ASSESSMENT IMPACT OF RECLAIMED WATER TO SOIL QUALITY BASED ON SOIL MICROBIAL COMMUNITY TOXICITY

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ABSTRACT

The research aimed to evaluate environmental risk of reused wastewater on soil applying slow-rate land treatment to irrigate rubber field. The experiment was conducted in the Vietnam Rubber Research Institute, Ben Cat ward, Binh Duong province. The wastewater of latex processing after secondary treatment may potentially harm to soil quality that would be showed through microbial community. The method used natural bacteria and determined inhibition effect on the soil microbial community bacteria in order to assess the changes in soil chemical and physical properties induced by irrigation. NH_3, and NO_3 concentrations to determine microbial health through measuring ammonification, nitrification, respectively, as a measure of the soil microbial community to decompose organic matter and release plant nutrients every 7 days of exposure during 28 days. Firstly, toxicity of the wastewater with different dilution (100%, 50%, 25% and 12.5%) causes soil microbial community activities and development as their nutrients. After exposing to the reused wastewater at different concentrations, most of soil parameters were increased at the day 7^{th}. Until the day 28^{th} of the experiment, concentrations of tested parameters were still not decreased. Concentration of NH_3 was decreased while organic carbon and total aerobic microorganism increased that may be resulted from metabolism processes of the soil but not from wastewater exposure. The reused wastewater of latex processing may be used to irrigate rubber trees without inhibition to the soil health.

Keywords*: Inhibitory effect, slow-rate land treatment, latex wastewater, toxicity test.*

INTRODUCTION

Vietnam to become the fourth largest exporter of natural rubber in the world (800,000 ton productivity) 4. At present, the growing rubber area is spread from the northern to the central provinces (less than 10,000ha) while other west-southern areas from over 50,000ha or between 10,000-50,000ha 5. The Vietnam rubber group reported that the rubber industry discharges 10 million m^3 wastewater every year. An average of loading rate of rubber industry is 25 m^3 wastewater/ton dried rubber, 35 m^3/ton rubber product and 18 m^3/ton latex. Rubber wastewater contains high contaminants, COD may be up to 1,000 – 10,000 mg/l, BOD_5 may be 1,700 – 9,000 mg/l and total nitrogen may be 45 – 1,600mg/l (Viet, 1999). Wastewater of latex processing was researched for irrigation 78 but pollutants are spread over a large area and may affect the crops 6. A serious threat of rubber wastewater towards environmental protection is high concentration of nitrogen in this effluent (Table 1).

Table 1. *Characteristics of process effluents from rubber processing 9*

Parameter	Typical range
pH	3.7 - 5.5
Biological oxygen demand	1,500 - 7000
Chemical oxygen demand	3500 - 14000
Suspended solids	200 - 700
Total nitrogen	200 - 1800
Sulphate	500 - 2000

All units are mg/l, except pH.

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Identification of bacteria which can grow in the concentrated latex wastewater was studied by Choorit et al., 2003. After 40 h of cultivation, 34% of COD was decreased by *Rubrivivax gelatinosus* and *Thiobacillus* sp. (Choorit et al., 2003). Four kinds of *Thiobacillus* sp. were isolated from domestic and rubber wastewaters in Thailand by Kantachote and Innuwat (2004). All isolates could grow in pH of 2.0 - 7.0 (optimum 6.5), temperature of 25 - 45°C (optimum 30 - 35°C) under both aerobic and anaerobic conditions. The highest COD removal (54%) can be obtained by *Thiobacillus* sp. WI1 cultivated in rubber wastewater for 14 days while the efficiency of strain WI4 for BOD and COD removal was 83% and 46% (Kantachote and Innuwat, 2004).

Microbial community in soil may improve the quality of the soil. Assessment of nutrient could show toxicity reduction of soil through microbial community. The specific objectives were 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. NH_3, and NO_3^- concentrations (concentrations per gram of soil) determined microbial health through measuring ammonification, nitrification, respectively, as a measure of the soil microbial community to decompose organic matter and release plant nutrients.

MATERIALS AND METHODS

Experimental site

The experiment sites were rubber plantation field located at the Vietnam Rubber Research Institute (RRIV), Ben Cat ward, Binh Duong province. The sites include rubber field and rubber factory inside the RRIV. These areas were under tropical climate. The annual rainfall of this area is 1,800mm/year.

Soil sampling and toxicity test

The surface soils were sampled randomly at 0-15 cm depth to test their physical and chemical properties using a core sampler. Soil collection should not receive any fertilizer or pesticide applications within the past 24 months. The moisture of the soil was 60%. After collecting, the surface soil samples were allowed to air dry until sievable by 2mm mesh sieve.

Soil microbial community toxicity was determined by Soil Microbial Community Toxicity Test Guidelines US EPA 712-C-96-161, 1996. The soil samples were exposed with treated rubber wastewater at different concentrations (100%, 50%, 25%, and 12.5%). The quality was tested every 7 days during 28 days.

LABORATORY ANALYSIS

Soil chemical properties

Soil chemical properties were analyzed in the Laboratory of Faculty of Environment and Natural Resources of HCMUT including: soil pH, nitrogen (NH_3, NO_2, NO_3, TKN), organic matter, total aerobic microorganism. Parameters were tested by Standard Methods for the Examination of Water and Wastewater (APHA, 1998), published by American Public Health Association, American Water Works Association and Water Environment Federation.

Soil Microbial Community Toxicity Test

Soil microbial community toxicity was determined by Soil Microbial Community Toxicity Test Guidelines US EPA 712-C-96-161, 1996. After sampling, all soil samples were incubated in darkness at approximately 22°C. Soils are then sampled on 5th day and 28th day and analyzed for NH_3 and NO_3 concentrations to determine microbial health through measuring ammonification, nitrification, respectively. Control samples were received a similar amount of water without the reused wastewater.

RESULTS AND DISCUSSION

Effects of the exposure to physical properties of the soil

pH:

Then soil samples were exposed from the day zero to the 28th. The result showed that pH of all samples decreased from time to time, from 7 to 4 (Fig. 1). However, pH of control samples were also down over time. This proved that soil pH was not only effected by contaminants of the wastewater but also depended on substances of natural soil. This report agrees with the observations of Eneje (2012) who reported that the soil pH of the rubber plantation is very strongly acidic (4.38) at 0-15cm 12.

Moisture:

At wastewater concentrations of 12.5; 25; 50 and 100%; moisture decreased over time from 65.33% to 40.88% (Fig. 2). Reduction of moisture from time to time affected on soil pH. This agrees with the observation of Eneje (2012) who reported that there was position correlation between moisture and pH value.

Effects of the exposure to chemical properties of the soil

Nitrogen:

Fig. 3 showed that TKN ratio of initial and exposure samples were down from time to time. With control samples, TKN concentration was also down at lower level than exposed samples. Being exposed at different concentrations, variation of TKN levels were very clearly at negative correlation between wastewater concentrations and soil TKN. This was proved that low concentration of wastewater supplied organic matter for microbes' activities.

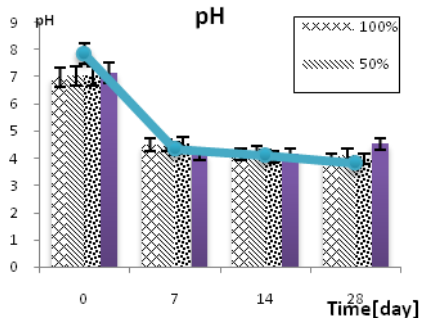

Figure 1. *Variation of pH during the exposure of reused wastewater with different dilution*

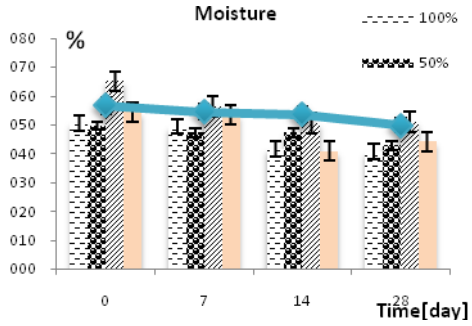

Figure 2. *Variation of moisture during the exposure of reused wastewater with different dilution*

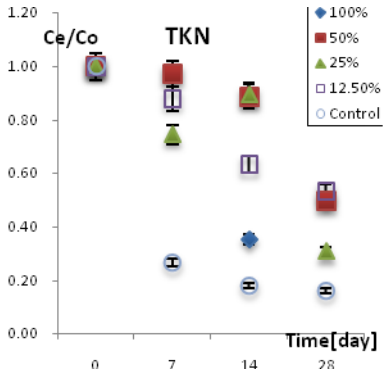

Figure 3. *Variation of TKN during the exposure of reused wastewater with different dilution*

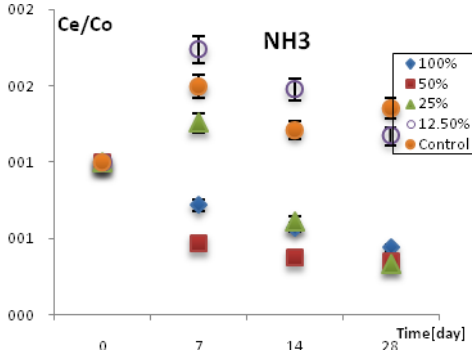

Figure 4. *Variation of NH_3 during the exposure of reused wastewater with different dilution*

NH_3 was clearly correlated with soil microbial community activities. Fig. 4 showed that NH_3 of control samples was slightly lower than other exposed samples. The result showed that treated rubber wastewater remained nutrients supplied to microbes development. However, microbes' activities were highest at 12.5% among other concentrations. With 100% of wastewater exposure, NH_3 concentration was up at the day 7th, and then decreased rapidly after the day 14th. This was showed that contaminants of the wastewater at high level inhibited soil microbial community along with time. Toxicity of the wastewater with different concentrations causes soil microbial community activities and development as nutrients that were showed by NH_3 increasing. In the next 14 days, combination between nutrient reduction and soil accumulative chemicals (metabolism products of microbes) may inhibit on microbes that was proved by NH_3 decreasing. The decrease was showed clearly in 100% compared with NO_2 incease to the 14th day at the same concentration while NO_3^- increased until the day 14th, 28th; NO_2^- decreased in negative correlation with NO_3^- (Fig 5 and 6). At first, microbes' activities were in adaption stage then proceed of the development and parameters were up respectively. The higher level of the wastewater may resulted in the stronger inhibitory of the microbial community.

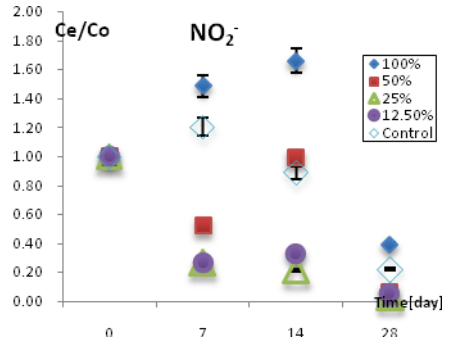

Figure 5. *Variation of NO_2 during the exposure of reused wastewater with different dilution*

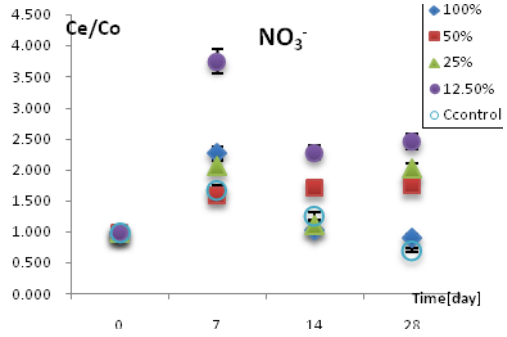

Figure 6. *Variation of NO_3 during the exposure of reused wastewater with different dilution*

Carbon:

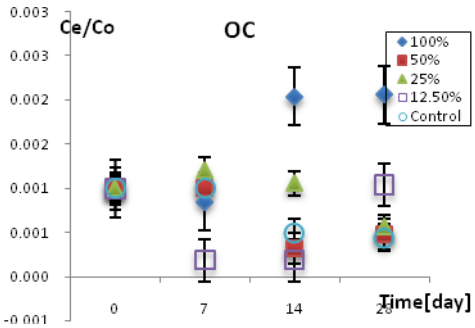

Figure 7. *Variation of organic carbon during the exposure of reused wastewater with different dilution*

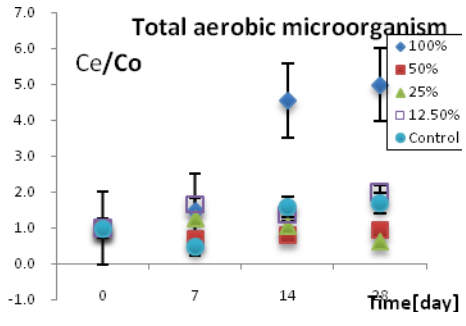

Figure 8. *Variation of total aerobic microorganism during the exposure of reused wastewater with different dilution*

While organic carbon and total aerobic microorganism were increased (Fig 7 and 8). This may be due to microbes' development creating biomass growth up. Thus, concentration of NH_3 reducing may not result from higher level of the wastewater but from other metabolism processes. In addition, there was still no sign of reducing of its growth until the day 28th. In conclusion, the reused wastewater of latex processing may be used to irrigate rubber tree and have no inhibition to the soil health.

CONCLUSION

Toxicity test basing on soil microbial community was quickly, easily to conduct for toxic substances whose exposure is not anticipated. This test can be used to measure of the soil microbial community to decompose organic matter and release plant nutrients. After exposed to the reused wastewater at different concentrations, most of soil parameters were increased at the day 7th. Until the day 28th of the experiment, concentrations of tested parameters were still not decreased. Concentration of NH_3 was decreased while organic carbon and total aerobic microorganism increased that may be resulted from metabolism processes of the soil but not wastewater exposure. The reused wastewater of latex processing may be used to irrigate rubber trees without inhibition to the soil health.

Acknowledgment. The authors deeply appreciate financial support of DOST of Binh Duong.

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TÓM TẮT

ĐÁNH GIÁ ẢNH HƯỞNG NƯỚC TÁI SINH ĐẾN CHẤT LƯỢNG ĐẤT DỰA TRÊN ĐỘC TÍNH CỘNG ĐỒNG VI SINH VẬT ĐẤT

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Nghiên cứu này nhằm đánh giá rủi ro môi trường của nước thải được tái sử dụng bằng phương pháp cánh đồng lọc chậm để tưới cho cây cao su. Thí nghiệm được tiến hành tại Viện Nghiên cứu Cao su Việt Nam, phường Bến Cát, tỉnh Bình Dương. Nước thải của ngành chế biến mủ cao sau xử lý thứ cấp có khả năng gây tổn hại đến chất lượng đất được đánh giá qua hoạt động của cộng đồng vi sinh vật. Phương pháp này sử dụng vi khuẩn tự nhiên và xác định khả năng ức chế vi khuẩn trên cộng đồng vi sinh vật đất để đánh giá những thay đổi về hóa học và tính chất vật lý đất do nước tưới gây nên. Nồng độ NH_3, NO_3 được sử dụng để xác định sức khỏe của vi sinh vật thông qua các thông số quá trình amon hóa, nitrat hóa. Phương pháp này đánh giá hoạt động phân hủy chất hữu cơ và giải phóng các chất dinh dưỡng của cộng đồng vi sinh vật đất mỗi 7 ngày tiếp xúc trong thời gian 28 ngày. Đầu tiên, cộng đồng vi sinh vật sử dụng các chất có trong nước thải ở các nồng độ pha loãng khác nhau (100%, 50%, 25% và 12,5%) để hoạt động và phát triển. Sau một thời gian tiếp xúc với nước thải, hầu hết các thông số đất đều tăng lên ở ngày thứ 7. Cho đến ngày thử nghiệm 28, nồng độ của các thông số thử nghiệm vẫn không giảm. Nồng độ NH_3 giảm trong khi cacbon hữu cơ và tổng vi sinh hiếu khí tăng có thể là kết quả của quá trình trao đổi chất của đất, không phải do tiếp xúc với nước thải. Nước thải tái sử dụng chế biến mủ cao su có thể được sử dụng để tưới cho cây cao su mà không có sự ức chế đối với sức khỏe đất.

Từ khóa: *Ức chế, phương pháp cánh đồng lọc chậm, nước thải ngành chế biến mủ cao su, thử nghiệm độc tính cộng đồng vi sinh vật đất.*

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