ASSESSMENT OF TREATED LATEX WASTEWATER REUSE FOR PERENNIAL TREE IRRIGATION ON GROUND WATER QUALITY

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ABSTRACT

The study aimed to assess nutrient contamination to aquifer from reuse of latex wastewater for perennial tree irrigation. The latex wastewater contains high nitrogen concentrations and BOD that are required high treatment costs to meet Vietnam Industrial effluent standards. The reuse of secondary treated effluent for rubber tree irrigation may be a potential benefit in terms of treatment cost reduction as well as nutrient reuse.

A pilot experiment was done in two lots of 100 rubber trees each. The area of each lot was 7m x 2.5m. One lot was controlled without irrigation. The used irrigation water was taken from effluent of a facultative waste stabilization pond of latex processing industry. Hydraulic rate, nutrient loading and COD loading applied to the lot were 8m$^{3/}$ha/week, 12.5 kgN/ha/day and 0.5 kg COD /ha/day respectively.

GMS modeling was used for assessing nitrogen and COD transport in the aquifer. The first order reaction modeling was used for biological conversion of COD and nitrogen during the infiltration in the vadose layer. The results shown that transport of total nitrogen and COD in the ground water were reached stable levels at 2 meter depth after 10 months and 10 meter after 12 months of irrigation. In addition, scanning electron microscopy (SEM) images used to compare the soil quality among the sites.

Keywords: *Latex processing wastewater, nutrient reuse, Vietnam Industrial effluent standards, Groundwater Modeling System (GMS), scanning electron microscopy (SEM).*

INTRODUCTION

Vietnam Rubber Group reported that the rubber industry emits by 10 million cubic meters of wastewater annually [1]. The latex wastewater contains high organic and high nitrogen (COD: 1,000 ÷ 10,000 mg/l, BOD_5: 1,700 ÷ 9,000 mg/l and total nitrogen: 45 ÷ 1,600 mg/l) [2]. To meet Vietnam Industrial effluent standards, the reuse of secondary treated effluent for rubber tree irrigation may be a potential benefit in terms of treatment cost reduction as well as nutrient reuse. Due to high nutrient composition, orientation to reuse wastewater after aerobic biological treatment for irrigation combining with higher processing soil treatment may reduce costs of chemical and electricity. In addition, reuse of nutrient compositions (nitrogen, phosphorous, potassium) may decrease the amount of chemical fertilizers and improve soil quality by providing useful microorganisms and humus after aerobic biological treatment. The study aimed to assess nutrient contamination to aquifer from reuse of latex wastewater for perennial tree irrigation.

MATERIALS AND METHODS

Experimental site

The experiment was conducted at the Rubber Research Institute of Vietnam (RRIV) in Ben Cat District, Binh Duong province, Vietnam.

A pilot experiment (*Figure 1*) was done in two lots of 100 rubber trees each. The distance between rubber tree of each lot was 7m x 2.5m. Lot 0 (L0) was controlled without irrigation. Lot 1 (L1) was watered by latex wastewater after anaerobic stage with 20 liters per rubber tree. Two observation wells about 18-20 meters in depth were drilled in the two lots L0, L1.

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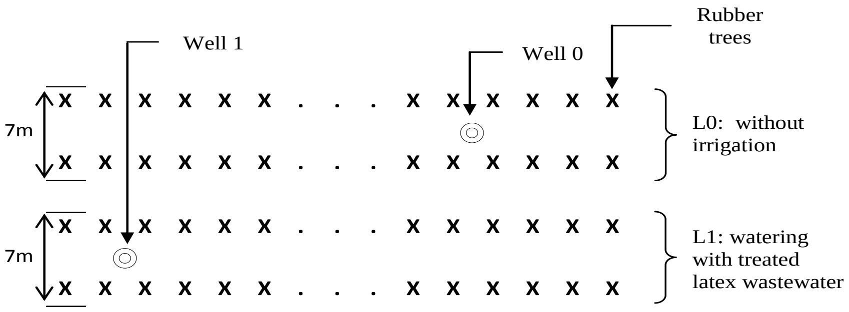


Figure 1. *Pilot scale irrigation experiment*

The used irrigation water was taken from effluent of a facultative waste stabilization pond of latex processing industry. Hydraulic rate, nutrient loading and COD loading applied to the lot were 8m^{3}/ha/week, 12.5 kgN/ha/day and 0.5 kg COD /ha/day respectively.

Sampling and testing quality of the wastewater

Treated wastewater was irrigated on every Thursdays, from 08:00am during 1-2 hours. Irrigation flow at each rubber's root was controlled by a counter clock to ensure 20 liters in every 12-14 seconds per rubber tree, or equal to 10 m^3 per ha per week. The experiment was conducted in 16 weeks. Water samples from the 2 observation wells were taken by water pumps and then brought to the laboratory for analyzing pH, COD, TKN, N-NH_4, N-NO_3 and P - PO_4.

Table 1. *Characteristics of latex wastewater after anaerobic pond*

No	Latex wastewater	Average concentration
1	pH	6.77
2	COD (mg/L)	407
3	TKN (mg/L)	176
4	NH_3 – N (mg/L)	157
5	PO_4 – P (mg/L)	282

Table 2. *Modeling of latex wastewater*

Type of stream, (i)	Latex wastewater (CS)		
	Latex wastewater of anaerobic pond *lt*	Anaerobic effluent *kk*	Effluent of facultative/ secondary treatment *hk*
COD (j), mg/L	1000	500	250
TKN (k), mg/L	500	150	60
Irrigation load TL (n)	**Irrigation load m^3/ha/day**		
	30		
	50		
	80		
	120		

Note: **(i)** – Type of wastewater: *bi, kk, hk;* **(j)** – COD: 1000, 500, 250 mg/L; **(n)** – 30, 50, 80, 120 m^3/ha/day

Soil sampling and analyzing

Surface soil were sampled for SEM analysing at two sites: i) Inside the lot L0, soil were taken from the top, at 35cm depth and then mixed for one sample named D3; and ii) Inside the lot L1, soil were taken from the top, at 25cm depth and then mixed for one sample named CS3. SEM images at magnification 100 and 1,000 were conducted at the Innovation lab, Ryerson University, Toronto, Canada.

Input data for Groundwater Modeling System (GMS)

Irrigation load calculation option (n) 30, 50, 80 and 120 m^3/ha/day, the results of the water analysis by the software MODFLOW with input data showned in the Table 2.

RESULTS AND DISCUSSIONS

Pilot scale irrigation experiment

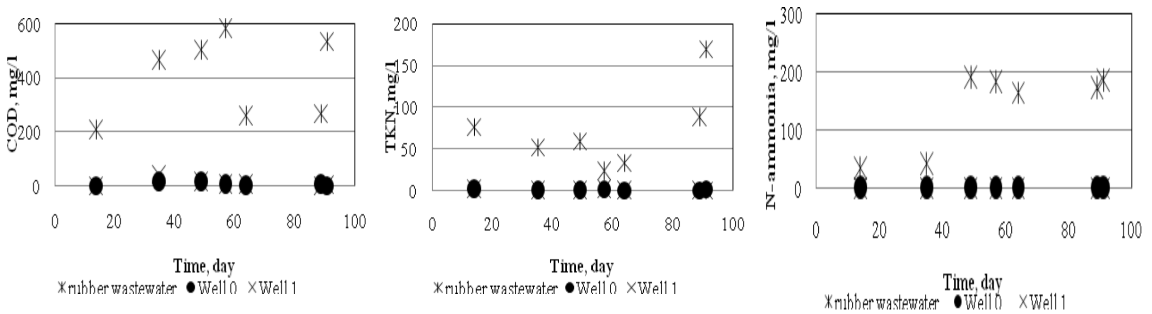
Static water levels in observation wells were at -9.5m as the drilling report while the depth of exploited water were about -20 m. The control experiment provided undetectable P - PO_4 presence. Phosphorus is usually in form of phosphate in acidic soils (alkaline soils) in which phosphate is adsorbed by iron and aluminum oxide. The effect of soil phosphorus adsorption is high if using wastewater rubber with much phosphorus. Concentrations of COD, TKN, N – NH_4 of the observation well No. 1 were lower than the control well's. These results showed similar to the permeability experiment (Lam, 2013), at a depth of 20 m, TKN and N - NH_4 were not detected, due to adsorption process of soil together with biological conversion of ammonia.

Pollution spreading in groundwater

The results of spread calculate by GMS software are shown in table 3, which show adversely distance from the border of irrigation area (with sides 100m × 100m) to the position at which the concentrations of COD and ammonia reaching the limit values of groundwater quality of QCVN 09:2008/BTNMT for edible use (COD ≤ 4 mg/l and N – NH_3 ≤ 0.1 mg/l).

Note: Q_{max} = Irrigation load (m^3/ha/day), H – Static water level, m

When irrigating latex wastewater with low concentrations of COD and ammonia (COD = 500 mg/l, N – ammonia = 150 mg/l), wells must be 60 m far from irrigated areas. This distance requires 30 m if COD is 250 mg/l. Results of COD and BOD of the GMS showed similar to the report of the EPA (1981), water quality by land treatment with BOD_5 ≤ 5 mg / l and N-NH_4 < 2 mg/L for the irrigation load weight 6 cm / week and BOD_5 load from 7-35 kg BOD_5/ha/week.



a) b) c)

Figure 2. *Change of contaminant concentrations: (a) COD, (b) TKN and (c) N – ammonia for irrigation water and water observation wells*

Table 3. *The results of spread calculate by GMS software*

	Distance (d) from the borders adverse to reach COD= 4 mg / l at static water level (m)					**Distance (d) from the borders adverse to reach ammonia= 0.1 mg / l at static water level (m)**				
Rubber Waste water	H(m) / Q_{max}	*0.5*	*2,0*	*5,0*	*10*	H(m) / Q_{max}	*0,5*	*2,0*	*5,0*	*10*
	COD (mg/l)	30	50	80	120	N – NH_3 (mg/l)	30	50	80	120
	1000	60	80	80	100	500	10	10	10	30
	500	30	60	60	80	150	10	10	10	20
	250	10	30	40	60	60	10	10	10	10

Scanning electron microscopy SEM

Scanning electron microscopy (SEM) images was used to compare the soil quality among controlled site (D3) and irrigated site (CS3), detailed in *Fig.3*. At magnification 100, the images showed that the porous medium of CS3 had a lower total porosity than D3. However, soil porosity between CS3 and D3 were not different at magnification 1000 and may result in contaminants movement in the same way among these sites.

CONCLUSION REMARKS

The results of latex wastewater spreading showed that shallow groundwater was affected with COD and ammonia in the irrigation areas higher than QCVN 09:2008/BTNMT, column A. This groundwater should be used for industry or irrigation targets. Scale irrigation experiment in the pilot at rubber block with the amount of water for the experiment block is about 8 m^3/ha/week and the load of COD water is 0,5 kg COD/ha/day with *latex effluent*, bCOD absorbed in static water 9.5 m can be reduced completely (~ 100%). As results of the GMS, TN and COD concentrations spread in the groundwater have stable after 10 months of continuous irrigation with static water levels 2 m and after 12 months with static water levels 10 m.

FUTURE WORKS

Nutrients of the treated latex processing may be reused for perennial trees like rubber trees. However, impacts of the reclaimed water need to be evaluate toxicity of chemical substances and mixtures using natural soils to microbial populations indigenous. The specific objectives are to assess the changes in soil chemical and physical properties induced by irrigation, to highlight the involved microbial health, and, to characterize the role and behavior of the organic matter.

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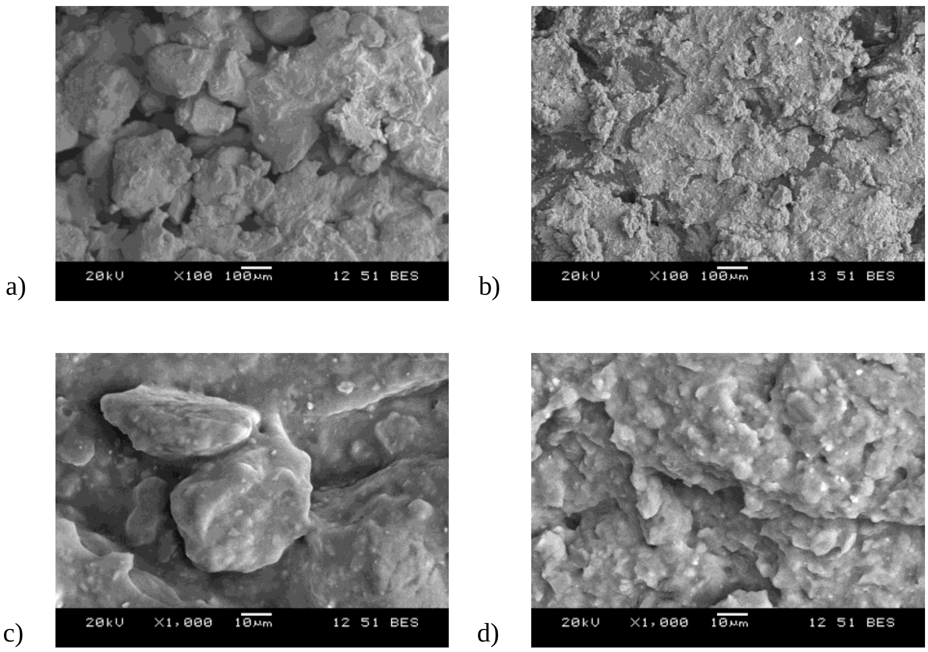

Figure 3. *SEM at magnification of 100: a) D3 – inside L0, b) CS3 – inside L1, and 1000: c) D3 – inside L0, d) CS3 – inside L1*

REFERRENCES

1. Vietnam Rubber Group – Report of wastewater treatment 2010 (2010),3 (in Vietnamese)
2. Viet. N. T – Thesis: Sustainable treatment of rubber latex processing wastewater: The UASB system combined with aerobic post-treatment, Proefschrift Wageningen Universiteit, 12.
3. Dan N. P, Nhung T. T. M, An H. K – Establishing standard and management mechanism of reclaimed water. Environment and Natural Resources Protection Conference 2006-2009. DOST - HCMC, 12/2009. (in Vietnamese)
4. Shiklomanov. Igor.A, World water resources – A new appraisal and assessment for the 21st century, United Nations, Educational, Scientific and Cultural Organization, 1998, 27.
5. ANPHA, AWWA, WPCF - Standard methods for the Examination of Water and Wastewater, 20th Edition. American Public Health Association. Washington, D.C. (1999).
6. U.S. EPA. Wastewater Technology Fact Sheet Rapid Infiltration Land Treatment. EPA 832-F-02-12, September 2002, 3.
7. Cincinnati., Ohio, Process design manual land treatment of Muicipal wastewater effluent, EPA/625/R-06/016, September 2006,2.
8. QCVN 01:2008/BTNMT: National technical regulation on the effluent of natural rubber processing industry.
9. QCVN 09: 2008/ BTNMT: National technical regulation on underground water quality.
10. Peng Wang and Arturo A. Keller. Natural and Engineered Nano and Colloidal Transport: Role of Zeta Potential in Prediction of Particle Deposition, Langmuir 2009, 25(12), 6856–6862.
11. Yong Wang and Jun Jiang. Phosphate adsorption at variable charge soil/ water interfaces as influenced by ionic strength. Australian Journal of Soil Research, 2009, 47, 529-536.

TÓM TẮT

ĐÁNH GIÁ TÁI SỬ DỤNG NƯỚC THẢI NGÀNH CHẾ BIẾN MỦ CAO SU ĐẾN CHẤT LƯỢNG NƯỚC NGẦM CHO TRỒNG CÂY LÂU NĂM

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Nghiên cứu nhằm đánh giá ô nhiễm nước ngầm trong tái sử dụng từ nước thải mủ cao su để tưới cây lâu năm. Nước thải mủ cao su có chứa hàm lượng nitơ cao và BOD cao, đòi hỏi phải được áp dụng công nghệ xử lý bậc cao để có thể đáp ứng tiêu chuẩn nước thải công nghiệp Việt Nam. Việc tái sử dụng nước thải sau xử lý bậc hai để tưới cây cao su có thể mang lại lợi ích do giảm chi phí xử lý đồng thời tái sử dụng chất dinh dưỡng.

Mô hình thí nghiệm được tiến hành với hai nghiệm thức, đó là nghiệm thức tưới và nghiệm thức không tưới với 100 cây cao su cho mỗi nghiệm thức. Diện tích mỗi nghiệm thức là 7m x 2,5m. Nước tưới được lấy từ đầu ra sau bể ổn định của hệ thống xử lý nước thải mủ cao su. Lưu lượng, tải lượng ô nhiễm và COD được sử dụng là 8m^3/ha/tuần, 12,5 kgN/ha/ngày và 0,5kg COD/ha/ngày.

Mô hình GMS đã được áp dụng để đánh giá lan truyền nitơ và COD trong tầng nước ngầm. Mô hình cho thấy phản ứng chuyển hóa sinh học của COD và nitơ trong tầng vadose. Kết quả nghiên cứu cho thấy tổng nitơ và COD trong nước ngầm đạt được mức độ ổn định ở độ sâu 2 mét sau khi tưới 10 tháng và ở độ sâu 10 mét sau khi tưới 12 tháng. Ngoài ra, kính hiển vi điện tử quét (SEM) được sử dụng để so sánh chất lượng đất giữa các vị trí thử nghiệm.

Từ khóa: *Nước thải ngành chế biến mủ cao su, tái sử dụng dinh dưỡng, tiêu chuẩn nước thải công nghiệp Việt Nam, mô hình dòng chảy nước dưới đất (GMS), kính hiển vi điện tử quét (SEM).*

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