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# EFFECTS OF IRRIGATING WITH KITCHEN WASTEWATER ON GROWTH AND DEVELOPMENT OF LETTUCE

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## ABSTRACT

Increased scarcity of water for irrigation has necessitated the exploration of the use of wastewater, especially greywater for crop production. Kitchen wastewater was used in this experiment to determine its effects on the growth and development of lettuce (Lactuca sativa). In this experiment, there were four treatments; untreated kitchen wastewater (U), wastewater treated only by removing oil (T1), filtered wastewater (T2) and farm water which was used as a control (C). The parameters measured included germination, number of leaves, leaf width and leaf length. The analysis of variance (ANOVA) was used to determine whether the differences were significant. Results showed that lettuce plants irrigated using untreated kitchen wastewater did not survive to maturity. However, when oil was removed, the plants survived to maturity, although the growth in terms of leaf width and length was significantly ($p < 0.05$) lower for T1 than the rest of the treatments bar the untreated wastewater. Lettuce watered with filtered water (T2) also showed significantly lower growth than lettuce watered using the farm water. It was concluded that untreated wastewater, when it contains oil may not be useable for crop production, but basic treatment e.g. removal of oil and/or filtering can render the water suitable to irrigate crops, although it may still contain some harmful elements. It was recommended that other forms of greywater e.g. bath and laundry water be investigated and other crops used in further experiments.

**Keywords:** Development, germination, greywater, growth, wastewater

## 1. INTRODUCTION

There is a worldwide increase in the demand for water. A need to grow more food and fibre to meet the increasing needs of the population is one cause of the rising demand. The situation is worsened by a changing climate especially in arid and semi-arid regions where the even limited rainfall is increasingly becoming unpredictable (IPCC, 2013). Due to all these factors, considering the use of wastewater for irrigation has become more significant than before (Morris *et al*., 2003). Wastewater can be defined as water polluted by mixing with waste (Cornish *et al*., 1999). Domestic wastewater can be from processes such as bathing, toilet flushing, laundry and dishwashing, and is categorized into grey and blackwater. Greywater is the water from kitchen, bathrooms and laundry, while blackwater is from toilets (Darvishi *et al*., 2010). Greywater often contains high concentrations of degradable organic materials from cooking and some residues from soaps (Ridderstolpe, 2004). There is, however, still some discussion that kitchen wastewater, because of its potential for contamination by pathogens, should be considered to be blackwater (YourHome, 2017).

Swaziland, and most parts of southern Africa has over the past 3 decades been affected by droughts (Oseni and Masarirambi, 2011), and there is increasingly lack of water for irrigation, and in some seasons even limited for domestic purposes, necessitating water rationing. This has, to some extent hindered the country's attempt to improve the socio-economic situation of its people. About two-thirds of the country's population lives on less than a dollar per day (CSO, 2007; Tevera and Matondo, 2010). Food and nutrition security, though promoted by encouraging households to grow their own food, is affected by lack of water to irrigate crops. Some of the solutions to these problems are rainwater harvesting and the use of wastewater, especially greywater, to irrigate crops.

Greywater is preferred to be used to irrigate crops, over blackwater because of its relatively better quality. Yet still, there is need to take precaution when using it, as it may result in health and environmental hazards. In most African countries, wastewater, though not always treated, has been used for urban and peri-urban vegetable agriculture (Owusu*et al.*, 2012).

It is important that wastewater be treated, to remove the harmful pollutants. Treatment of wastewater to be used for irrigation should be able to balance the removal of harmful effects of the pollutants and at the same time maintain the beneficial nutrient content often associated with wastewater. Wastewater may contain essential elements that plants require for their growth (Darvishi *et al.*, 2010). In a study carried out by Singh *et al.* (2012), it was observed that domestic wastewater used with fertilisers resulted in more yield when compared with that of groundwater with fertilizers, and also the physico-chemical properties of the soil were improved when wastewater was used. Ghosh*et al.* (2010), in their study, found out that kitchen wastewater was usable for irrigation in horticulture after treating it using ceramic microfiltration membrane in combination with other physicochemical treatments.

It is important to select the level of treatment that will remove the deleterious effects of wastewater, while maintaining the beneficial elements of wastewater. Common wastewater problems include waterborne diseases, destruction of soil structure due to elements contained in the water, reduced soil permeability (Travis *et al.*, 2010; McFarland *et al.*, 2007) and increased incidences of crop diseases and pests (FAO, 1992).Another common problem with use of wastewater, though seemingly less important, is the unpleasant odour associated with such water (McFarland *et al.*, 2007).

With the various sectors competing for the limited water resource, there is need for agriculture to consider the use of wastewater for irrigation i.e. to find out to what extent used water can be exploited and what precautions need to be taken prior to its use. When appropriately treated, wastewater can go a long way towards fighting poverty in water scarce regions such as some parts of Swaziland, as the increased crop production can improve the livelihood of many in the communities through improved health and increased access to food. This study therefore has been carried out with the aim of examining the effects of using greywater to grow crops.

## 2. MATERIAL AND METHODS

### 2.1 Description of Study Area

The study was carried out in a greenhouse in the Luyengo Campus, Department of Agricultural and Biosystems Engineering (ABE), University of Swaziland. A lettuce (*Lactuca sativa*) crop was grown for the experiment. The reasons for opting for a lettuce crop were: a) that lettuce has a short maturity term and b) that it is sensitive to environmental conditions (Sewadogo *et al*., 2014; Castillo *et al*., 2006) and also sensitive to poor water quality (Mzini and Winter, 2013). Therefore by using lettuce, a minimum threshold for tolerance for greywater would have been determined.

### 2.2 Research Study Design

The research was experimental, consisting of four treatments which were the various levels of treatment for the water used to irrigate the lettuce. Each treatment was replicated 8 times. The treatments were as follows:

a) **Untreated greywater (U)**
This was water collected from the campus kitchen of the University of Swaziland. The water was collected every afternoon after dishwashing. The water was delivered to the plants as collected.

b) **Treated greywater 1 (T1)**
This waskitchen water where only oil was removed. The wastewater was poured into a container with a spout at the bottom. The oil was allowed to float, owing to density difference, and oil-less water was let out of the container using the spout.

c) **Treated greywater 2 (T2)**
This was wastewater that was treated by filtration. The water was passed through sand which was filling three-quarters of a 25-litre bucket. The bucket had a spout at the bottom to let out the filtered water.

d) **Farm water – Control (C)**
This water was used as the control for the experiment. It was water used at the Luyengo Campus Farm, and is diverted from the river.

Each treatment had eight (8) replications. The lettuce was planted as seeds in pots. The soil used was sandy loam from the ABE Farm, the soil was mixed together and put in 32 five-litre pots, and then lettuce seeds were sown. Each treatment, as earlier described, had 8 pots which represented 8 replications for each treatment. The treatments were lined up along each other. Through the mixing of the soil, the homogeneity of soil in all the pots was to a greater extent ensured. Watering of the lettuce was done at the same time for all the treatments and replications.

**2.3 Data Collection**

Parameters that were measured in this experiment were: germination percentage, leaf number, leaf width and length. Apart from germination, which was taken once, the other parameters were taken on days 7, 14, 21, 28 and 35 after planting.

**2.4 Data Analysis**

The data was analysed as follows: Firstly, the plant development over the 35 days was observed. This was done by first determining the germination rate and then counting the number of leaves at 7 day intervals. Secondly, it was to determine if there was any significant difference in growth of the lettuce among the various treatments, and this was determined at significant level $p = 0.05$, using the analysis of variance (ANOVA). For this analysis, the parameters used were leaf width and length.

**3.1 RESULTS AND DISCUSSIONS**

The parameters that were recorded include: germination percentage, leaf number, leaf width and leaf length. The results for the various parameters are presented and discussed as follows:

**3.1 Germination**

For this parameter, the germination rate was determined. This was the percentage of pots wherein the seeds germinated to the total number of pots for that particular treatment. For all the treatments, there was 100 % germination, which suggests that the quality of water did not interfere with the eventual germination of the seeds. However, it must be noted that the timing of germination was not recorded, so whether the germination was delayed for some of the treatments is not known.

**3.2 Number of leaves**

The number of leaves was recorded on the $7^{th}$, $14^{th}$, $21^{st}$, $28^{th}$ and $35^{th}$ day. Figure 1 shows the average number of leaves per treatment over the 35 days period. Results show that the lettuce watered using untreated water (i.e. greywater from the kitchen) had an average of 2 leaves, that later dried off, and the plants slowly died such that by the $28^{th}$ day, all the plants had died. Plants under Treated 1 (T1), Treated 2 (T2) and the control (C) had average number of leaves being 9.8, 11.3 and 10.9 respectively on day 35. When using ANOVA, there was significant difference among the 3 treatment ($p < 0.05$), with T1 having significantly fewer leaves on day 35 than T2 and C. However, there was no significant difference in number of leaves between T2 and C. This means that after treating the water by merely removing oil, the water still had some damaging effects which significantly affected the development of lettuce, yet still much improved when compared to the untreated greywater (U) which resulted in the death of lettuce before reaching maturity.

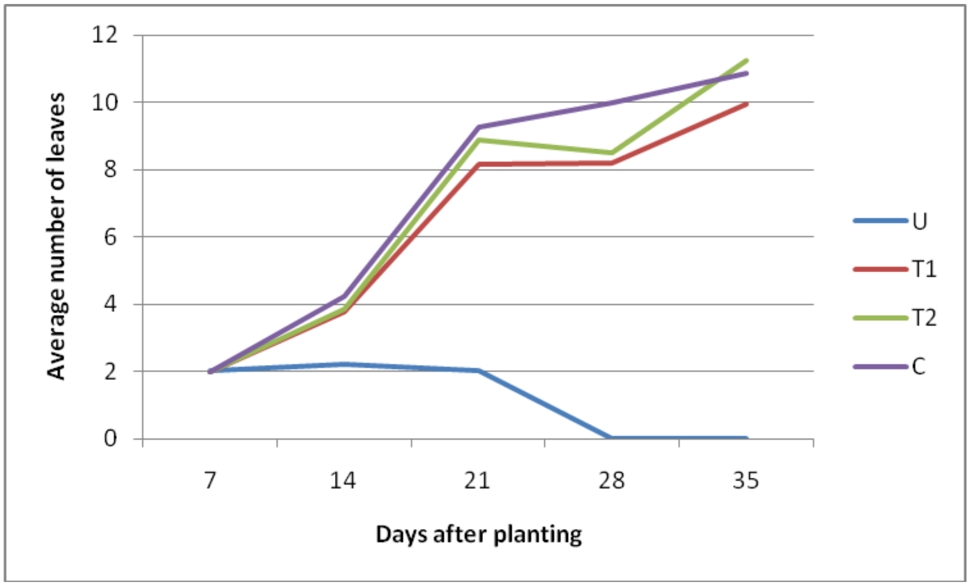


**Figure 1: Average number of leaves for the four treatments over the 35 days period.**

### 3.3 Width and length of leaves

Width, which was measured across the broadest portion of the leaf, and length which represented the length from leaf base to tip, were also measured. Figure 2 shows the average leaf width and length for the various treatments measured on the 35th day, showing that lettuce watered with farm water (control) had the highest growth, followed by T2, which is filtered wastewater, and T1, where treatment was only by removing oil had the least growth among the 3 treatments (untreated water excluded).

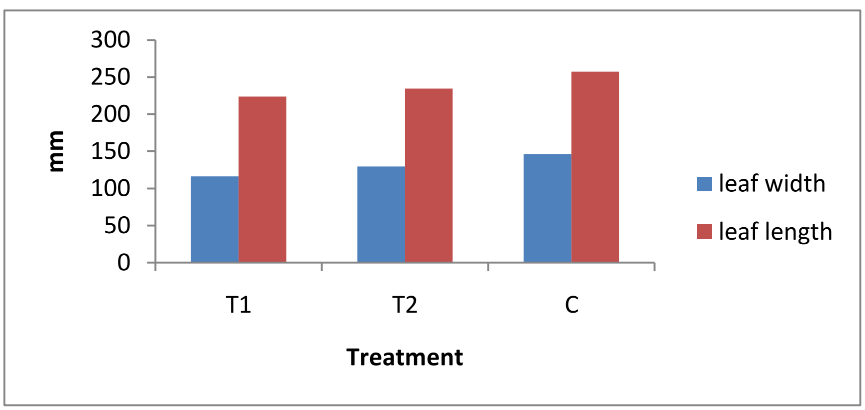


**Figure 2: Leaf width and length for the Treated 1, 2 and the Control measured on Day 35.**

In Table 1, the statistical analysis for the width and length for the 35th day is shown. The lettuce under the control treatment recorded highest leaf dimensions, with width of 147 mm and length 257 mm. The plants from filtered water (T2) had average width of 130 mm and length 234 mm, and lettuce from T1 (greywater with oil removed), had the least width of 116 mm and length 224 mm. In both cases of width and length, the farm water had significantly larger leaves than for lettuce under T1 and T2 (in both cases $p < 0.05$). Also, T2 had significantly larger leaves in terms of width than T1 but there was no significant difference in length between Treated 1 and Treated 2 ($p > 0.05$).

**Table 1: Analyis of Variance results for Treated 1, 2 and the Control on Day 35**

| Treatments | Mean Difference (mm) | P-value |
|---|---|---|
| **Leaf Width** | | |
| T1 - T2 | -13.558 | 0.048* |
| T2 - C | -16.750 | 0.041* |
| T1 - C | -30.308 | 0.000* |
| **Leaf Length** | | |
| T1 - T2 | -10.413 | 0.312 |
| T2 - C | -22.875 | 0.013* |
| T1 - C | -33.288 | 0.011* |

*significant at $p < 0.05$

Compared to the untreated wastewater, both levels of treatment, i.e. removing oil and filtration, significantly removed the harmful effects of the wastewater such that in both treatments, the lettuce survived through to maturity, unlike for the untreated water, whereby the plants were all dead by Day 28. The fact that just by removing the oil from the wastewater, there was significant improvement in the growth and development of the plants is indicative of the destructive nature of oil. This could have resulted from the oil sticking onto the plant roots and therefore repelling water and also making it difficult for the plants to respire through the roots.

Although treating the water by both removing oil and also sand filtration did improve the quality of wastewater to be useable to irrigate the lettuce plants to maturity, it was observed that the growth was significantly higher for the plants watered using farm water than the other treatments. This suggests that the treatment procedures (oil removal and filtration) were not adequate enough to remove all the harmful effects of the wastewater.

## 4. CONCLUSION

From the experiment, it was shown that greywater from the kitchen may be used for crop production, however if there is oil in the water, which is common with kitchen wastewater, the oil will need to be removed as it results in the death of plants. The death of plants may be caused bylimited plant respiration and/or absorption of water by plants. It was also noted that passing the water through a sand filter further improves the quality and removes more of the harmful effects. Based on the results obtained, there is a potential to use greywater, with less costly forms of treatment. It is recommended that further investigation of wastewater use for irrigation be pursued and other forms of greywater e.g. bathroom and laundry water be used. More plants of varying length of growing period may also be introduced into the study.

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