CHANGING OF SOIL STABILITY IN IRRIGATION WITH RECLAIMED WATER

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SUMMARY

This study sets out to investigate the potential damage of treated latex wastewater in irrigation, among which is the possible degradation of soil structure and stability. Study field is located in Rubber Research Institute of Vietnam, Ben Cat, Binh Duong.The rubber field was irrigated by treated latex wastewater and stopped from September 2012 to April 2015 (16 months after irrigating). Soil was sampled on surface to characterize physical, chemical properties of soil. Probable risks for adverse changes in the structure and stability of soil were characterized: pH, EC (electrical conductivity) of water extracts and exchangeable cations (Ca, Mg, K, and Na) and Sodium Adsorption Ratio (SAR).Scanning Electron Microscopy (SEM) was used to analyzed chemical properties in the soil. The study emphasizes the need to carefully examine irrigation water quality and suggests that shrinkage analysis could be used to monitor the physical changes of soil properties.

Keywords: *treated wastewater, soil stability, soil salinity, Sodium Adsorption Ratio (SAR), Scanning Electron Microscopy (SEM).*

INTRODUCTION

The differential nature of treated waste water to the original water source, along with the need to use the treated wastewater (TWW) for irrigation increased, may appear environmental issues, including the decline in the structure and the stability of the land.These risks can occur for adverse changes in the structure and the stability of the soil and hydraulic properties of soil irrigated with TWW so may stem from the higher reaction from dissolved organic matter, suspended solids, sodium absorption ratio (SAR), and salinity in TWW than water source [1].

During 1996 and 2010, results of researches showed that impacts of TWW irrigation were closely related to soil stability, soil texture (e.g. clay sedimentation in the deeper soil layers, stable, saturated hydraulic conductivity, flow regimes and land degradation). The results showed that the water quality is impacted from waste, depending on the nature of the soil (e.g. texture, humus) and environmental conditions (e.g. methods of cultivation, the proportion wetting). TWW is used for watering plants and monitoring noteworthy indicators stabilize soil texture areas to ensure the sustainability of the structure.

Soil structure is an important factor, but often overlooked, in the processes occurring in soil, such as hold and filter water, nitrogen and phosphorous cycles, and reduce greenhouse gas [2]. Soil structure decline is increasingly seen as a form of land degradation [3]. Soil structure directly affects the ability to retain and transport water and organic components and inorganic, affecting movement of water in the soil and maintain, erosion, nutrient recovery, absorption of roots, and yield [4]. Probable risks for adverse changes in the structure and stability of soil were characterized: pH, EC (electrical conductivity) of water extracts and exchangeable cations (Ca, Mg, K, and Na) and Sodium Adsorption Ratio (SAR).

MATERIALS AND METHODS

Study sites

Study field is located in Vietnam Rubber Research Institute, Ben Cat, Binh Duong. Undisturbed soil samples were collected at two rows of rubber in the surface layer 10cm-22cm with geography site (Table 1).

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Table 1. *Location of soil samples*

Rubber trees	TWW Irrigated rubber trees			Non irrigated rubber trees		
Depth of soil	17 cm	10 cm	15 cm	22 cm	19 cm	14 cm
GPS coordinate	$11^0$11’46”N, $106^0$36’34”E	$11^0$11’46”N, $106^0$36’35”E	$11^0$11’45”N, $106^0$36’36”E	$11^0$11’46”N, $106^0$36’34”E	$11^0$11’45”N, $106^0$36’35”E	$11^0$11’45”N, $106^0$36’37”E

Table 2. *Physical and chemical properties of the soil*

Natural moisture	Natural weight	Dried weight	Density	Porosity	Void ratio	Saturation rate	Permeability coefficient
%	g/cm^3	g/cm^3	%		%		cm/s
20.4	2.01	1.67	2.60	35.8	0.557	95	9.0×10^{-6}

(Source: Laboratory of Faculty of Geology and Petroleum Engineering, HCMUT)

Soil sampling

Physical and chemical of soil in the field were surveyed under the Standard 22 TCN 259-2000 [5].The rubber field was irrigated by treated latex wastewater and stopped from September 2012 to April 2015 (16 months after irrigating).Three (03) soil samples were taken on the rubber rows at depth 10cm to 22 cm (Table 1), and packed, then transported to the Lab for testing.The controlled lot was taken three (03) samples as the same steps.

Table 3. *Change of electrical conductivity before and after irrigating*

Parameter	Non-irrigated	Irrigated
pH	6.3	6.14
t^0 (^{o}C)	29.6	30.8
EC (μS/cm)	0.221	0.443

Physical and chemical soil analyses

H170 Portable pH & Conductivity Meter Starter Kit is used to test pH, temperature, Electrical conductivityof soil at the site.After sampling, the air dried soil samples were crushed and sieved to <2mm size. Cations (Ca, Na, Mg, and K) were analyzed by Inductively coupled plasma mass spectrometry (ICP-MS), under EPA 200.9 [6].Electrical conductivity (EC), Sodium Adsorption Ratio (SAR) were typically used to evaluate soil salinity problem of soil. In which, SAR was calculated by the below formula:

SAR = $[Na^+]$/SQRT (($[Ca^{2+}]$ + $[Mg^{2+}]$)/2) (Eq-1)

To evaluate changes of ions in soils, electronimages at 600μm were analyzed by the Scanning Electron Microscopy INCA at Innovation lab, Ryerson University, Toronto, Canada. Option of processing was normalized as all elements analyzed with 5 iterations.

RESULTS AND DISCUSSIONS

Physical and chemical properties of the soil

Result of soil geology survey, 32 of 40 drill holes were determined as clay loam (table 2) with grey-yellow, grey-white at 1 to 11 meter or 1 to 15 meter. Other holes were clay mud with plum at 1 to 15 meters. Permeability rates were varied from 1.97×10^{-6} (cm/s) to 3.14×10^{-6} (cm/s) among these drill holes. Physical and chemical of soil in the field were characterized as the table 2.

The soil moisture 20% means that organic nutrient of the soil was poor that leads to less water holding capacity. These may cause drough of soil, and limit crop productivity [7]. The table 3 shows that EC of TWW irrigated lot was high as twice as the controlled lot. The different EC was caused by transportation of existed ions of TWW, but not remarkableness. Meanwhile, pH parameter was slight down due to increased H^+ in soil.This result was in agreement with the observed chemical properties of Mariam Y. Sou, in which pH was decreased from 8.4 to neutral level.

The Fig.1b, 1c, 1dshows that K^+, Ca^{++}, Mg^{++}ions of the non-irrigated lot were moved down the deeper layer. These means that K^+, Ca^{++}, Mg^{++} movements were vertical direction. However, it seems that Na^+ transportation was contrast. The differentiate proves that there is no rule of cations movement but depending on ions'affinity to substances existing in the water or effect of molecular weight in which $Na^+ < Mg^{++} < K^+ < Ca^{++}$.

Changes of ions accumulation capacity in soil

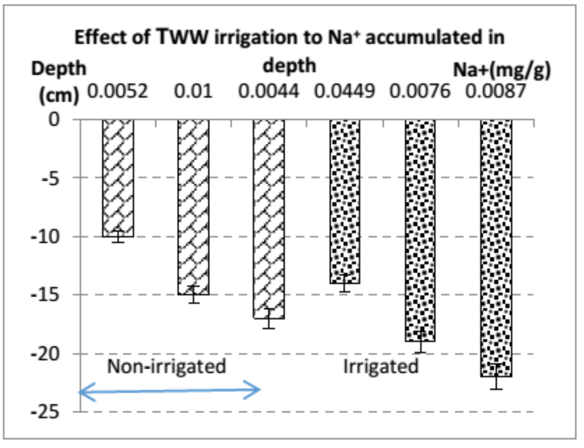

Fig. 1a. *Effect of TWW irrigation to Na+ accumulated in depth*

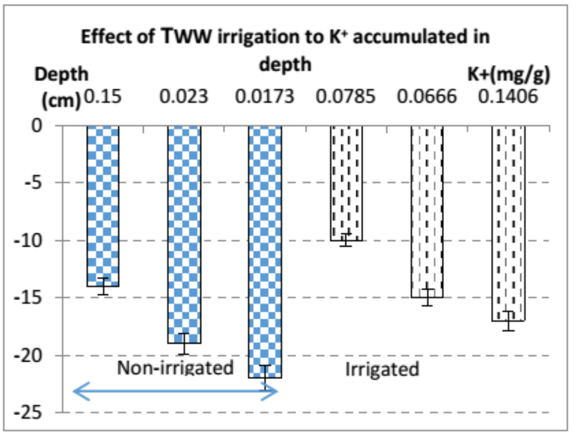

Fig. 1b. *Effect of TWW irrigation to K^+ accumulated in depth*

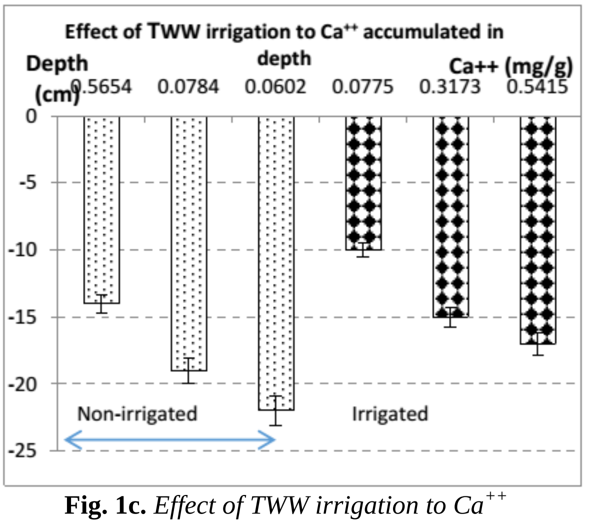

Fig. 1c. *Effect of TWW irrigation to Ca^{++} accumulated in depth*

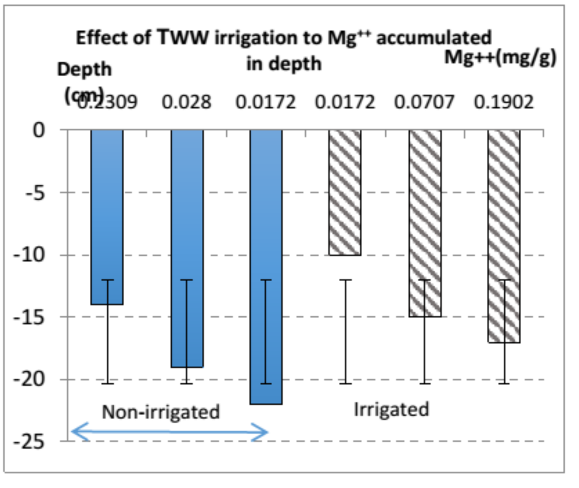

Fig.1d. *Effect of TWW irrigation to Mg^{++} accumulated in depth*

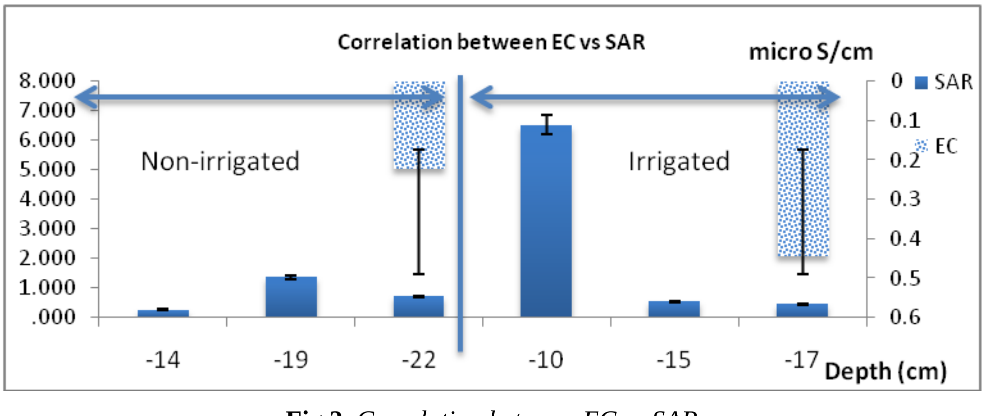

Fig.2. *Correlation between EC vs SAR*

The EC increasing of the reclaimed water irrigation lot was thesame asin comparison with SAR changes between the two lots.In the controlled lot, SAR level was depended on presented cations (no rule for various depths). Applying TWW irrigation, EC level was high up twice and clear change of SAR level. The high level of SAR concentrates right on subsurface layer (high humus soil layer) and slowly decreases on depths 10cm – 15cm – 17cm as 6.53mg; 0.55mg; 0.45mg respectively.Also, according to US salinity Laboratory Staff [7], a saline soil has an EC of the saturated paste extract of more than 4 dS/m. EC of saturated soil is greater than 4dS / m, equal to 40mmol salinity / liter. Salt tolerance of plants is very diverse and some species may be negatively affected if EC <4dS / m[8].

The SAR showed different to the result of Mariam Sou [9] that irrigated plots had larger SAR. Also, EC increased and reached a value of 1,567µs/cm.These might result from higher sodium concentration, and with rapid movement downward of the cations.

Electron images analyses of chemical properties changes

The Fig.3a,3b shows that the differentiate of atomic spectrum between the two lots which is clearly presented the peaks possibly omitted 0.270, 2.130 keV.In comparison with the non-irrigated soil samples (Fig.4), percentage of elements were higher than the irrigated soil samples. Particularly, iron percent was lowest and other elements were higher as Si, Al and O. These proves that high oxygen may come from the TWW and help microbial community activities in soil.

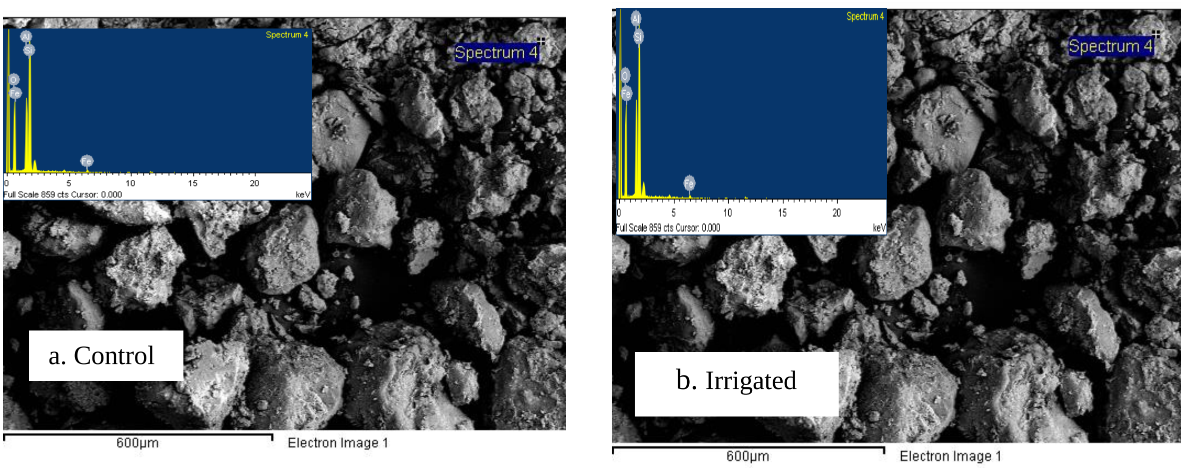

Fig. 3. a.b. *Atomic spectrum of soil in non-irrigated (control) and irrigated soil samples*

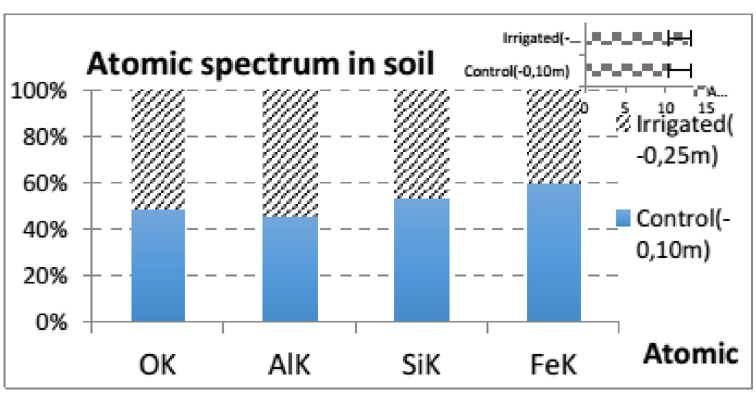

Fig.4. *Correlation of atomic in non-irrigated (control) and irrigated soil samples*

Table 4. *Analyses percentage of elements*

Sample	Atomic (Weigh, %)	Min	Max	Average	STDEV
Control	OK	51.01	64.27	58.858	±5.616
	AlK	1.62	16.52	10.715	±6.555
	SiK	17.71	38.93	29.108	±8.974
	FeK	1.5	2.21	1.757	±0.394
Irrigated	OK	56.58	67.96	61.365	±4.764
	AlK	11.46	13.77	12.673	±0.952
	SiK	19.62	28.6	24.81	±3.754
	FeK	0.95	1.56	1.1475	±0.278

Analysist results of elements'atomic percentageswere presented in the table 4 that oxygen percentagesin both lots were highest comparing to other elements (Al, Si, Fe).The iron percents were from 1.50% to 2.21% (±0.394) in the control lot and decreased from 0.95% to 1.56% (±0.278) in the irrigated lot. Decreasing of iron was agreement in pH slightly down to 6.14 (table 3).Soil chemical changes causing from accumulation capacity of ions in the soil may leads to changes of transportations of contaminants in porous media.Ionic strength is a property affecting the settling behavior of soil particles. According to Sparks [10], increasing ionic strength may screen repulsive forces between two particles, enhance the aggregation. In the study of Hur and Jung [11], conductivity was used to measure the ionic strength of soil suspension solutions.

CONCLUSIONS

In conclusion, saline of soil in the TWW irrigated lot is not higher than the recommended level to ensure soil stability, soil structure or soil damage for the clay loam. These might result from short monitoring time to evaluate soil salinity. Meanwhile, SEM analyze proveseffects of irrigation water components to vary ions in the soil or soil particles. Soil chemical changes causing from accumulation capacity of ions in the soil may leads to changes of transportations of contaminants in porous media.

Other studies on shrinkage, swelling of soil should implement in certain soils and conditions and to evaluate soil structure stability of long term use.

Acknowledgements

We deeply thank all supports from the RRIV, Binh Duong DOST, CARE-Rescif center, HCMUT (number granted T-MTTN-2015-95) and also FENR, CEPP Labs of HCMUT.

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TÓM TẮT

ĐÁNH GIÁ SỰ THAY ĐỔI CHẤT LƯỢNG ĐẤT TRỒNG CÂY TỪ VIỆC TƯỚI BẰNG NƯỚC THẢI SAU XỬ LÝ

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Nghiên cứu được thực hiện tại Viện Nghiên Cứu Cao Su Việt Nam, huyện Bến Cát, tỉnh Bình Dương nhằm xác định ảnh hưởng của việc tưới cây bằng nước thải cao su sau xử lý đến chất lượng đất trồng cây. Vườn cây cao su được tưới bằng nước thải cao su sau xử lý và ngưng tưới từ tháng 9/2012 đến tháng 4/2015 (ngưng tưới 16 tháng). Các mẫu đất được tiến hành lấy mẫu để xác định các thông số vật lý như pH, độ dẫn điện EC, thông số hoá học như khả năng trao đổi cations (Ca, Mg, K, và Na) và tỷ lệ hấp thụ Natri (SAR) nhằm đánh giá các ảnh hưởng đến cấu trúc, tính ổn định của đất trồng cây. Các phân tích hình ảnh bằng kính hiển vi điện tử quét được sử dụng để đánh giá sự thay đổi tính chất hoá học đất, thể hiện năng lượng nguyên tử của các ions hiện diện trong đất. Việc áp dụng nước thải sau xử lý (nước tái sinh) cần được cân nhắc kỹ lưỡng chất lượng nước tưới, đánh giá ảnh hưởng đến sự thay đổi cấu trúc đất.

Từ khoá: *nước thải cao su sau xử lý, tính ổn định của đất, độ muối của đất, tỷ lệ hấp thụ Natri (SAR), kính hiển vi điện tử quét (SEM)*

Ngày nhận bài:20/6/2015; Ngày phản biện:06/7/2015; Ngày duyệt đăng: 30/7/2015

Phản biện khoa học: *ThS Nguyễn Thị Thu Thủy - Trường Đại học Kỹ thuật Công nghiệp - ĐHTN*

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