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POTENTIAL OF VETIVER FOR PHYTOREMEDIATION OF WASTE IN RETTING AREA

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KEYWORDS

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ABSTRACT

Retting of coconut husk is one of the major environmental hazards in the back waters of Kerala in India. Retting accelerates the polluting process of natural water by the activity of bacteria and fungi. So many researches have been done relating to retting of coconut husk in the coast of Kerala. No researches have been done so far to remove the pollutants to protect the ecosystem. Traditional methods of waste water treatment are expensive and impractical. Phytoremediation offers a cost effective, eco-friendly solution, for the existing problem by utilizing plants to remove the pollutants from contaminated water. The study was focused to determine the efficacy of *Vetiver zizanioides* (VZ) grown in containers of retting leachetes collected from retting area. While the plant was growing the researcher collected water samples periodically from March 2010 to March 2011 and the Physico-Chemical parameters were measured. Quantities of organic pollutant mainly Polyphenols present in the retting leachetes were also measured. The results were compared with the control kept in the same condition. A significant change was noticed in all the parameters studied. Remarkable reduction in Polyphenols was also confirmed by FTIR and UV-Vis. Spectroscopy of the ret leachetes. Research findings concluded that *Vetiver zizanioides* is a reliable plant for phytoremediation of pollutants in retting area.

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INTRODUCTION

Retting of coconut husk is the major environmental hazards in the back waters of Alappuzha District of Kerala. In Karthikapally area retting of coconut husk and coconut fibres results in appreciable loss of biomass and prized fishes. Large quantities of organic pollutants are released in to water by the activity of bacteria and fungi. Highly turbid brownish water and mercaptan like smell prevail in the yards and nearby area. There are so many publications on various aspects of retting of coconut husk along the coast of Kerala. Long history of retting for coir production has left its mark on the environment. The blackening of sediments in polluted area is due to local chemical reaction where sulphate gets converted to sulphide. Sediments are indicators of quality of over lying water. No researches have been done so far to remove the pollutants to protect the ecosystem. Hence a scientific approach to this problem becomes imperative in the later period to turn the attention to find a new economical remediation technology. The Traditional methods of purification can purify water of low quantity and may disrupt soil structure and reduce soil productivity. If the entire water resources and reservoirs were gripped by pollution, traditional methods are not applicable and it is not wise and economical. The one and only way out is to follow natural methods. An eco-friendly application is the need of the hr. Hence the present study was mainly designed a new green technology called Phytoremediation which utilizes plants to decontaminate soil, water and air environment (Prasad *et al.,* 2001). Phytoremediation is clear, simple, cost effective, non environmentally disruptive (Wei and Zhou, 2004) and most importantly its by products can be find a range of other uses (Paul and Smeal, 2003).

Phytoremediation is mainly confined to the area occupied by root system and as a consequence small plants with low yield and reduced root system do not support efficient phytoremediation and most likely do not prevent the leaching of contaminant to the ground water. In addition non perennial plants particularly those with slow growth and low biomass production require a long term commitment for remediation. *Vetiver zizanioides* (VZ) is one of the very few plant, if not the only one that has the potential to meet all the criteria required for phytoremediation (Luu *et al.,* 2009) VZ has successfully removed poly cyclic aromatic hydrocarbon (Paquin *et al.,* 2002), *Trinitro toluene* (Konstantinos *et al.,* 2006) and phenol as well as heavy metals (Luu *et al.,* 2009). The high affinity of VZ for both organic and inorganic chemicals led us to speculate that the grass could be used to develop a cost effective and environment friendly remediation for waste water in retting area. VZ is both a xerophytes and hydrophytes and not affected by either drought or flood. It is also tolerant to frost, heat, sodiac and saline condition. VZ can grow in wide range of soil pH. It is characterized by its large biomass, growing up to 2m in height and having a dense root system extending up to 3m in depth (Dulton *et al.,* 1996). The objective of this study is to investigate the effectiveness of VZ in removing the pollutants in retting area.

MATERIALS AND METHODS

Pilot studies have been carried out in the laboratory Department of Chemistry, Bishop Moore College, Mavelikara, by using containers of 10 litre capacities to carry out the experiment. The Physico-chemical analysis of waste water was analyzed. Healthy *Vetiver* clums were selected from Vetiver nursery, Bishop Moore College, Mavelikara. The clums of root length 10 cm and shoot length 10 cm were floated in waste water in containers by the support of thermocol. Each container has one clums and their axis was kept submerged in the waste water and they were kept in the open garden to get natural light. Control was also kept under the same conditions. Waste water was collected from five stations of retting area. Five stations representing different ecological conditions were selected. Station I (Puluki lake) connecting to Kayamkulam Kayal used for retting of coir fibre imported from Tamil Nadu. Station II (a pit) situated in the bank of the lake used exclusively for retting. Station III (a pond) an open region used for retting of coconut husk. Station IV (a pond) entirely free from retting, from which the people of that area consume water for their basic needs. Station V (a pond near retting region). People here are forced to consume ret-polluted water and continue to be contaminated on daily-basis, as they meet their basic needs. The treatments for the experiments are as follows

T_1 —- Control (water from station I)
T_2 —- Water + VZ (water from station I)
T_3 —- Control (water from station II)
T_4 —- Water + VZ(water from station II)
T_5 —- Conrol (water from station III)
T_6 —- Water + VZ (water from station III)
T_7 —- Control (water from station IV)
T_8 —- Water + VZ (water from station IV)
T_9 —- Control (water from station V)
T_{10} —- Water + VZ (water from station V)

The Physico-Chemical parameters like pH, Elecrtical Conductivity (EC), Total dissolved Solid (TDS),Chemical Oxygen Demand (COD), Biological Oxygen Demand (BOD), Dissolved Oxygen(DO), CO_2, H_2S, Hardness, Chloride, Fluoride, Iron, Phosphate, Nitrate, Polyphenols and MPN Coliform were analyzed by standard methods (APHA 1995) . All the experiments were done in triplicate. The UV-Vis spectral analysis of the ret leachates was carried out using UV-Vis Double Beam Spectro Photometer 2201. The spectrum was recorded from 200 to 700nm. Distilled water was used as the blank. FTIR spectra of the ret leachates before and after planting VZ were also analyzed.

RESULTS AND DISCUSSION

The Physico-chemical parameters of water samples from different stations treated with VZ were given in Table I-V**.** Comparatively low pH values in all the stations except station IV may be due to the high retting activity (Nirmala *et al.,* 2002). The low pH of retting zones could be due to the pectinolytic hydrolysis of any organic matter present in the fibre. As the pH falls many insoluble substances become more soluble and are available for absorption and may affect the ecosystem. In the present study the low value of pH become almost neutral after one month of planting VZ. EC of polluted water is directly proportional to its dissolved mineral matter content. The value of EC in the present study ranges from 1500 to 2500 Mmhos/

Table 1: Physico–chemical parameters of water in station I treated with VZ

Parameters	T_1 Initial	Final	Growth time in months	T_2 Initial	Final
pH	5.1	5.7	1	5.1	6.9
EC	2460	2450	6	2460	56
TDS	1574.4	1568	6	1568	35.84
COD	44	40	8	44	9.5
BOD	50.3	50	8	50.3	10.5
DO	0.88	0.89	8	0.88	6
CO_2	20.6	5.6	2	20.6	0.09
H_2S	15	5	2	15	0.01
Hardness	106	101	2	106	75
Chloride	6887	6900	2	6887	843
Fluoride	0.76	0.77	1	0.76	0.26
Iron	1.2	1	1	1.2	0.86
Phosphate	5.213	5	2	5.213	2.53
Nitrate	33.3	33	2	33.3	18.5
Polyphenols	45	44	12	45	18
MPN Coliform	540	397	12	540	31

Table 2: Physico –chemical parameters of water in station II treated with VZ

Parameters	T_1 Initial	Final	Growth time in months	T_2 Initial	Final
pH	5	5.6	1	5	7.1
EC	2500	2350	6	2500	60
TDS	1600	1504	6	1600	38.4
COD	45	42	8	45	15.5
BOD	60.2	54.5	8	60.2	9.5
DO	nil	0.26	8	nil	6
CO_2	32	15	2	32	1.2
H_2S	22.2	10.7	2	22.2	0.09
Hardness	206	204	2	206	80
Chloride	241.4	240.7	2	241.4	150
Fluoride	0.15	0.13	1	0.15	0.01
Iron	1.3	1.26	1	1.3	0.2
Phosphate	7.8	7.6	2	7.8	2.7
Nitrate	20.5	20	2	20.5	10.6
Polyphenols	150.67	150.2	12	150.67	21.7
MPN Coliform	350	345	12	350	33

Table 3: Physico –chemical parameters of water in station III treated with VZ

Parameters	T_1 Initial	Final	Growth time in months	T_2 Initial	Final
pH	5.85	5	1	5.85	6.3
EC	1500	1478	6	1500	25
TDS	960	945.92	6	960	16
COD	20	19.4	8	20	12.6
BOD	85.3	84	8	85.3	10.67
DO	nil	0.67	8	nil	5.73
CO_2	25.74	12.4	2	25.74	3.2
H_2S	41	20.5	2	41	3.4
Hardness	20.8	20	2	20.8	10.5
Chloride	951.4	900	2	951.4	250
Fluoride	ND	-	-	-	-
Iron	ND	-	-	-	-
Phosphate	10.825	10	2	10.825	6.2
Nitrate	22.08	21.6	2	22.08	15.2
Polyphenols	260.4	259.6	12	260.4	33.2
MPN Coliform	1600	1600	12	1600	63

Table 4: Physico –chemical parameters of water in station IV treated with VZ

Parameters	T_1 Initial	Final	Growth time in months	T_2 Initial	Final
pH	6.8	6.5	1	6.8	7.2
EC	1654	1593	6	1654	20
TDS	1058.56	1019.52	6	1058.56	12.8
COD	50	49.5	8	50	25
BOD	30.7	28.2	8	30.7	10.7
DO	4.5	4	8	4.5	6.2
CO_2	ND	-	-	-	-
H_2S	ND	-	-	-	-
Hardness	10.5	10	2	10.5	4.2
Chloride	100.5	98.7	2	100.5	50
Fluoride	ND	-	-	-	-
Iron	ND	-	-	-	-
Phosphate	7.75	7	2	7.75	3.1
Nitrate	30.5	30	2	30.5	9.2
Polyphenols	ND	-	-	-	-
MPN Coliform	280	220	12	280	23

Table 5: Physico - chemical parameters of water in station V treated with VZ

Parameters	T_1 Initial	Final	Growth time in months	T_2 Initial	Final
pH	6.8	6.5	1	6.8	7
EC	1550	1593	6	1550	29
TDS	1058	1038.5	6	1058.56	15
COD	50	49.5	8	50	25
BOD	40.5	28.2	8	40.5	10
DO	3.5	4	8	3.5	6
CO_2	ND	-	-	-	-
H_2S	ND	-	-	-	-
Hardness	10.5	10.2	2	10.5	4
Chloride	102.5	98	2	102.5	50
Fluoride	ND	-	-	-	-
Iron	ND	-	-	-	-
Phosphate	8.75	8	2	7.75	3
Nitrate	35.5	34	2	30.5	8.5
Polyphenols	80.6	80.6	12	80.6	24.1
MPN Coliform	920	920	12	920	33

All the values are the averages of triplicate and all the values except pH,EC (Mmhos/cm) were expressed in mg/L

cm. It is observed that by planting VZ the EC decreased to a very low value which is in agreement with observation made by Lakshmana *et al*. (2008). A comparative study of EC of different stations after planting VZ is shown in Fig.1. High value of BOD, COD and low concentration of DO, kills fish and large segments of slow moving rivers and lakes becomes almost abiotic. In the present study BOD and COD values of all the stations are found to be very high than the permissible limit. It was observed that experiment sets with VZ had a higher BOD and COD removal efficiency which is in agreement with Kanokpron *et al*. (2008). A comparative study of BOD in different stations after planting VZ is given in Fig. 2 Likewise in the present study Hardness of station I and II were found to be ranging from 106-206mg/L. On planting VZ a 60% removal was observed in 2 months which is in agreement with Paul and Barbara, (2001). A comparative study is given in Fig. 3. According to Bureau of Indian Standard the permissible limit of DO is 3 mg/L. When the water quality of retting zone in the present study was examined in this context it was found that the value ranges from 0 to 4.5mg/L. The presence of oxygen is

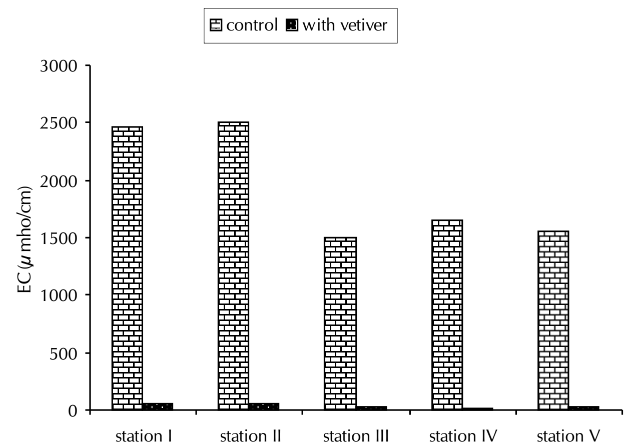

Figure I: Comparison of EC values using VZ among different stations after 6 months

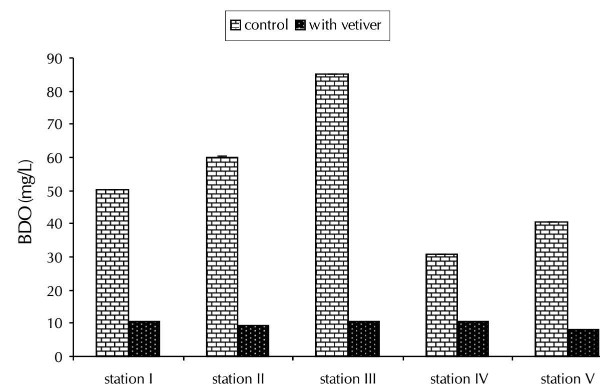

Figure 2: Comparison of BOD values using VZ among different stations after 8 months

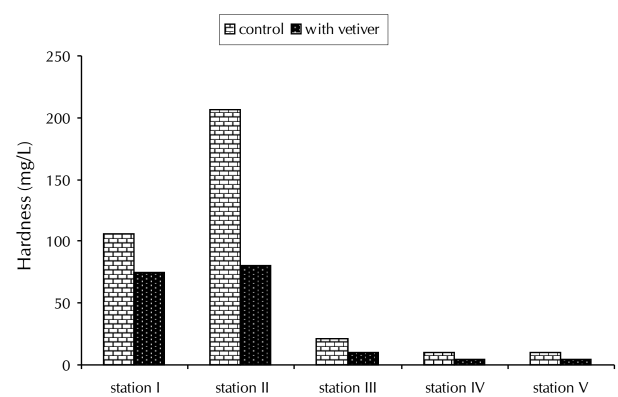

Figure 3: Comparison of Hardness values using VZ among different stations after 2 months

essential for the survival of most organisms in water. Result shown in Fig. 4 demonstrates the role VZ in increasing the concentration of DO which is in agreement with Barbara *et al.* (2003). Concentration of nitrate in all the stations are found to be very high than the permissible limit. It may be due contamination by decaying organic matter and nitrogenous fertilizers (Aravind and Priyakant, 2005). High nitrate level may cause blue baby syndrome in infants below six months. In all the stations the level of nitrate was reduced by planting

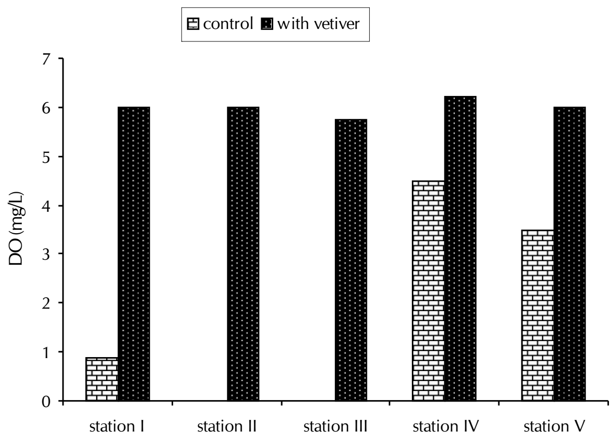

Figure 4: Comparison of DO values using VZ among different stations after 8 months

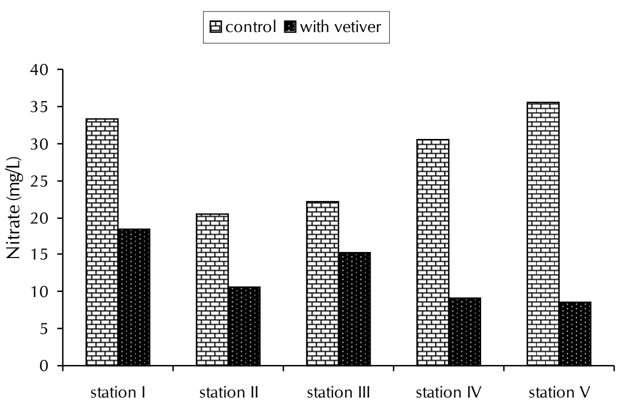

Figure 5: Comparison of Nitrate reduction using VZ among different stations after 2 months

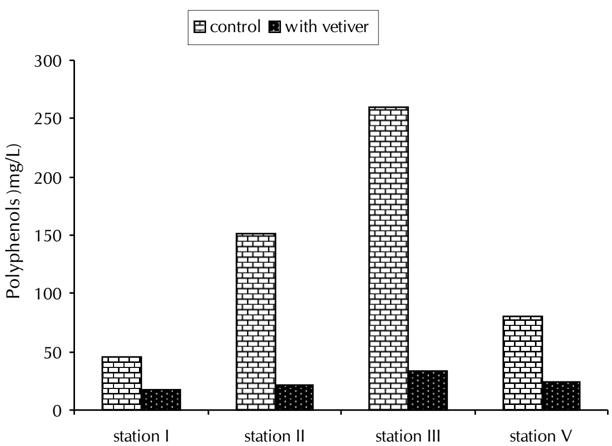

Figure 6: Comparison of reduction Polyphenol using VZ among different stations after 12 months

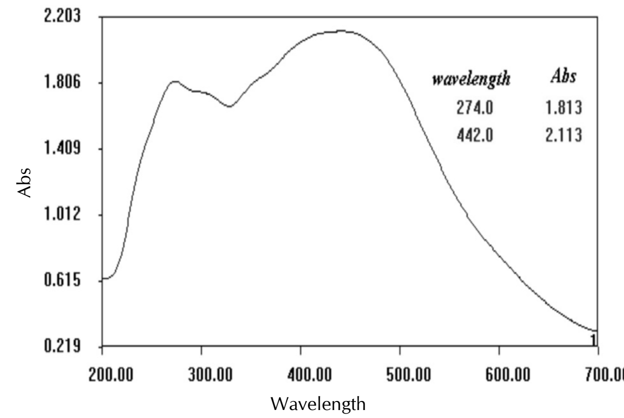

Figure 7: UV Spectra of ret leachate from station III

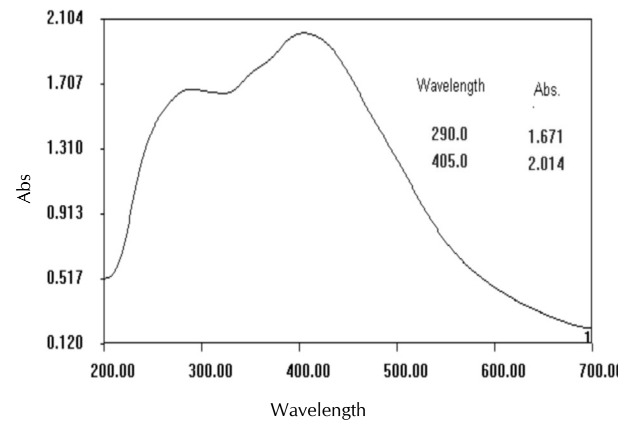

Figure 8: UV Spectra of ret leachate after 2 months

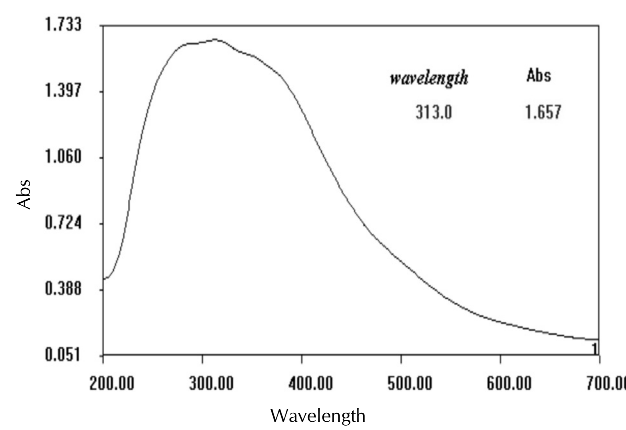

Figure 9: UV Spectra of ret leachate after 4 months

VZ after a period of one month which is in agreement with Stefanie *et al.,* 2003 (Fig. 5).

Polyphenol as Tannin concentration of water in retting area ranges from 260.4 to 45 mg/L. The phenolic compounds contained in the effluents were considered to be the major components that lead to organic pollution. The continuous discharge of phenol and related compounds tends to increase pollutant loads and create an oxygen demand in the receiving water. Early studies were done to remove tannin by UASB reactor (Neena *et al.,* 2007) in the laboratory. In the present study planting a low cost eco-friendly VZ, the concentration of Polyphenols was reduced which is in agreement with phenol absorption by (Singh *et al*., 2008; Luu *et al*., 2009) (Fig.6). The presence of coliform organisms in water is indicative of the water being contaminated with faecal matter. Physical and chemical conditions of water are influenced by the population of bacteria (Badge and Varma, 1991). With an increase in EC,

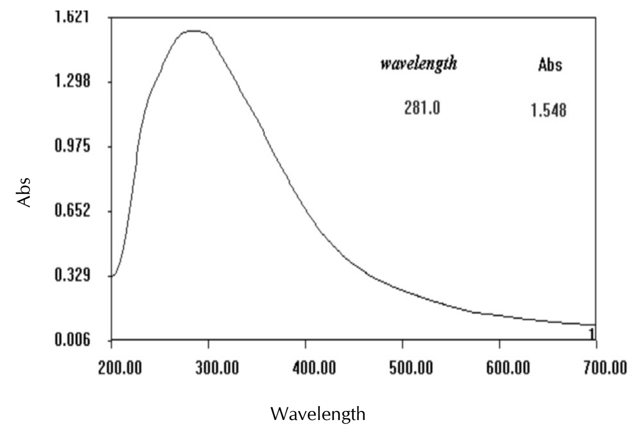

Figure 10: UV Spectra of ret leachate after 6 months

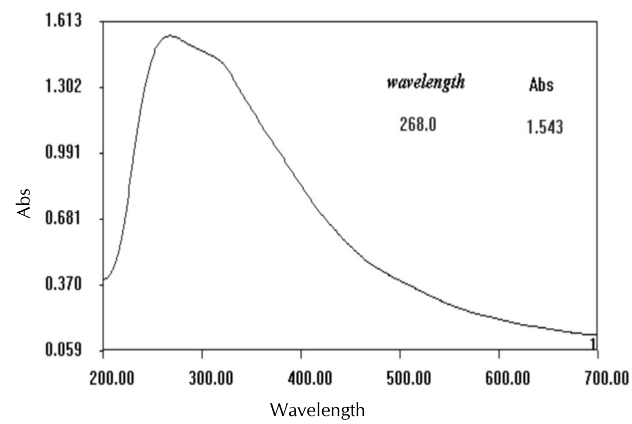

Figure 11: UV Spectra of ret leachate after 8months

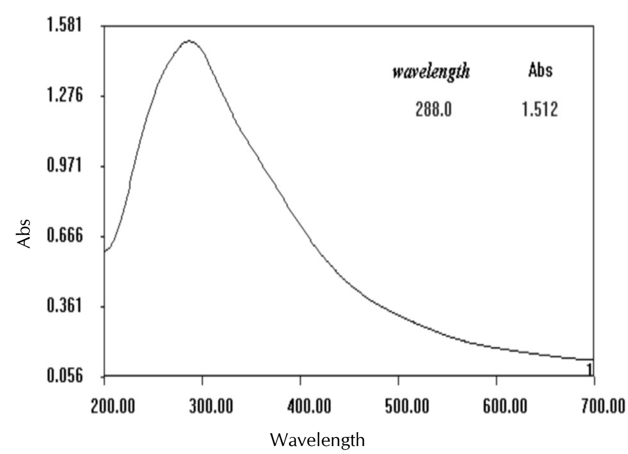

Figure 12: UV Spectra of ret leachate after 10 months

coliforms too increased in number. Higher temperature favoured their growth and multiplication. DO has an inverse relationship with the coliform and is directly proportional to COD and BOD. The organic matter is the food of coliform bacteria (Mathew, 2003). In the present study all the stations show a high value of MPN coliform which is in accordance with Nirmala *et al.* (2002). By planting VZ the value of MPN coliform is reduced by about 12 months. Fig. 7 shows the UV spectra of ret leachate collected from station III. The spectra show two absorption maxima. The absorption maxima at longer wavelength may be due to the presence of phenolic

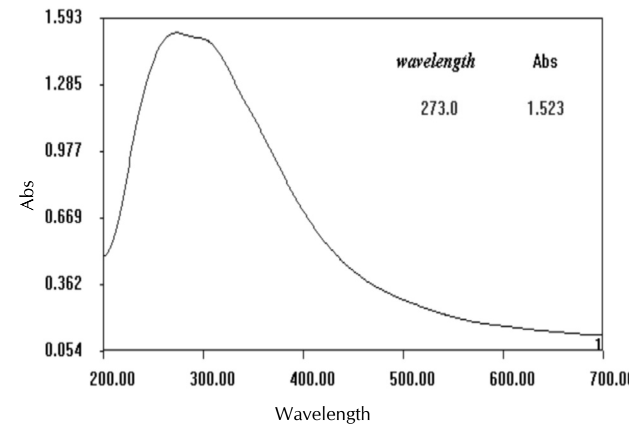

Figure 13: UV Spectra of ret leachate after 12 months

acids such as hydroxy cinnamic acid derivatives and absorption at shorter wavelength may be due to the presence of P- hydroxybenzoic acid derivatives (Naczk *et al.,* 2001). Laboratory ret set by soaking coconut husk in water were monitored by Nazareth and Mavinkurue, (1987) confirmed the presence of P-hydroxy phenolic and methoxy compounds in the leachates. Figs. 8-13 shows the UV absorbance of the leachates after planting VZ. From the data, the absorbance of phenolic acids decreased with duration of planting. This clearly suggests that VZ is highly beneficial for waste treatment in retting area. Fig. 14 shows the FTIR spectrum of the ret leachate from station III, (a) shows the FTIR spectrum of the leachetes before planting VZ and (b) after planting VZ for a period of 12 months. The broad absorption band at 3100 – 3500 cm^{-1} region in (a) is due to the O-H stretching vibrations of hydrogen bonded hydroxyl group. This may arises due to the presence of several phenolic compounds in the ret extract (Nazareth and Mavinkurue, 1987). In (b) the narrowing of the peak at this region may be due to the absorption of phenolic compounds by VZ. The peak at 1600 cm^{-1} is seen in (a) (ret leachate) may be due to the coupling of H-O-H bending with C = O stretching vibration. After planting VZ this peak is shfted

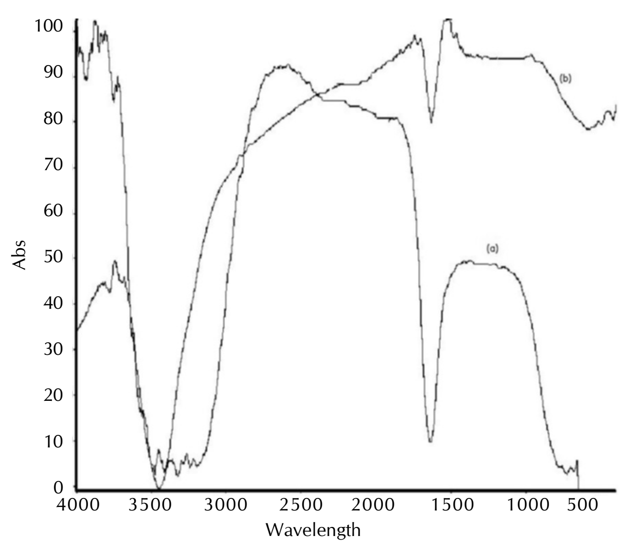

Figure 14: FTIR Spectrum of ret leachates (a) before planting VZ (b) after planting VZ for a period of 12 months

to a longer transmittance region due to the assimilation of some phenolic acid groups present in the ret leachetes. FTIR analysis of ret leachate has also been confirmed with U.V analysis.

CONCLUSION

Phytoremediation is a sustainable way to mitigate pollution from the environment. Vetiver grass has successfully shown its potential towards phytoremediation since the last 2 decades. The grass has evolved the self-mechanism to tolerate various environmental extremities such as temperature salinity, alkalinity, floods, heavy metal contamination, and the presence of organic pollutants. Researchers all over the world are coming up with a new face of VZ with respect to checking the environmental hazards.

REFERENCES

APHA. 1995. Standard methods for the examination of water and waste water. 19th Ed**s.**American Public health Assoaiation, Washington.

Aravind, M. and Priyakant. 2005. GIS based determination ofsuitable ground water qualityzones for drinking purpose A case study of Dist. Manipuri,Uttar Pradesh. *Poll. Res.* **24(1):** 59-68.

Badge, U. S. and Varma, A. K. 1991. Interaction between coliform bacteria and its aquatic environment, Narendra Publishing House,New Delhi.*Current trends in Limnology.* **1:** 105-112.

Barbara, H., Ron, C. and Paul, T. 2003. http://www.vetiver.org/ICV3-Proceedings/AUS_hydroponic.pdf.

Dulton, P. A., Smith, R. J. and Truong, P. N. V. 1996 . Vetiver grass hedges for erosion control on cropped flood plain: *Hedge hydraulics. Agric.Water Mag.* **31:** 91-104.

Konstantinos, C., Makris, K. M., Shakya, R. D., Dibyendu S. and Devanand P. 2006. High uptake of 2, 4, 6- trinitro toluene by Vetiver grass- Potential for phytoremediation ?, *Environmental poll.* **146(1):** 1-4.

Kanokpron, B. and Monchai, C. 2008. Domestic Waste Water Treatment using Vetiver Grass Cultivated with Floating PlatformTechnique, *AU J, T,* **12(2):** 73-80.

Luu, T. D., Paul, T. Raffaella, M., Tam, T. and Neil, F. 2009. Vetiver grass, Vetiver zizanioides: A choice plant for phytoremediation of heavy metals and organic waste. *Inter. J. phytoremediation* **11:** 664-691.

Lakshmana, P. P., Jayashree, S. and Rathinamala, J. 2008. Application of vetiver for water and soil restoration. *http://www.vetiver.org/*TVN India 1st workshop proceeding//Chapter2-3 pdf.

Mathew, K. P. 2003. The Chemistry of a River Published by Book Enclave, ISBN: 81-8152-026-3.

Nirmala, E. Jalaja, T. K. and Remani, K. N. 2002. Pollution hazards on the people and ecosystem of selected coir retting yards in the back waters of calicut Dist. Final report submitted to kerala Research programme on local level development Centre for development studies

Neena, C., Ambily, P. S. and Jisha, M. S. 2007. Anaerobic degradation of coconut husk leachete using UASB Reactor. *J. Environ.Biol.* **28(3):** 611-615.

Naczk, M., Pink, J., Amarowick, R., Pink, D. and Shahidi, F. 2001. Multivariate model for the prediction of soluble condensed tannins in crude extract of polyphenols from canola and rapeseed hulls , *J. AOCS*. **78(**4): 411-414.

Nazareth, S. and Mavinkurue, S. 1987. Laboratory studies on retting of coconut husk. *Inter. Biodeterioration.* **23(6):** 343-355.

Prasad, N. M. R., Samjiamjiaras, R. and Thammanoon, H. 2001. The wonder of a grass Vetiver and its multifold application. *Asia infrastrut. Res. Rev*. **3:** 1-4.

Paul, T. and Smeal, C. 2003. Research development and implication of Vetiver system for waste water treatment*: GELITA Australia, Pacific Rim Vetiver Network Tech. Bull.* **3.**

Paul, T. and Barbara, H. 2001. MECH, Vetiver grass for water treatment *PacificRim Vetiver Net work. Techanical Bull. No.* **2**

Paquin, D., Ogoshi, R., Camphel, S. and Li, Q. X. 2002. Bench scale phytoremediation of polycyclic aromatichydrocarbon contaminated withmarine sediments withtropical plants*: Inter. J. phytoremediation.* **4:** 297-313.

Stefanie, W., Paul, T., Alison, V. and Cameron, S. 2003. Response of Vetiver grass to extreme nitrogen and phosphorus supply http://www.vetiver.com/ICV3-Proceedings/AUS_Extreme%20N%26P.pdf

Singh, S., Melo, J. S., Susan, E. and Souza, D. 2008. Potential of Vetiver (Vetiver zizanioides L.Nash) for phytoremediation of phenol. *Ecotoxicology and Environmental safety.* **71(3):** 671-676.

Wei, S. H. and Zhou, Q. X. 2004. Discussion on the basic principles and strengthening measures for phytoremediaton of soil contaminated with heavy metals. *Chinese. J. Ecol*. **23:** 65-72.