mg/l	Removal efficiency %
1	Hyacinth	1 day	1463.20	1419.80	43.40	2.96
2		2 day	1463.20	1419.80	43.40	2.96
3		3 day	1463.20	1407.40	55.80	3.81
4		4 day	1463.20	1410.00	53.20	3.63
5		5 day	1463.20	1413.60	49.60	3.38
6		6 day	1463.20	1413.50	49.70	3.39

Table 5: Removal efficiency of Canna Indica Plant for DO

Sl. No	Plant	Retention time	Initial DO in mg/l	Final DO in mg/l	Reduction in DO mg/l	Removal efficiency %
1	Canna Indica	1 day	15.130	4.862	10.268	67.86
2		2 day	15.130	4.653	10.477	69.24
3		3 day	15.130	4.512	10.618	70.17
4		4 day	15.130	4.323	10.807	71.42
5		5 day	15.130	3.925	11.205	74.05
6		6 day	15.130	3.725	11.405	75.38

Table 6: Removal efficiency of Canna Indica Plant for BOD

Sl. No	Plant	Retention time	Initial BOD in mg/l	Final BOD in mg/l	Reduction in BOD mg/l	Removal efficiency %
1	Canna Indica	1 day	6.808	1.952	6.856	71.33
2		2 day	6.808	1.654	5.154	75.70
3		3 day	6.808	1.325	5.483	80.53
4		4 day	6.808	1.285	5.523	81.13
5		5 day	6.808	1.213	5.595	82.18
6		6 day	6.808	1.035	5.773	84.79

Table 7: Removal efficiency of Canna Indica Plant for TDS

Sl. No	Plant	Retention time	Initial TDS in Mg/l	Final TDS in Mg/l	Reduction in TDS mg/l	Removal efficiency %
1	Canna Indica	1 day	1463.20	1438.40	24.80	1.69
2		2 day	1463.20	1432.20	31.00	2.11
3		3 day	1463.20	1426.00	37.20	2.54
4		4 day	1463.20	1419.80	43.40	2.96
5		5 day	1463.20	1415.60	47.60	3.25
6		6 day	1463.20	1415.60	47.60	3.25

Table 8: Removal efficiency of Vetiver Plant for DO

Sl. No	Plant	Retention time	Initial DO in mg/l	Final DO in mg/l	Reduction in DO mg/l	Removal efficiency %
1	Vetiver plant	1 day	7.538	1.613	5.925	78.60
2		2 day	7.538	1.595	5.943	78.84
3		3 day	7.538	1.548	5.990	79.46
4		4 day	7.538	1.535	6.003	79.63
5		5 day	7.538	1.532	6.006	79.67
6		6 day	7.538	1.528	6.01	79.72

Table 9: Removal efficiency of Vetiver Plant for BOD

Sl. No	Plant	Retention time	Initial BOD mg/l	Final BOD mg/l	Reduction in BOD mg/l	Removal efficiency %
1	Vetiver plant	1 day	2.261	0.510	1.751	77.44
2		2 day	2.261	0.501	1.760	77.84
3		3 day	2.261	0.495	1.766	78.10
4		4 day	2.261	0.489	1.772	78.37
5		5 day	2.261	0.477	1.784	78.90
6		6 day	2.261	0.474	1.784	79.03

Table 10: Removal efficiency of Vetiver Plant for TDS

Sl. No	Plant	Retention time	Initial TDS in mg/l	Final TDS in mg/l	Reduction in TDS mg/l	Removal efficiency %
1	Vetiver plant	1 day	1463.20	368.60	1094.60	74.80
2		2 day	1463.20	367.80	1095.40	74.86
3		3 day	1463.20	367.00	1096.20	74.91
4		4 day	1463.20	366.80	1096.40	74.93
5		5 day	1463.20	365.60	1097.60	75.01
6		6 day	1463.20	365.40	1097.80	75.02

Table 11: Removal efficiency of Vetiver Plant for Zinc

Sl. No	Plant	Retention time	Initial zinc mg/l	Final zinc mg/l	Reduction in zinc mg/l	Removal efficiency %
1	Vetiver plant -2	1 day	0.97	0.91	0.06	6.18
2		3 day	0.97	0.84	0.13	13.40
3		5 day	0.97	0.83	0.14	14.43
4		7 day	0.97	0.83	0.14	14.43

Table 12: Removal efficiency of Vetiver Plant for Copper

Sl. No	Plant	Retention time	Initial copper mg/l	Final copper mg/l	Reduction in copper mg/l	Removal efficiency %
1	Vetiver plant	1 day	1.59	1.39	0.20	12.57
2		3 day	1.59	1.21	0.38	23.89
3		5 day	1.59	1.09	0.5	31.44
4		7 day	1.59	1.08	0.51	32.07

Table 13: Removal efficiency of Vetiver Plant for Lead

Sl. No	Plant	Retention time	Initial lead mg/l	Final lead mg/l	Reduction in lead mg/l	Removal efficiency %
1	Vetiver plant	1 day	0.63	0.49	0.14	22.22
2		3 day	0.63	0.41	0.22	34.92
3		5 day	0.63	0.34	0.29	46.03
4		7 day	0.63	0.33	0.30	47.61

Table 14: Removal efficiency of Pharagmites Australus Plant for Zinc

Sl. No	Plant	Retention time	Initial zinc mg/l	Final zinc mg/l	Reduction in zinc mg/l	Removal efficiency %
1	Phragmites Australus-1	1 day	0.97	0.96	0.01	4.08
2		3 day	0.97	0.91	0.06	6.18
3		5 day	0.97	0.88	0.09	9.27
4		7 day	0.97	0.87	0.1	10.67

Table 15: Removal efficiency of Pharagmites Australus Plant for Copper

Sl. No	Plant	Retention time	Initial copper mg/l	Final copper mg/l	Reduction in copper mg/l	Removal efficiency %
1	Phragmites Australus	1 day	1.59	1.38	0.21	13.20
2		3 day	1.59	1.33	0.26	16.35
3		5 day	1.59	1.25	0.34	21.38
4		7 day	1.59	1.22	0.37	23.27

Table 16: Removal efficiency of Pharagmites Australus Plant for Lead

Sl. No	Plant	Retention time	Initial lead mg/l	Final lead mg/l	Reduction in lead mg/l	Removal efficiency %
1	Phragmites Australus	1 day	0.63	0.57	0.06	9.52
2		3 day	0.63	0.55	0.08	12.69
3		5 day	0.63	0.52	0.11	17.46
4		7 day	0.63	0.51	0.12	19.04

The synthetic waste water samples which are prepared to represent the waste water quality parameters such as Total hardness, Biological oxygen demand, Dissolved oxygen, Total dissolved solids, Lead, Zinc and Copper and tested for removal efficiency of different plants. The results of comparison are as shown in Table 17 and Table 18. From the prepared Phytoremediation models it was observed that the BOD and DO concentration from synthetic solution has reduced due to the plants uptake of oxygen and also due to the micro organisms which are residing on the plant roots. The concentration of TDS, Total hardness, Lead, Zinc and Copper are reduced in the synthetic solution that it may be accumulated in the plant root zone and in the steam (G. Bhaskar, and V.T. Deeptha 2009).

Table 17: Removal efficiency of different plants for Total hardness, DO, BOD and TDS

Plant	Total hardness	DO	BOD	TDS
Hyacinth	69.28	37.06	33.70	3.35
Canna indica	-	71.35	79.27	2.63
Vetivera	-	79.72	79.03	74.92

Table 18: Removal efficiency of different plants for Zinc, Lead and Copper

Plant	Zinc	Lead	Copper
Vetivera	14.43	47.61	32.07
Phragmites australus	10.67	19.04	23.27

5. Conclusion

Based on the Phytoremediation technique applied to many plants, it was found that it may be the cost-effective method when compared with other conventional methods. The plants can be easily monitored but initial implementation of the process may take long time such as the growth of the plants and uptake of pollutants. Also, this method may require large surface area for implementation. It was found that the removal efficiency of Canna Indica plant is greater when compared with Hyacinth plant for DO and BOD. The removal efficiency of Hyacinth plant is good for Total hardness removal from the synthetic sample. The removal efficiency of Vetiver plant is very good for DO, BOD and TDS removal. Also, the removal efficiency of Vetiver plant is more when compared with Phragmites austrilus plant for Lead. If the Phytoremediation study may be taken for many months then it may show the good removal efficiency. The plants such as Hyacinth, Vetiver, Phragmites austrilus and Canna Indica may be recommended to treat the waste

water disposed from Dairy industry, Bewerage industry, Slaughter industry, Textile industry, Fertilizer industry and Dying industry.

References

1. Dhanya, G and Jaya, D. S (2013) "Pollutant removal in waste water by vetiver grass in constructed wetland system "Department of environmental science, University of kerala, Kariavattom Campus, Thiruvanthapuram , International Journal of Engineering research and Technology, ISSN:2278-0181,vol2, issue 12.
2. Ajibade F.O. Adeniran K.A., Egbuna C.K., (2013) "Phytoremediation Efficiencies of Water Hyacinth in Removing Heavy Metlas in Domestic Sewage (A Case study of University of Ilorin, Nigeria), and Science. Vol 2, issue12, pg.16-27.
3. K. Sri Lakshmi, V. Hema Sailaja, (2017) "Phytoremediation a promising technique in waste water treatment". International journal of scientific research and management vol 5. Issue 6, pg5480-5489.
4. Technical and Regulatory guidance document for constructed treatment wetlands, The Interstate Technology Regulatory Council Wetlands Team, USA, ITRC (2003).
5. Mini Mathew, Sr. Claramma Rosary, Mathukutty Sebastian and Sandra Maria Cherian, (2015) "Effectiveness of Vetiver System for the Treatment of Waste Water from an Institutional Kitchen, (ICETEST).
6. Ashton Lim Suelee, Sharifah Nur Munirah Syed Hasan, Faradiella Mohd Kusin, Ferdaus Mohamat Yusuff, Zeliana Zaiton Ibrahim (2017) "Phytoremediation Potenials of Vetiver Grass for Treatment of Metal-Contaminated Water. Water, air, and soil pollution v.228 no.4 pp. 158.
7. M. Kumari, BD Tripathi , (2015) "Effects of phragmites Australis and Typha latifolia of heavy metals from secondary treated effluents", international journal of environmental science and technology 12(3),1029-1038.
8. Archana Dixit, Savitha Dixit, CS Goswami (2011) "Process and plants for wastewater remediation" Sci. Revs. Chem. Commun.: 1(1), 71-77.
9. Ochekwu, Edache Bernard; Madagwa Blessing, (2013) "Potentials of water Hyacinth. Eichhornia Crassipes (mart.) Solms in crude oil polluted water" Vol 17.
10. Neetu Rani, Bhupendrer Singh, Vivek kumar (2015) " Feasibility of Typha and Canna for pulp and paper mill waste water treatment through small wetlands" Int journal of Env Science Vol 6.
11. Dr. H. Karibasappa, A. Akil, N. Dhanabal , et al. (2017) " An Experimental Investigation on Recycling of Grey Water Naturally by Using Canna plants" Vol 6.
12. G. Bhaskar, V.T. Deeptha et al. (2009) "Root zone technology for campus waste water treatment" Journal of Env Research and development. Vol 3.