EFFECTS OF NUTRIENTS IN SEWAGE SLUDGE ON HORTICULTURE PLANTS

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A report submitted in partial fulfilment of the
requirements for the award of the degree of
Bachelor of Civil Engineering

Faculty of Civil Engineering
Universiti Teknologi Malaysia

APRIL 2007

I declare that this project report entitled “Effects of Nutrients in Sewage Sludge on Horticulture Plants” is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

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Date	:	24 April 2007

To my beloved family members who show 100% support for everything that I have done for the completion of this project.

Thanks for all your love, patience and guidance!

ACKNOWLEDGEMENT

This is a fulfilling moment when the report has been completed successfully after a few months of hard work.

First of all I would like to express my utmost gratitude and appreciation to my project supervisor Dr. Johan Sohaili for all his cooperation, guidance, ideas, sharing, facilitation and advice throughout the project time frame. Without him there won't be any contribution of my work to myself and the society.

I would like to extend my gratitude to all staffs in the Environmental Engineering Laboratory, Faculty of Civil Engineering UTM, who have been helping out to make my work successful. Not to forget Dr. Zaharah from Faculty of Science UTM who had contributed her idea on making my laboratory analysis an easy task. I would like to thank all my friends and juniors who are interested in my work for all your interests fuel my excitement and passion to push myself further.

Thank you my dear for bearing with me all the while. Food prepared by you is always delicious and I really appreciate it every time you prepare something to end my hunger after some serious work.

Last but not least, I would like to thank my parents for showing great patience, support and understanding throughout the project time frame especially when I'm far from home and unable to return home frequently. I love you all and I hope you all will be proud of your son for his work.

ABSTRACT

Generally municipal sewage sludge can be used as fertiliser as it contains a lot of nutrient but the level of each particular nutrient has not yet been established locally. This study focused on Nitrogen, Phosphorus, Potassium and Sulphur content in municipal sewage sludge from Taman Berlian, Kluang, Johor and UTM. Comparison was made between the sludge sources and fertiliser which was available on market in determining the nutrient content and efficiency of each feed to support plant growth. Abelmoschus esculentus (Lady's Finger) was selected as the plant receiving different types of feed. Leaf length and stem height were the parameter used to determine plant growth along with the chemical content of the plants. This study attempts to explain the relationship between plant growth and nutrients deficiencies and suggest alternative evaluation for future in-depth studies.

ABSTRAK

Secara amnya, enapcemar kumbahan boleh digunakan sebagai baja kerana ia mengandungi banyak bahan nutrien. Namun kandungan setiap nutrien masih belum diketahui secara terperinci. Kajian ini memberi fokus kepada kandungan Nitrogen, Fosforus, Kalium dan Sulfur dalam enapcemar kumbahan dari Taman Berlian, Kluang, Johor dan UTM. Perbandingan berdasarkan kandungan nutrien di antara enapcemar kumbahan Taman Berliang dan UTM serta baja di pasaran dijalankan untuk mengetahui kandungan nutrient serta keberkesanan nutrien daripada enapcemar kumbahan dan baja terhadap tumbesaran tumbuhan hijau. Abelmoschus esculentus atau dikenali sebagai bendi telah dipilih sebagai subjek dalam kajian ini dan tumbesaran bendi diukur dalam parameter seperti panjang daun dan tinggi keseluruhan tumbuhan selain mendapatkan kandungan kimia dalam tumbuhan. Kajian ini cuba menyatakan hubungan antara tumbesaran tumbuhan dengan keadaan kekurangan sesetengah nutrient dan mencadangkan kaedah alternatif untuk kajian yang selanjutnya.

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LIST OF SYMBOLS AND ABREVIATIONS

As	-	Arsenic
B	-	Boron
BOD	-	Biochemical Oxygen Demand
C	-	Carbon
Ca	-	Calcium
$CaCO_3$	-	Calcium Carbonate
Cd	-	Cadmium
Cl	-	Chlorine
cm	-	Centimeter
CO_2	-	Carbon Dioxide
$CO(NH_2)_2$	-	Urea
Cr	-	Chromium
Cu	-	Copper
COD	-	Chemical Oxygen Demand
DDT	-	Dichloro-Diphenyl-Trichloroethane
DO	-	Dissolved Oxygen
Fe	-	Iron
ffu	-	Focus Forming Units
H	-	Hydrogen
H_2O	-	Water
$H_2PO_4^-$	-	Dihydrogen Phosphate
H_2S	-	Hydrogen Sulphide
HAc	-	Hydrogen Acetate
Hg	-	Mercury
HPO_4^{2-}	-	Hydrogen Phosphate
K	-	Potassium

K_2O	-	Potassium Oxide
kg	-	Kilogram
m	-	Meter
m^3	-	Meter Cube
Mg	-	Magnesium
mg/kg	-	Miligram per Kilogram
mg/L	-	Miligram per Liter
ml	-	Mililiter
Mn	-	Manganese
Mo	-	Molybdenum
N	-	Nitrogen
ng/kg	-	Nanogram per Kilogram
NH_3	-	Ammonia
NH_4^+	-	Ammonium
NH_4-N	-	Ammonia Nitrogen
NO_3-N	-	Nitrate Nitrogen
Ni	-	Nickel
NO_2^-	-	Nitrite
NO_3^-	-	Nitrate
N:P	-	Nitrogen to Phosphorus
N:S	-	Nitrogen to Sulphur
NPK	-	Nitrogen, Phosphorus and Potassium
NPKS	-	Nitrogen, Phosphorus, Potassium and Sulphur
O	-	Oxygen
P	-	Phosphorus
P_2O_5	-	Phosphorus Pentoxide
PAH	-	Polycyclic Aromatic Hydrocarbons
Pb	-	Lead
PCB	-	Polychlorinated Biphenyls
PCDD	-	Polychlorinated Dibenzodioxins
PCDF	-	Polychlorinated Dibenzofurans
PFU	-	Plague Forming Units
PO_4^{2-}	-	Orthophosphate
S	-	Sulphur

Se	-	Selenium
SiO_2	-	Silica
SO_2	-	Sulphur Dioxide
SO_4^{2-}	-	Sulphate
$TCID_{50}$	-	Tissue Culture Infection Dose for 50% response
TS	-	Total Dry Solids
UV	-	Ultra-Violet
Zn	-	Zinc
%	-	Percent
°C	-	Degree Celcius

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CHAPTER 1

INTRODUCTION

1.1 Historical Overview

Historically, the problem of human waste disposal began when communities first formed. At that time, human waste could be handled by surrounding land or waterways since population densities were still low enough. As populations grew, the nearby land could not handle all the wastes, so waste was dumped into streams and rivers.

For thousands of years, Chinese society returned sewage, called “night soil,” to surrounding farmland. This practice helped maintain soil fertility by closing the nutrient cycle. Nutrients from farms were exported to the cities in crops, and the nutrients in the municipal wastes were returned to the farms. This type of system was ideal because two problems were solved at once: maintaining soil fertility and treating a source of pollution. Night soil was valued so highly that those farmers were reputed to compete with one another by locating attractive outhouses along roads to entice users. Chinese society was unique in its development of an ecologically sound system for recycling waste where as most other early urban civilizations focused on improving ways to dispose of wastes from cities, often causing problems downstream.

In 1559, sewage was allowed to flow out onto land used for growing crops in Bunzlau, Germany (Cecil *et al.*, 1998). Large-scale cropland application of municipal wastewater was first practiced about 150 years ago after flush toilets and sewer systems were introduced into cities in Western Europe and North America. The wastewater was discharged without any treatment, and receiving watercourses became heavily polluted. Later the concept of sewage farm, which is a farm that is irrigated and fertilized with raw sewage, was introduced. In 1869, the practice was implemented in Berlin, Germany, which bought large areas of cropland to be irrigated with raw sludge. The city of Paris, France also purchased farmland to be irrigated with sewage. In 1897, Melbourne, Australia went to land treatment of raw wastewater at Weribee (Cecil *et al.*, 1998). The concept eventually gained wide acceptance throughout the region both in Europe and the United States.

1.2 Current Practices

The main components of sewage sludge are human waste, food waste and animal waste. Though direct application of these wastes onto crops is still widely practiced by world wide suburban populations, the systematic application of treated or untreated sewage sludge remains a problem to the global community. There are several risks involved, including the risk from contaminated food by *E. Coli* O157:H7, which has resulted in numerous deaths and contamination of food by *Salmonella sp.* And other bacteria; the risk from contaminated water, which has resulted in many persons being ill, as well as numerous deaths; and the risk of ingesting fish contaminated with heavy metal such as mercury, as compared with ingesting heavy metal from bio-solids-contaminated food.

Although there is still a lot of debate regarding the safety of treated sludge application on land. Discontinuation of marine disposal has put more pressure on land-base method of utilisation and disposal. In 1997 the United States oversaw a 54% of sludge and biosolids in land application and distribution while in 1999 on average in Europe, 36.4% of the biosolids was used in agriculture (Epstein, 2003).

In Malaysia, several researches regarding the potential of sewage sludge had been carried out under the banner of Indah Water Konsortium Sdn. Bhd. The researches are Sewage Sludge as Fertilizer for Various Crops, which is to assess the potential application of treated sludge as fertilizer and/or soil amendment to enable the company to develop an inexpensive method of converting sludge to organic stabilized fertilizers for commercial ornamental plants or other land application; Sludge as Soil Amendment, which is to assess the potential use of treated sludge as soil amendment for the reconditioning of sandy and degraded soils for agricultural and forestry development as well as for ground bio-engineering for erosion control and slope stabilization; Co-Composting of Sewage Sludge and Municipal Solid Waste, which is to develop a technology for producing good quality compost in a short time period under controlled conditions from sewage sludge and municipal solid waste for use as soil conditioner or fertilizer; Application of Sewage Sludge in Forest Rehabilitation and Regeneration, which is to elucidate the efficiency of using sewage sludge in rehabilitation of degraded forest and ex-mining land, focusing on the effects of sewage sludge application on the soil water chemistry and water quality, along with the monitoring of growth responses of the forest plantation species due to application of sewage sludge; and Drying of Sludge for Building Material Application, which is to characterize sludge so as to determine its engineering feasibility and suitability as clay amendment in production of building components.

1.3 Problem Statement

As of September 2005, there are a total of 8,138 sewage treatment plants serving a population of 14,386,050 in Malaysia (IWK, 2006). Unfortunately the treated sludge is disposed either at landfills and incinerators. Many countries such as the United States, United Kingdom, Australia and Singapore are practicing land application of sludge due to its economical and environmental advantages. However in Malaysia, land application of sludge is currently not allowed, as there are still insufficient studies to provide sufficient parameters and guidelines to be implemented.

In Malaysia, domestic wastewater is treated separately from industrial wastewater, which in turn generates safer sewage sludge in the sense of environmental and human health aspects. Under the 9th Malaysia Plan, the government will be promoting agro-based industries so there will be a steady rise on the demand of fertilizer. Utilising the high potential of nutrient content in treated sewage sludge would provide significant cost reduction in fertilizer acquisition while minimising overall disposal of solid waste to landfills and incinerators. In light of the current development, it is therefore crucial for studies on the characteristics of sludge to be carried out in the hope of formulating an efficient and hazard free land application of sludge master plan, which will ultimately benefit the country's agro-based industries and economy.

1.4 Objective

The objectives of this study are:

i) To identify sewage sludge nutrient content from selected Sewage Treatment Plants.

ii) To study the feasibility of sludge application as fertilizer by comparing the nutrient content in the sludge with the nutrient content in selected fertilizer sold on the market.

iii) To assess the level of safety of the application of sludge as fertiliser to public health in terms of E. *Coli* concentration.

1.5 Scope of Study

In order to be categorized as fertilizer, a matter must possess the contents of macronutrient and micronutrient needed by plants. The primary concern of the study is to determine the content of macronutrients namely Nitrogen (N), Phosphorus (P), Potassium (K) and Sulphur (S) which are taken up by plants in large quantities.

Sludge samples will be taken from primary oxidation pond at Universiti Teknologi Malaysia, Skudai, Johor and secondary oxidation pond at Taman Berlian, Kluang, Johor. Samples will be analysed at the Environmental Laboratory of Faculty of Civil Engineering in UTM. Results are then compared with the existing nutrient content from fertilizers on the market, thus determining the feasibility in terms of economical efficiency.

One of the main concerns of sludge application as fertiliser is the contamination of pathogens, which are hazardous to human health. There are several methods of detecting the level of safety of sludge content. By applying the concept of microbial indicators, this study will only focus on the most general and economical detection method, which is the detection of E. *Coli* population.

Abelmoschus esculentus (lady's finger) will be grown as part of the experiment in measuring the efficiency of sewage sludge from Taman Berlian and Universiti Teknologi Malaysia. Four polystyrene boxes which are the experiment control, box receiving fertiliser solution, box receiving sludge solution from Taman Berlian and box receiving sludge solution from Universiti Teknologi Malaysia, will be prepared for each type of plant. Plant height and leave length will be measured to indicate the growth difference between the four boxes for each type of plant.