The Use of Vetiver Grass to Rehabilitate City Garbage Leachate by Isotope Techniques

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Abstract: The objective of this research work was to solve the impact of leachate from city garbage on the environment through to the use of vetiver grass. The experiment was conducted in the Royal Working Area at the Doi Tung Development project, Chiang Rai Province, northern Thailand during 2001-03. The city garbage was packed in circular cement blocks, 1.5 m diam. and 1.5 m high. Each block was covered with topsoil to a depth of 10 cm. The leachate from the garbage was drained through a pipe fixed at 120cm and trapped for analysis. The experimental design was an RCB with 5 replications, having 4 treatments in each replication. The treatments included: (i) control, (ii) vetiver grass planted on 50% of the area with the spacing of 10 x 10 cm, (iii) vetiver grass planted on 75% of the area with the spacing of 10 x 10 cm, (iv) vetiver grass planted on 100% of the area with 10 x 10cm spacing. Root distribution of the vetiver grass was studied using ^{32}P techniques. ^{32}P solution was injected into the garbage at the depths of 30, 60, 90, and 120 cm. The results indicated, more roots were found at 30cm depth, but clearly declined at lower depths. The ^{32}P radioactivity was detected at the edge of the block for each depth. Also observed was that the dense roots of vetiver entangled and acted as a underground dam. Treatment # 4 showed the full efficiency in trapping leachate. Moreover, vetiver could absorb more macro elements when it was older. The concentration of residual sodium carbonate (RSC) and sodium absorption ratio (SAR) were f round to be extremely high in the garbage residue, making it unsuitable for normal growth of plants. Yet, the vetiver grass was able to grow in this adverse condition-a miracle plant indeed!

Key word: ^{32}P, vetiver grass, root distribution, rehabilitation, garbage, leachate, water quality, major element, minor element

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1 INTRODUCTION

The main problem in the residential area of a city is garbage. Waste materials have created pollution problems and caused much land deterioration without vegetation cover (Shu *et al.*, 2000). The success of reclamation schemes are largely dependent on the choice of plant species and their methods of establishment (Bradshaw, 1987).

The use of vetiver grass, which was introduced by His Majesty The King for conserving the environment can explain His majesty's great concern for His subjects, by applying the concept of " *Using nature to solve nature*". This method is an economical means because vetiver is cheap and easily planted (Tantivajkul, 2000). Vetiver grass (*Vetiveria zizanioides*), due to its unique morphological and physiological characteristics, which is widely known for its effectiveness in erosion and sediment condition (Greenfield, 1995), has also been found to be highly tolerant to extreme soil conditions including heavy metal contamination (Truong and Baker, 1998:) Truong (2000) found this grass was

To grow vetiver grass on city garbage was a methodology to rehabilitate leachate. Mahisarakul (1996) indicated that vetiver roots could become an efficient underground natural dam. The best root distribution was at a depth of 120 cm. This research work aimed to emphasize the effectiveness of vetiver grass grown on the waste with the purpose of trapping nutrients thereby, rehabilitate the waste water.

2 ENVIROMENTAL APPLICATIONS

The experiment was conducted in The Royal Working Area at the Doi Tung Development Project, Chiang Rai Province, Northern part of Thailand during the year 2001 – 03.

The city garbage was packed in the cement blocks with 1.5 x 1.5 m (diameter x height) and cement sealed bases. The waste properties are shown in Table1.

Table 1 City garbage analysis

pH	Moisture*	Total(%)			% Mg[4/]	%Fe[4/]	% Mn[4/]	%Co[4/]	%S[5/]
	75^{o}C (20 hr.)	N[1/]	P_2O_5[2/]	K_2O[3/]					
5.5	5.44	3.86	1.8	4.59	0.365	0.0612	0.025	0	0.665

*Fresh city garbage moisture 80%

3 MATERIALS AND METHODS

A Randomized Complete Block design with 5 replications was used. There were 4 treatments, comprising:-

1. Control without vetiver grass planting.
2. 50% of the area vetiver grass.
3. 75% of the area vetiver grass.
4. 100% of the area vetiver grass.

Vetiver grass, cultivar Surat Thani (*Vetiveria zizanioides* (L.) Nash), was used. It was derived from clonal propagation through tissue culture. The plants were transplanted from the culture for survival test, then grown for three months before conducing the experiment.

3.1 Experimental Preparation

The waste was decomposed by microbes, which produced leachate. It was trapped by a plastic tank outside the cement block at a depth of 120 cm. Inside the cement block, there were two PVC tubes with 3-inch diameter and 80 cm in length. Making 10 furrows on each tube, which rested on a layer of 30 cm deep garbage. Each furrow had 5 cm in diameter with intervals of 5 cm. The holes were covered with plastic net. The tubes were placed at 50 cm apart from each interval side of the cement block at the depth of 120 cm. There were two connected tubes with 3 furrows between the two main tubes. The purpose of making furrows was to intercept leachate and drained out leachate from the cement block through the outlet tube, which connected to the 100 L plastic tank.

Filling up the cement block with waste and compacting it to keep bulk density (BD) as conventional practice (BD = 1 g/cm^3). The height of garbage compaction was 140 cm and was covered with 10 cm of soil.

The vetiver grass was planted at a spacing 10 x 10 cm in 50%, 75% and 100% of the surface block area. Measurements of leachate and sludge were collected every 3 months. In the first 5 months, watering at 10 L/day occurred when there was no rain. Later 20 L of water was applied to each block in the same case.

3.2 Root Distribution Studies by Using ^{32}P Injection Isotope Technique

Root characteristics and root distribution were the goal of the study. It was completely randomized design with 4 replications. The selected vetiver grass at the age of 11 and 17 months were collected from the center of the block. Making two holes at 5 cm (R) apart from each side of the selected plants with the depth of 30, 60, 90 and 120 cm (D) respectively was performed. The ^{32}P labeled solution as carrier 1000 mg P L^{-1} (KH_2PO_4) (IAEA, 1987) was injected into these holes, which contained activity of 0.30 G Bq/hole. The holes were filled with waste and checked for contamination by using a Geiger Müller counter for monitoring.

Root activity was determined by a Liquid Scintillation β counter. Samples were taken 5, 30, 40, 50 and 60 cm from the labeled plants at 11 months of age on the left and right side of the vetiver plant. Similar sampling was made at 17 months**.**

3.3 Analysis

The plant samples were then dried at 65-70 degrees Celsius. The ash was dissolved in 20-30 ml of 2NHCl. The P-32 activity was counted by Cerenkov Technique using a Liquid Scintillation Counter. The value of the disintegration per minute (dpm) per gram of plant was compared with the dpm/g plant background (natural ^{32}P).

3.4 Plant Samples

Plant samples were taken 15 days, 4, 8 and 16 months after transplanting to analyze for N, P, K, Ca, Mg and S.

3.5 Leachate Quality

Leachate was selected from the tank of each treatment at 4,8 and 16 months after transplanting the vetiver.

Analytical analysis of pH, EC (electric conductivity), Ca , Mg, K, Na, Cl^-, $CO_3^=$, HCO_3^-, $SO_4^=$ SSP (Soluble Sodium Percentage) RSC (Residual Sodium Carbonate), SAR (Sodium Adsorption Ratio) was performed.

4 RESULTS AND DISCUSSION

The root growth of vetiver was naturally distributed. There was question whether vetiver grass could be or not be the miracle grass. Researcher have conducted many experiments using this grass to control erosion (Surapol Sanguankaeo *et al.*, 2000; Shoaib Jalal Uddin, 2000), trapping plant nutrients and agrochemicals by using vetiver hedges (Truong, *et al.*, 2000).

4.1 Root Distribution Studies

The use of ^{32}P techniques was used to show the quantity of roots. If the root contacted the point of ^{32}P, it indicated high counts. This experiment used vetiver grass (*Vetiveria zizanioides*) clone from Surat Thani province and used city garbage as the culture. Root characteristics and root distribution are shown in table 2 and 3 at 11 and 17 months respectively after transplanting.

Table 2 ^{32}P contents (dpm) in *Vetiveria zizaniodes* at 11 months after transplanting

Treatments % Grown vetiver	depth (cm)	^{32}P traces (dpm) Distances (cm) from the point of injection								
		Left side					Right side			
		60	50	40	30	5	30	40	50	60
50	30	300	98	290	1515	5290	3100	951	218	301
75	30	210	52	85	380	7010	195	81	300	98
100	30	228	75	110	460	8123	327	1428	458	192
50	60	58	67	291	59	482	955	73	119	60
75	60	49	77	82	78	345	165	98	220	145
100	60	90	78	66	125	1149	489	211	93	80
50	90	45	63	90	339	412	98	89	126	80
75	90	66	48	345	49	466	140	382	321	69
100	90	70	90	180	245	388	210	198	110	90
50	120	52	43	106	87	288	84	46	52	88
75	120	49	49	50	66	469	182	73	70	65
100	120	51	46	59	65	241	82	65	81	50

Table 3 ^{32}P traces (dpm) in vetiver grass at 17 months after transplanting

Treatments (%) grown vetiver grass	depth (cm)	^{32}P traces (dpm) Distances (cm) from the point of injection														
		Left side							Right side							
		60	50	40	30	20	10	5	10	20	30	40	50	60		
50	30	22	21	514	56	346	6233	28289	1391	1841	6710	551	519	4235		
75	30	15	17	17	220	4260	3059	3869	27	639	17	234	33	35		
100	30	21	29	36	44	45	3362	4027	644	19	38	11	20	23		
50	60	39	53	24	28	331	352	1617	489	384	44	20	35	38		
75	60	167	234	19	20	397	276	204	55	108	29	596	27	15		
100	60	1922	12	28	25	40	812	42995	9686	639	13	14	3876	41		
50	90	19	32	34	6	18	421	1560	77	23	10	33	35	28		
75	90	27	17	26	30	40	38	810	46	37	29	19	47	22		
100	90	29	32	22	23	32	33	335	21	20	17	23	14	11		
50	120	19	43	29	21	79	104	7106	134	56	47	47	31	34		
75	120	6	18	348	30	46	22	42	55	43	534	39	29	16		
100	120	460	23	19	23	146	215	200	5729	2568	41	46	2396	61		

Results indicate that roots were distributed to all over the cement block area. The highest concentration of roots occurred at 30 cm depth in 50%, 75% and 100% of the area. This agreed with the work of Mahisarakul *et al.* (1996), who found 10.3 months after transplanting the distribution of roots at 30 cm depth of both directions of 90 cm and 60 cm on the left and the right side of the treated grass. Abdul – Salam *et al.* (1993), using an excavation technique to study the roots showed that 88% of the active roots existed at a depth of 40 cm and 92% of the roots were recorded at a horizontal radius of 20 cm. The same technique was performed by Yoon *et al.* (1996), which showed that the massive root system was in the top 0.4 – 0.5 m. It might say that each hill (Table 2 and Table 3) had a root distribution to 60 cm apart from the hill and 120 cm depth. The active roots entangled in the waste as an underground natural dam.

4.2 Leachate and Sludge

Leachate and sludge was collected monthly from the period between January 2002 and March 2003 (3-16 months after transplanting). The results of the wastewater are shown in Table 4.

The treatments of vetiver grass (*Vetiveria zizanioides*) at 50%, 75% and 100% of the area of the cement block showed highly significant differences from the control treatment. The minimum of leachate during the experiment was 100% treatment. The 75% of growing vetiver was also very interesting. The results did not show any differences from the 100% when the vetiver was older. The measurement of the sludge is shown in Table 5.

Table 4 Leachate (L) in the year 2002-03

Treatment % grown vetiver	Jan 2002	Mar	May	July	Sept	Nov	Jan 2003	Mar
C	27.2 b	21.3 c	261.8	79.3 b	131.9 b	241.7 a	124.6 b	142.7 b
50%	17.9 a	19.3 b	278.4	65.0 a	93.1 a	221.1 a	114.7 ab	97.5 a
75%	18.2 a	18.4 b	243.3	54.9 a	90.8 a	204.2 a	109.2 a	94.2 a
100%	15.1 a	16.3 a	212.5	57.4 a	61.2 a	195.3 a	107.4 a	91.7 a
	**	**	ns	**	**	**	**	**
CV%	12.00%	5.70%	26.60%	11.80%	24.70%	16.10%	6.90%	6.50%

Means followed by a common letter are not significantly different at the 5% level by DMRT.
ns = non significant, ** = highly significant different

Table 5 Sludge (gm) in the year 2002-03

Treatment % grown vetiver	Jan 2002	Mar	May	July	Sept	Nov	Jan 2003	Mar
C	30.4	23.8 a	297.0	140.0 a	202.2 b	67.9	20.7 b	57.7 c
50%	32.6	28.8 b	290.9	124.0 a	159.1 a	65.1	21.0 a	36.1 b
75%	26.6	28.6 b	309.5	115.6 a	151.7 a	59.6	19.3 ab	23.8 a
100%	27.8	29.3 b	300.2	123.6 a	112.8 a	40.1	17.1 a	24.0 a
	ns	**	ns	**	**	ns	**	**
%CV	25.6%	7.40%	8.40%	15.60%	20.70%	53.00%	10.00%	6.5%

Means followed by a common letter are not significantly different at the 5% level by DMRT.
ns = non significant, ** = highly significant different

The results were the same as leachate. This proves that vetiver grass, grown on city garbage areas, can reclaim leachate and sludge. The pattern chosen for growing vetiver grass in this situation should consider the economics. If so, 75% of the area planted to vetiver grass will provide the best performance.

4.3 Leachate Quality

To evaluate and monitor the quality of water it was analyzed for: pH, EC, Ca, Mg, Na, K, Cl, $CO_3^{=}$, HCO_3^-, and $SO_4^{=}$. From this data, the SSP (soluble sodium percentage), RSC (residual sodium carbonate) and SAR (Sodium adsorption ratio) were calculated. EC and SAR (U.S. Salinity Laboratory 1969) were used to classify the irrigation water quality.

Comparison leachate quality which flowed through the vetiver hedge grown on different portions of the area of the cement block at 4, 8 and 16 months after transplanting respectively is shown in Table 6. The results show that the older the vetiver grass, the better the leachate quality. At the beginning, the leachate sampling was under the decomposition process, so it emitted odour, and the pH was in the range 7.2-7.5.

The EC in the 4th month was a very high concentration (6360 CNa–6862 μ mho/cm at 25^{o}C) and was classified as C4. The sodium (Na), (Chloride) (Cl^-) and bicarbonate (HCO^-_3) were also very high. On the other hand Ca, Mg and $SO_4^{=}$ were in low concentration. The sodium adsorption ratio (SAR) (Table 6) was calculated by $Na^+/(Ca^{++} + Mg^{++})/_2$.

Table 6 Comparison leachate quality passing through different portion of vetiver grass grown on the city garbage in the cement block at 4, 8 and 16 months after transplanting respectively

Treatment % grown vetiver	pH			EC (μ mho/cm^{-1}) At 25°C			meqL^{-1} Ca			Mg		
	4*	8*	16*	4*	8*	16*	4*	8*	16*	4*	8*	16*
C	7.48	7.98	7.80	6360	3318	1489	8.23	5.94	5.66	4.77	3.34	2.97
50	7.20	7.92	8.10	6770	3148	1439	6.97	5.48	3.93	4.39	2.78	2.30
75	7.22	7.76	7.7	6506	3205	1752	6.75	5.18	5.34	4.50	2.86	2.35
100	7.40	7.98	7.8	6862	3362	1596	9.66	5.68	4.91	4.44	3.22	2.47

Treatment % grown vetiver	meqL^{-1} Na			K			Cl^-			$CO_3^{=}$		
	4*	8*	16*	4*	8*	16*	4*	8*	16*	4*	8*	16*
C	20.98	3.34	4.20	8.28	3.00	2.08	29.60	8.88	4.16	8.28	3.00	2.08
50	21.65	2.78	2.92	13.4	3.00	1.40	27.81	8.64	2.50	13.4	3.00	1.40
75	20.71	2.86	3.32	11.12	3.60	2.08	25.38	8.40	2.94	11.12	3.60	2.08
100	21.59	3.22	3.53	20.88	3.20	1.60	27.78	9.78	4.02	20.88	3.20	1.60

Treatment % grown vetiver	meqL^{-1} HCO_3^-			% SSP			meqL^{-1} RSC			SAR		
	4*	8*	16*	4*	8*	16*	4*	8*	16*	4*	8*	16*
C	26.88	21.00	13.96	61.98	49.80	29.70	22.15	14.72	5.91	8.22	4.36	1.88
50	25.3	19.10	9.10	65.13	53.55	31.32	27.35	13.57	4.25	9.01	4.65	1.77
75	25.40	22.30	11.34	64.19	53.99	30.09	25.27	17.78	4.89	8.66	4.75	1.45
100	17.66	21.8	11.00	61.95	54.64	32.19	24.44	16.18	4.94	8.56	5.60	2.63

* Months after transplanting

The high value of SAR (approximately 9) was caused by high Na concentration, as a result this was classified as a S_3 (U.S. Salinity Laboratory 1969). The use of residual sodium carbonate (RSC) value was used to consider water quality by the concept of Eaton (1950). It was concluded that waters with more than 2.5 meq L^{-1} (RSC) are not suitable for irrigation. Waters containing 1.25 to 2.5 meq L^{-1} are marginal and those containing less than 1.25 meq L^{-1} of RSC are probably safe. The value of RSC was shown in table 6 were 22.15-27.35 meq L^{-1}. That means this leachate could not be used as irrigation water. The vetiver grass was shown toxic symptoms of Na with more dry leaves than normal. It could be explained by sodium accumulation did exist in the root zone. The crop probably had difficulties in extracting enough water (Ayers and Westcot, 1976).However, this grass could resist the adverse conditions.

The leachate quality at the 8th month after transplanting showed lower values than the 4th month, so the leachate remained the causal problem. The EC and SAR values were classified by the U.S. Salinity Laboratory (1969), as poor quality (C4-S2). Sodium and chlorides had a slight to moderate restriction on use, but bicarbonate was rated severe. The RSC value was high making it not suitable to use for irrigation.

5 PLANT UPTAKE

The uptake of macronutrients by vetiver grass was shown in Table 7. No difference among treatments existed. The vetiver grass could absorb more macronutrients at the forth month of age and gradually decreased with increasing age, except S.

It may be interpreted that the mixture of the city garbage contained less macronutrients (Table1). For S, during the decomposition period, sulfur was in the form of organic matter soluble sulfate in the soil solution. It proves that sulfur is a component of protein and will be transformed to humus as a large fraction of the sulfur remains in organic combination (Tisdale and Nelson, 1975). The analysis of S showed that at 15 days after transplanting to 8 months, vetiver grass could scarcely consume the S but at 16 months, the plant could uptake S about 2 times higher than in the first 8 months. It may explain that at approximately 16 months, the activities of microorganisms decreased or the decomposition process is complete. Protein sulfur could then be available to vetiver grass.

Table 9 The macronutrients uptake by vetiver grass (*Vetiveria zizanioides*) grown on city garbage in the cement block at 15 days, 4 month, 8 months and 16 months after transplanting

Treatment % grown vetiver grass	Uptake (%) N				**P**				**K**			
	15d 1/	4m 2/	8m 2/	16m 2/	15d 1/	4m 2/	8m 2/	16m 2/	15d 1/	4m 2/	8m 2/	16m 2/
50	15.6	1.68	1.13	0.99	0.122	0.158	0.163	0.182	2.021	2.160	2.107	1.592
75	1.62	1.86	1.15	0.83	0.138	0.177	0.172	0.194	1.927	2.231	2.006	1.434
100	1.50	1.84	1.11	0.87	0.126	0.168	0.162	0.221	1.976	2.122	1.965	1.531

Treatment % grown vetiver grass	Uptake (%) Ca				Mg				S			
	15d 1/	4m 2/	8m 2/	16m 2/	15d 1/	4m 2/	8m 2/	16m 2/	15d 1/	4m 2/	8m 2/	16m 2/
50	0.167	0.269	0.210	0.253	0.089	0.110	0.145	0.131	0.115	0.112	0.085	0.181
75	0.181	0.287	0.203	0.215	0.088	0.122	0.146	0.136	0.140	0.116	0.085	0.174
100	0.156	0.279	0.215	0.249	0.084	0.118	0.145	0.135	0.119	0.116	0.675	0.157

1/ d = days after transplanting, 2/ m = months after transplanting

6 CONCLUSION

- Vetiver roots could distribute and become massively entangled acting as an underground natural dam.
- The amount of leachate and the measurement of sludge were lowest in the treatment of vetiver grass at 100% of the area but it was not significantly different with 75% of the area of vetiver grass. For the economic and safety purposes, we should consider vetiver as phytoremediation at 75% of the area.
- The older vetiver grass grown on city garbage would help to make better quality leachate.
- Vetiver grass could uptake some macronutrients.
- Vetiver grass can be used for phytoremediation purposes.

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A Brief Introduction to the First Author

Mrs. Jittiwan Mahisarakul, Senior Scientist, is working in Nuclear Research in the Agriculture Section, Department of Agriculture, Ministry of Agriculture and Co-operatives since 1972. She uses nuclear technology as a tracer technique to study root characteristics and distribution of vetiver grass, corn, soybean, mungbean, cassava, rubber tree etc. and estimates the agronomic effectiveness of natural and chemical fertilizers. From her studies, she realizes that the vetiver grass is a miracle grass and can be used for phytoremediation.