# Effect of Detergents from Laundry Greywater on Soil Properties and Plant Growth

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**Abstract**— Laundry wastewater contains detergent compounds which are classes of the organic micro-pollutants. The disposal of these compounds into the land has several adverse effects on soil composition and characteristics. In this study, changes in the soil properties such as water holding capacity, Electrical Conductivity, pH, cation exchange capacity, exchangeable sodium percentage, and sodium adsorption ratio were examined after the irrigation with laundry wastewater. The experiment consists of irrigating soil samples with first, second, third wash water and analyse the soil for physiochemical parameters. The soil sample is also irrigated with tap water as control treatment. The various effects of different detergent concentrations on seed germination and on plant growth were also evaluated. The findings highlighted the adverse effects of laundry wastewater discharge on soil properties which brings unfavorable changes in soil physiochemistry and high detergent concentration is unhealthy for plant growth.

**Keywords**— Cation exchange capacity, Exchangeable sodium percentage, laundry wastewater, Organic micro-pollutants, Sodium adsorption ratio, Soil physiochemistry, Water holding capacity.

## 1 Introduction

Water scarcity is an aggravating concern worldwide. The reasons include low rainfall and excessive demand for water due to the combined effect of increased consumption per capita and population growth. One of the important consequences of increase of population is the necessity of wastewater reuse. In this context wastewater reuse in agriculture seems to be one of the most explored strategies in most water management programs as agriculture is the leading user of freshwater worldwide, which accounts for almost 85% of global water consumption. Implementation of good practices and particular attention to the protection of environment is needed for the reuse of wastewater in agriculture.

Along with the irrigation plants in the urban centres with conventional wastewater treatment systems, greywater (GW) reuse appears as the best solution for rural and urban areas. Despite its apparent clarity these waters should not be used directly on soil without sufficient treatment as it is often the case. Generally, greywater is the result of the use of soaps, vegetable oils, detergents, water and other kitchen and washing residues. Indeed, grey water appears as a source of elevated levels of compounds such as surfactants, boron, oils, and salt which can alter soil properties, damage plants and contaminate groundwater.

Detergents are used in several domestic washing actions. The presence of surfactants (surface-active agents) which provide cleaning properties improves their efficiency. Surfactants in irrigation water have been recognized as a major contributor to the reduction of hydraulic conductivity of soils and is a component that can lead to water repellent soils with unfavorable impacts on agricultural productivity and environmental sustainability. Environmental risks associated with infiltration of greywater into soil during irrigation and the fate of these pollutants in greywater and the combined impact of these pollutants on soils, plants and receiving waters are not known.

The environmental pollution arising from detergent use is becoming a growing concern. Careless handling and disposal of detergents is due to the lack of information on the effects of detergent on living organisms and soil. Therefore, a thorough investigation on the ecological disorder that may arise from improper handling or disposal of detergents needs to be done because there is no alternative to detergent for now. Understanding the effect of detergents on the soil properties can leads to design a proper management for the laundry wastewater disposal or reuse for irrigational practices. The present study was performed to assess the adverse effects of discharged laundry greywater on the soil characteristics and the potential impact on plant growth.

### 1.1 Detergent Components

A large proportion of the laundry detergents are non-volatile compounds especially salts. Hence, a portion of these salts (which is not retained on clothes) must be present in the laundry effluent. The laundry effluent also contains a variety of suspended solids and sorbed substances (both inorganic and organic matter, and pathogens) released from clothes. Some of these salts can be beneficial to plants, especially nutrients, but a balanced concentration of nutrients is required to avoid nutrient deficiency or toxicity. There are chances of occurrence of eutrophication in water bodies receiving laundry greywater because of the presence of nutrients such as phosphates. Later Phosphate-free detergents were developed in order to limit the adverse effects of laundry greywater on the environment.

However, laundry greywater has many Organic micropollutants (OMPs) which are highly persevering in the environment. Surfactants (surface active agents) are the major OMPs

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in the greywater because they are used in the generation of detergents and hygiene products. One of the most important active anionic surfactants among detergents were alkylbenzene sulfonate (ABS), which is non-biodegradable. The long-term stability of non-biodegradable substances allows to transmit the pollution to long paths. Later, linear alkylbenzene sulfonate (LAS) was proposed and used as an alternative for ABS. This anionic surfactant, which is four times more toxic than ABS, is biodegradable having degradability 97% to 99%.

## 2 METHODOLOGIES

### 2.1 Collection of Laundry greywater

The detergent used for the experiment is powdered laundry detergent. The detergents were selected according to the dominant brands used in the study area based on the information gathered from the local community during the collection of soil samples. A fix of ten clothes was used in each washing process which is placed in an automatic washing machine and one full cap (125g) of detergent was added into 60L of water (2.1g/L). The laundry greywater generated after the first, second and third wash each of 1 Litre was collected. Physio-chemical Characteristics of laundry greywater and tap water used for washing were analysed.

### 2.2 Collection of Soil

Soil samples were collected from a locality which is approximately 7km from Calicut city. The samples were collected in month June. The study area was selected because there is no direct discharge of laundry greywater into the soil. The soil sampling point should be selected at an undisturbed land where there is no human activity recorded. The samples were collected by first eliminating the top 10–15 cm of soil and the samples were dug for 30 cm depth of soil by using a spade.

### 2.3 Irrigation and Soil testing

The soil samples collected from the field are taken in four bags each containing equal quantity of soil. These samples are irrigated with first, second, third wash water and fourth bag with tap water. The irrigation is continued for two months. The properties of soil after two months of irrigation were investigated.

### 2.4 Soil Chemical Analysis

The characteristics of soil samples including pH, electrical conductivity (EC), CEC (the sum of exchangeable cations, Ca, Mg, K and Na), exchangeable sodium percentage (ESP), Sodium adsorption ratio (SAR), water holding capacity (WHC) and percentage of various nutrients of the soil were determined before and after the experiment.

### 2.5 Germination studies

The experiments were carried out in a room with sufficient sunlight needed for the growth of seeds. The seeds used for the study is the mung bean seeds (Vigna radiata). The first, second, third wash water were applied for watering the seeds. water without detergent was applied to seeds to serve as control for each treatment. The experiments were also carried out using three watering solutions prepared by dissolving in tap water respectively 1.0 gram (low concentration, LC), 2.5 gram (normal concentration, NC) and 5 grams (high concentration, HC) of a laundry detergent and tap water as a control treatment.

Mung bean (Vigna radiata) seeds were grown for 2 weeks. Four pots were taken, each filled with cotton which serves as a growth medium for seeds. The seeds are kept on the cotton. The seedlings were watered daily during the investigated periods. The germination of seeds was observed daily and observations made were carefully recorded. The data collected from the studies were analyzed to determine if there were significant differences among the means obtained from the various treatments. Radicle length was also measured at the end of the experiment and recorded in centimeters (cm).

## 3 RESULTS AND DISCUSSIONS

The results of the analysis of soil irrigated with laundry grey water and tap water are given in the table 1.

### 3.1 Soil pH and EC after Irrigation

TABLE 1
SOIL CHARACTERISTICS AFTER IRRIGATION

| Parameter | Unit | Soil irrigated with first wash water | Soil irrigated with second wash water | Soil irrigated with third wash water | Soil irrigated with tap water |
|---|---|---|---|---|---|
| pH | | 8.01 | 7.3 | 6.8 | 6.44 |
| EC | µs/cm | 786.3 | 543.7 | 243.1 | 113.2 |
| WHC | % | 36.21 | 39.30 | 41.51 | 45.9 |
| CEC | meq/100g | 26.7 | 22.1 | 18.7 | 11.3 |
| ESP | % | 2.6 | 1.3 | 0.9 | 0.57 |
| SAR | | 0.86 | 0.72 | 0.63 | 0.59 |

Figure 1 depicts the pH of the soil after being irrigated by laundry grey water and tap water. The results shows that the detergent solutions brought about increase in the pH value of the soil. It was also clearly observed that the pH is increased with increase in the detergent concentration of the solution.

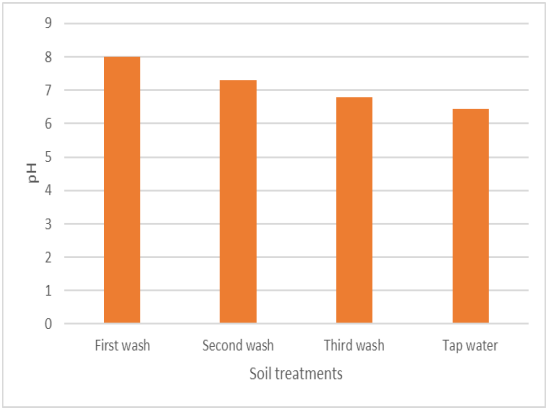


**Fig. 1** pH of soil after irrigation with laundry greywater and tap water

This could be explained by the fact that the detergent com-

posed of alkalis and several salts. It was determined that the pH of soil irrigated with tap water was 6.44, which indicates deficiency of Ca and Mg ions in the soil. The soil pH increased after irrigation with first, second, third wash laundry water. Soil changed from acidic to basic. The presence of sodium in the wash water can potentially increase the pH level in the irrigated soil. The soil pH might reach higher alkaline levels by frequently receiving the detergents for a long time.

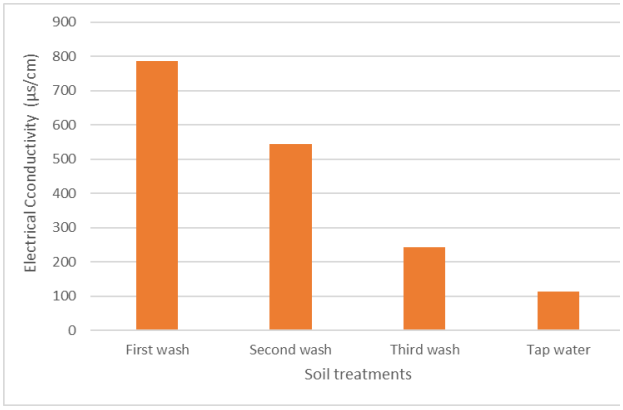


**Fig. 2** EC of soil after irrigation with laundry greywater and tap water

Soil having high levels of soluble salts are called saline soils. Soils high in sodium are called sodic soils. Saline-sodic soils are soils high in both soluble salts and sodium. Soluble salts are measured by electrical conductivity (EC) of a saturated paste soil extract. The electro-conductivity (EC) of soil after irrigation by laundry grey water and tap water is presented in Figure 2. The maximum EC was recorded in the soil irrigated with first wash water (786.3 µS/cm) and was followed by the soil irrigated with second wash water (543.7 µS/cm). The minimum EC was recorded in the soil irrigated with tap water (113.2 µS/cm). These results indicate that the EC values increased with water contain higher chemicals in detergent.

### 3.2 Changes to Soil Water Holding Capacity

The water holding capacity (WHC) of soil decreases with increase in detergent concentration. The highest WHC is found to be for soil irrigated with tap water (45.9%). And the lowest WHC is for the soil irrigated with first wash water (36.21%). This might be caused by swelling of some clay particles which changes the hydraulic capacity of the soil profile and resulted in reduced retention of soil water and increased depth of infiltration.

### 3.3 CEC, ESP and SAR of Soil After Irrigation

CEC was determined according to the concentrations of Ca, K, Na, and Mg ions. These elements indicate the total amount of exchangeable cations which are removed from the soil using a solution contains a neutral salt held within a given mass of soil. Figure 4 shows that the highest of CEC was found when soil irrigated with first wash water of 26.7 meq/100g. Soil CEC after irrigated with second, third wash water were reduced to 22.1 meq/100g and 18.7 meq/100g respectively due to the decreases in the concentrations of these cations in the soil with the frequent washing process. The lowest soil CEC is found to be 11.3meq/100g for tap water irrigation.

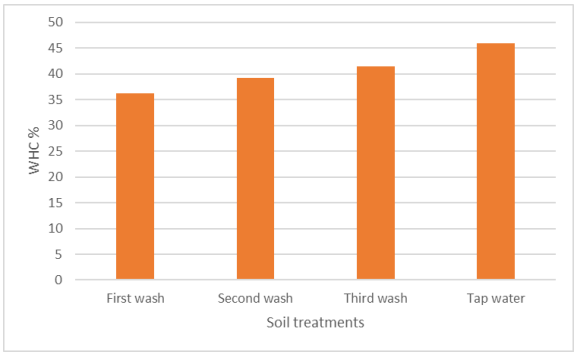


**Fig. 3** WHC of soil after irrigation with laundry greywater and tap water

The highest Exchangeable sodium (ESP) percentage was recorded in the soil irrigated with first wash laundry grey water (2.6%) (Figure 5) and the lowest ESP is for soil irrigated with tap water (0.57%).

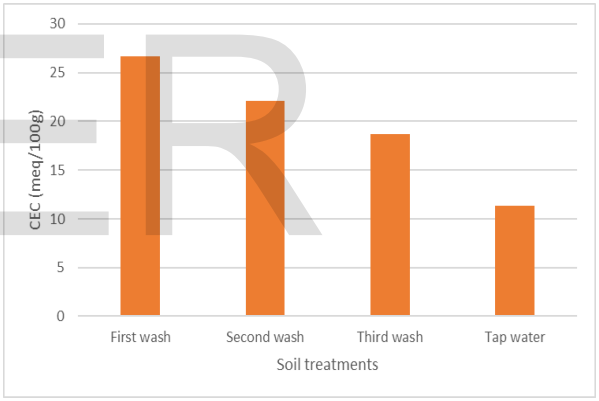


**Fig. 4** Soil CEC after irrigation with laundry greywater and tap water

These results indicate that the ESP in the soil irrigated with llaundry greywater has increased compared with the soil irrigated with Tap water.

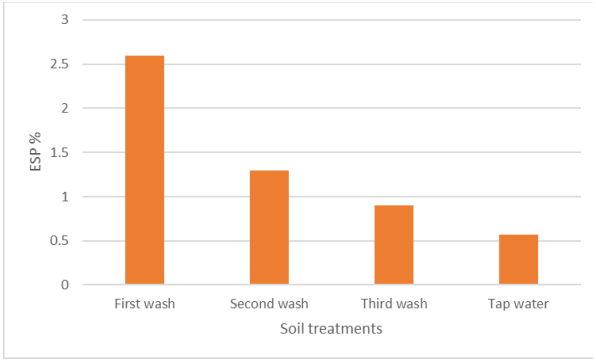


**Fig. 5** ESP of soil after irrigation with laundry greywater and tap water

The presence of high concentration might increase the possibility of sodium toxicity to plants. The increase of ESP to more than 15% which might be caused due to the frequency's irrigation of soil with laundry greywater, the higher levels of exchangeable $Na^+$ in soil could cause soil aggregates to crumple due to the spread which leads to poor water access to soil- This process is called deflocculation and occurs in sodic soil.

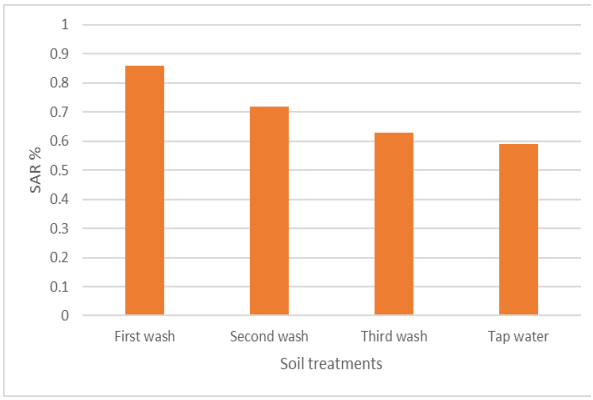


**Fig. 6** Soil SAR after irrigation with laundry greywater and tap water

Sodium adsorption on the ratio (SAR) of soil after drainage in four different replicates was subjected to every type of irrigation water. Based on the data presented in Figure 6, SAR soil was mostly higher in the irrigated soil first wash and second wash where the SARs were 0.86 and 0.72, respectively. A higher SAR may lead to the degradation of the soil structure and permeability. When the $Na^+$ (sodium) predominates, soils can become sodic.

### 3.4 Germination of Seeds

From the germination studies, the results obtained showed clearly that the germination of seeds were reduced by the presence of detergents in the irrigating solutions. Also seeds irrigated with detergent solutions that germinated had expressive reduction in germination trait such as radicle length. This is because high dose of detergents around a germinated seed reduces the water uptake, results in seed germination and metabolic activities were delayed and could lead to damage of cell membrane.

## 4 Conclusion

The direct discharge of laundry greywater into the soil produces adverse effects on the soil properties. The use of water with high concentrations of detergent is not suitable for application in irrigation for agricultural activities. It is because they have a very alkaline pH in which seed germination and plant growth were drastically reduced. Although low concentration of detergent in watering solutions enhanced plant growth in some respect by contributing to the nutrient levels, yet regular and continual use of such solutions for irrigation lead to nutrient toxicity to plants, increase in the EC and pH of soil and increase in water repellency of soil, thereby limiting plant growth in future and adversely affecting agricultural productivity and environmental sustainability. An adequate management for greywater discharge should be adopted in order to prevent the destruction of soil structure. The detergents in the laundry greywater must be reduced to a minimum concentration which would have no adverse effects on the environment.

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