

INFLUENCE OF BIO-ETHANOL DISTILLATION RESIDUE ON WATER QUALITY OF AN UNDERGROUND DAM

By

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KEYWORDS: Bio-ethanol, Sugarcane, Vinasse.

Abstract

BIO-ETHANOL made from sugarcane is considered clean energy since the carbon accumulated in the plant is obtained from the atmosphere so that there is no net CO₂ flux when the biomass-energy is burned. In Okinawa, where the major sugarcane production takes place in Japan, a project for making bio-ethanol from molasses is being conducted. However, wasted liquid, called vinasse, that is 15 times as much as the distilled ethanol, is generated during the distillation, which is certainly a problem when creating sustainable energy. This vinasse is extremely dark brown and contains highly concentrated macro- and micro-nutrient elements, so it could be used as a liquid fertiliser. However, effects of the application of the vinasse on a soil are unknown. In addition, in Miyakojima in Okinawa, where the cultivated land area is limited and depends on an underground dam as a main water source, the sugarcane growers are anxious about the influence of colour especially and nitrate contamination of ground water by applying vinasse to their fields. We examined how the application of vinasse affects the ground water by analysing the drainage through a soil column after the application of 500 mL of vinasse and diluted vinasse over a 29-day period. From the ionic analysis for the nitrate concentration of the drainage of the each column, the potential for nitrate contamination in the underground dam by applying the diluted vinasse is of little concern. By the fact that application of the genuine vinasse caused the highly colored drainage, and with respect to possible salinity, we propose that the amount and times of diluted vinasse application as a fertiliser be limited.

Introduction

Japan imports about 80% of its energy. The Ministry of Economy, Trade and Industry and the Ministry of the Environment in the Japanese Government launched a project for producing bio-ethanol from the materials which do not conflict with food, such as dumped foodstuffs, extra-lumber for architecture and molasses.

The amount of the bio-ethanol made in Japan in 2005–2006 was about 30 kL, and a lot of effort is needed to accomplish the short term goal, 1.5 million kL/year, by 2015.

In Miyakojima Island in Okinawa, the area of sugarcane is around 8400 ha and the total amount of the production of sugarcane is approximately 300 kt.

In this island, producing bio-ethanol from molasses is being worked on as a part of the project. About 6000 t/year of molasses is made, and most of it has been transported to the main island of Japan for use as food for livestock. In the distillation process, ethanol is refined out of the residue, called vinasse.

In Miyakojima Island, at the refinery, 15–20 litres of vinasse for each litre of ethanol are produced, while using conventional technologies, 10–13 litres is produced in Brazil (Rocha *et al.*, 2007). The vinasse in Miyakojima is an extremely dark, brown-coloured liquid, of acid nature, which has highly concentrated chemical components.

Returning vinasse to the farm as a partial or total substitute for mineral nutrients is thought to be a possible solution for disposal of the vinasse (Rocha *et al.*, 2007).

However, since an underground dam supplies domestic water for the people in Miyakojima, sugarcane growers are concerned about the influence of the vinasse on it. In addition, nitrate contamination to the underground dam is also a concern.

The objective of this study is to assess the impact of diluted or non-diluted vinasse application on the groundwater by analysing drainage infiltrated through soil.

For the analysis, a column study was conducted and the turbidity, pH, EC and anions in the drainage were measured.

Materials and methods

Soil sample and vinasse material

The soil we used in this experiment was located in the experimental field in the University of the Ryukyus. The soil is low alkaline red clay soil and is widely spread in the Okinawa main island and in the other small separated islands, including Miyako Island.

The vinasse from the experimental bio-ethanol producing facility in Miyako Island had been applied to a column study. The vinasse is dark brown colored and, has highly concentrated chemical elements (Table 1).

Table 1—Chemical properties of the vinasse used in this experiment.

	Na	Mg	P	S	K	Ca	Cl ⁻	NO ₃ ⁻	pH
	mg L								
Vinasse	603	2709	180	4164	23 970	1564	11 082	0	4.1

Column study

A total of 5 columns were made from polyvinyl chloride (PVC) pipe with inside diameter of 18.2 cm, length of 105 cm and a drain-hole with 1.5 cm diameter at the side 1 cm above the bottom of the column.

The bottom of the column was closed by the square PVC board which allowed the column to stand still. Twenty centimetre length tubes were fixed into the drain-hole, connecting the column and the flask which collects the drainage sample coming through the column.

The column was filled with mixed soil, 4 of 5 columns were saturated with water to compare buffer effects of soil with and without water, which was expected to allow the components of the vinasse to move more freely and remained for 24 hours to let the water drain by gravity.

The depths of the soil in the each column were equal to 96 cm. The photographs of the column just before the application are shown in Figures 1 and 2.

We set up 4 series of vinasse applications with 3 different concentrations of vinasse and 1 control (water) versus saturated soil columns, and a vinasse versus an unsaturated soil column.

Table 2 shows a tested series of column study. The different concentrations of vinasse were: a raw vinasse and diluted vinasse by 10% and 2%, and 500 mL of water poured into the column by hand. Sample-collections and applications were performed every morning. Samples were reserved in the refrigerator at 4°C.

Table 2—Tested series of column study.

Column code	Vinasse application	Pre-soil condition
	Rate of dilution(%)	Saturated(+)/ unsaturated(-)
A	—	—
B	—	+
C	10	+
D	2	+
E	Water (control)	+



Fig. 1—The prepared columns.



Fig. 2—The flask collecting the drainage from a column.

Measurements of the drainage water properties

For each drainage sample, we measured turbidity, pH, EC and anions. Anion contents measured were limited to nitrate, chloride and sulfate among the column c, d and e. pH and electrical conductivity were measured by turbidity sensor, pH sensor and EC meter respectively.

For the determination of anion contents in the drainage sample, each sample was filtrated through a membrane filter with a 5 mL plastic syringe to a vial of 500 μ L volume and measured by ion chromatography.

The drainage of Column A was dripped for the first time at the 16th application (8 litre), while the other columns were obtained from the beginning of the application.

Results

The chemical properties of the drainage from the each column are shown in Figure 3. In each analysis, there was little variation detected up to the 15th application. After that point, the turbidity and EC of the drainage from columns A and B (applications of genuine vinasse) drastically escalated with each additional application. However, the drainage from columns C and D showed no change in turbidity and less increase in EC than for the raw vinasse.

Only when raw vinasse was applied was there a drop in pH of the drainage to approximately 6.5. In columns C, D and E, nitrate and sulfate concentrations in the drainage showed little fluctuation, and the highest density was found in Column E followed by D, then C at the 29th application. On the other hand, the chloride concentration in the drainage from columns C and D increased although the latter showed only a little gain (Figure 4).

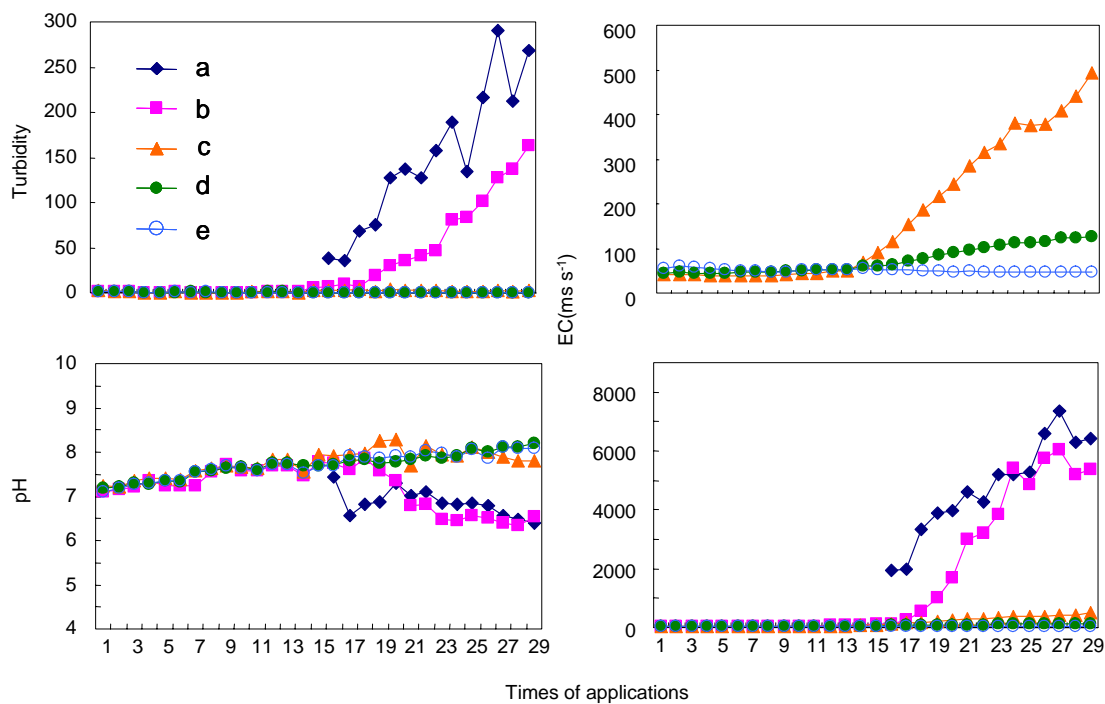


Fig. 3—Chemical analysis of the drainage collected from 5 columns, each alphabets (A, B, C, D, and E) correlates with column codes in Table 2.

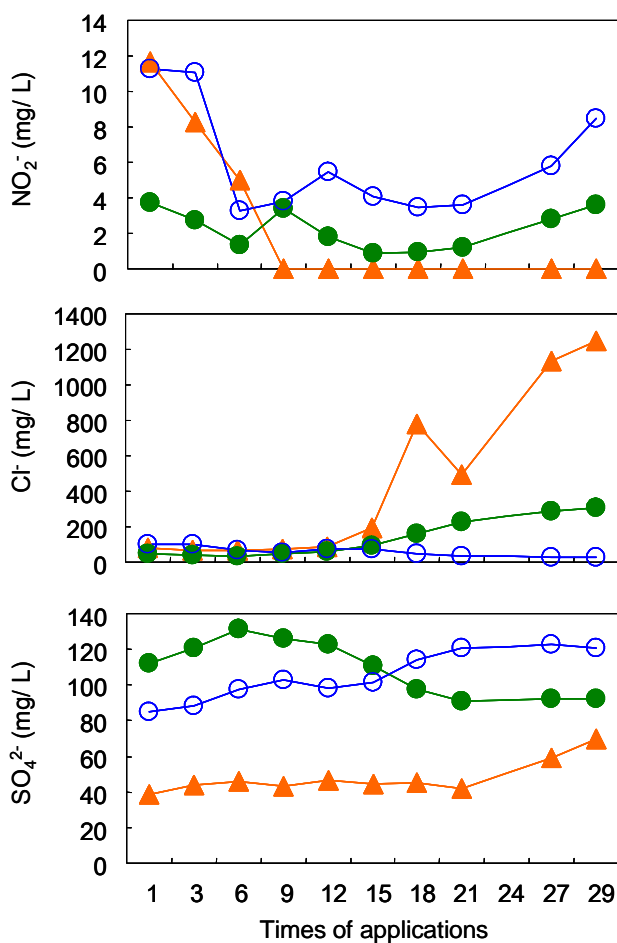


Fig. 4.—Anion analysis of the drainage from 3 columns (C, D and E).

Discussion

Effects on ground water quality

Though the present study gives the extreme results of unusual day-to-day applications of vinasse as a fertiliser, only applying the raw vinasse to the soil has the potential to cause observable effects on the turbidity and pH of the underground water.

Besides, by applying the raw vinasse to an unsaturated column continuously, both electric conductivity and pH reached the same levels as the application of the raw vinasse to a saturated column. It suggests that whether soil is wet or not, applying the raw vinasse has a potential to contaminate the underground dam once it reaches the limitation of soil capacity as a buffer.

However, considering the depth of the soil layer down to the underground dam, the fact that it took 16 applications (8 litres equivalent to 308 mm) for the raw vinasse to infiltrate the unsaturated soil thoroughly is an important consideration.

Application of a limited amount or times of a diluted vinasse may not directly affect the turbidity or pH of the underground dam. Since an increase of nitrate and sulfate ions in the drainage was not detected, the contamination of nitrate to the underground dam is of less concern.

However, the constant applications of vinasse on the soil increased the electric conductivity of the drainage, which suggests possible inhibition of the growth of crops by the application of vinasse.

The concentration of chloride and EC are highly correlated ($r = 0.94$) and when the 10% diluted vinasse was applied continually, the concentration of chloride reached more than 1200 mg/L at the 29th application.

Consequently, salinity should be considered when determining how much the vinasse should be diluted and how many times it should be applied as a fertiliser.

REFERENCES

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INFLUENCE DES RESIDUS DE LA DISTILLATION DE BIO-ETHANOL SUR LA QUALITE DE L'EAU D'UN BARRAGE SOUTERRAIN

Par

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KEYWORDS: Bio-ethanol, Sugarcane, Vinasse.

Résumé

LE BIO éthanol fabriqué à partir de la canne est considéré comme une énergie propre puisque le carbone accumulé dans la plante est obtenu à partir de l'atmosphère de telle sorte qu'il n'y a pas de flux net de CO₂ quand la biomasse-énergie est brûlée. A Okinawa, zone principale de production de canne à sucre au Japon, un projet de fabrication de bio-éthanol à partir des mélasses a été réalisé. Cependant, un déchet liquide appelé vinasse, 15 fois plus important en quantité que le bio-éthanol, est généré pendant la distillation, ce qui entraîne un problème environnemental lors de la création d'énergie durable. Cette vinasse brun foncé, est fortement concentrée en micro et macro éléments et pourrait être utilisée comme engrais liquide. Cependant, les effets de l'application des vinasses sur le sol ne sont pas connus. De plus, à Miyakojima (Okinawa), où la surface en terre cultivable est limitée et dépend d'un barrage souterrain comme principale ressource en eau, les planteurs de canne sont inquiets à propos de la coloration et de la contamination en nitrates de la nappe phréatique après application de vinasse dans les champs. Ainsi, nous avons étudié comment l'application de vinasse affecte la nappe phréatique en analysant le drainage à travers une colonne de sol après application de 500 ml de vinasse pure et de vinasse diluée pendant 29 jours. A partir des analyses de concentrations en nitrates des eaux drainées de chaque colonne, le potentiel de contamination en nitrates dans le barrage souterrain en appliquant de la vinasse diluée est un problème mineur. Du fait que l'application de vinasse entraîne un drainage fortement coloré et une possible salinité, nous proposons que les quantités et fréquences d'apports de vinasse diluée comme engrais soient limitées.

INFLUENCIA DEL RESIDUO DE LA DESTILACIÓN DE BIOETANOL EN LA CALIDAD DEL AGUA DE LA PRESA SUBTERRÁNEA

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**PALABRAS CLAVE: Bioetanol,
Caña de Azúcar, Vinaza.**

Resumen

EL BIOETANOL producido de caña de azúcar es considerado como energía limpia, dado que el carbón acumulado en la planta se obtiene de la atmósfera, de tal manera que no hay flujo neto de CO₂ cuando se consume la energía de la biomasa. En Okinawa, donde se produce la mayor parte de la caña de azúcar en Japón, se efectúa un proyecto para producir bioetanol a partir de melaza. Sin embargo, de esto se genera el residuo líquido denominado vinaza, cuyo volumen es 15 veces más que el del etanol destilado, lo cual representa un problema en la producción de energía sostenible. La vinaza posee un color marrón muy oscuro y contiene altas concentraciones de macro y micronutrientes, por lo que puede utilizarse como fertilizante líquido. No obstante, los efectos de la aplicación de la vinaza sobre el suelo se desconocen. Además, en Miyakojima, Okinawa, donde el área para cultivo es limitada y depende de la presa subterránea como principal fuente de agua, los productores están preocupados por la influencia que tengan, especialmente el color y contaminación con nitrato en el agua subterránea, por la aplicación de vinaza en sus campos. En el presente trabajo se examinó cómo la aplicación de vinaza afecta el agua subterránea, por medio del análisis del drenaje a través de una columna de suelo, después de la aplicación de 500 ml de vinaza y vinaza diluida, por un período de 29 días. Del análisis iónico para determinar la concentración de nitrato del drenaje de cada columna, muestra que el potencial de la contaminación con nitrato de la presa subterránea es de poca importancia cuando se aplica vinaza diluida. Dado que la aplicación de la vinaza sin diluir provoca una coloración fuerte en el drenaje y, posiblemente salinidad, se propone que se limite la cantidad y frecuencia de aplicación de vinaza diluida como fertilizante.