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Characterisation of grey water and its influence on some basic soil properties

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Abstract
A experiments were conducted to examine the effects of greywater irrigation on changes in soil properties. The different proportions of grey water and ground water were used as experimental treatments. Surface soil samples (0-15) were analyzed for physical and chemical properties, *viz*., bulk density, porosity, pH, EC, organic carbon (OC), in soil. The pH and EC values of the greywater used in the study were 8.80 and 0.96 dSm^{-1} respectively. Results show that greywater irrigation had no significant effect on soil organic carbon. However, pH, EC and organic carbon was highest in treatment receiving 100% grey water. Bulk density of soil was increased while pore space of the soil were decreased with application of grey water.

Keywords: Characterisation, influence, greywater irrigation

Introduction
The need for water is growing with increasing population and the adverse impact of climate change especially in the field of agriculture & other sectors. Among the options for innovative water resources, reuse of grey water for agriculture crop production. Therefore, grey water resources are essential for socioeconomic development and yet water is often misused and wasted in today society. The responsible use and reuse of grey water is vital to the sustainability of the best options for water conservation available to communities located particularly in arid region. Therefore, grey water recycling offers a way in which people can save and reuse the waste water generated in their home.

The number of people living in either water-stressed or water scarce countries is expected to reach 3 billion by 2025 (Hanjra and Qureshi, 2010) [5]. The increased pressure on water resources can be attributed to population growth, climate change, and the rising demand for water in industrial sectors. The abstraction of water for irrigation in the agricultural sector amounts to 80% of the global water consumption, and is the limiting factor in food production in many countries (Hanjra and Qureshi, 2010) [5]. Innovative approaches are therefore, needed to attain both water and food security, particularly in Sub-Saharan Africa (Finley *et al*., 2009; Hanjra and Qureshi, 2010; Rodda *et al*., 2011) [4, 5, 11].

Grey water is specifically wash water and is used after bathing, kitchen washing and laundry water, excluding toilet wastes and free of garbage-grinder residues. When properly managed, grey water can be a valuable resource for horticultural and agricultural growers as well as home gardeners can benefit from. Constituent of grey water from various household sources such as automatic clothes washer, automatic dishwasher, bathtub & shower and sink, including kitchen. Automatic clothes washer have contents such as suspended solid, organic material, oil and grease, sodium and phosphates (from detergent), increased salinity, and pH.

Material & Methods
Methods of Grey water analysis
(i) pH of Grey water
The pH of grey water was measured with the help of a pH meter, as described by Jackson (1973) [6].

(ii) Electrical conductivity (dSm^{-1})
The electrical conductivity in the clear extract of grey-water was determined with the help of conductivity meter (Jackson, 1973) [6].

(iii) Determination of TDS

The TDS was determined by multiplication of EC (dSm^{-1}) of grey water with 640 and value was obtained in ppm.

(iv) Carbonates and bicarbonates

Analysis of carbonates and bicarbonates was based on simple acidimetric titration with standard sulphuric acid (N/10) using phenolphthalein and later on methyl red as indicators. When the colour of phenolphthalein disappears, it shows the conversion of carbonate into bicarbonate. Now methyl red can be added which gives yellow colour. The change of the colour from yellow to rose red was an indication of the neutralization of bicarbonates (Richards, 1954) [11].

(v) Calcium and magnesium

The usual method for the determination of $Ca^{++}Mg^{++}$ was by versenate (EDTA) titration method (Cheng and Bray, 1951) [3].

(vi) Residual sodium carbonate (RSC)

This was an important character for assessing the suitability of irrigation water considering of likely sodium hazard. It was calculated from the analysis data for carbonates bicarbonates and calcium plus magnesium in the following manner.

$$RSC (me/l) = (CO_3^{=}+HCO_3^{-}) - (Ca^{2+}\ Mg^{2+})$$

(vii) Chloride

Chloride in the grey water samples was measured by Mohr's titration methods. Grey water sample was titrated with the standard $AgNO_3$ solution till the first brick red ring appears.

Experimental details

A short term experiment study was conducted in on going research project under AICRP on IWM at south Pangabri plot of Dr. Rajendra Prasad Central Agricultural University, Pusa, Bihar, situated at 25°30' N latitude, 85°40' E longitude and 52.00 meter above mean sea level, in sub-tropical humid climate. The climate is sub-tropical having average annual rainfall 1135 mm. The soil of the experimental site belongs to order *Entisol*, suborder *Fluvents*, great group *Ustifluvent* and is taxonomically characterized as Calciorthents. The soil of experimental area having texture loamy sand, pH 8.3, organic carbon 3.59 g kg^{-1} and $CaCO_3$ content 430 g kg^{-1}. Tomato crop was grown with tillage during *Rabi* season. The source of N, P and K was urea, di-ammonium phosphate (DAP), muriate of potash (MOP), respectively. Dose of fertilizer was 120, 80, 80 (N, P_2O_5, K_2O). The design of experiment was Randomized Block Design (RBD) with three replications. Taking different proportion of fresh water and grey water for irrigation purpose into consideration, seven different treatments were made.

T_1 = Irrigation by 100% fresh water
T_2 = Irrigation by 75% fresh water + 25% grey water
T_3 = Irrigation by 50% fresh water + 50% grey water
T_4 = Irrigation by 25% fresh water +75% grey water
T_5 = Irrigation by 100% grey water
T_6 = Alternate irrigation by fresh and grey water
T_7 = Two irrigation by fresh water followed by one grey water

Soil sampling and processing

Representative soil samples from 0-15 cm depth were collected after tomato harvesting. All soil samples were air dried in shade and ground with the help of pestle and mortar. These ground samples were then passed through a 2 mm sieve and stored in polyethylene bags for further analysis of soil to determine various physico-chemical properties.

Physico-chemical properties of soil

Standard method were followed for analysis of following parameters.

(i) Soil reaction (pH)

The pH of soil was measured with the help of a pH meter, maintaining the soils, water ratio of 1:2 as described by Jackson (1973) [6].

(ii) Electrical conductivity (dSm^{-1})

The electrical conductivity in the clear extract of soil-water ratio of 1:2 was determined with the help of conductivity meter (Jackson, 1973) [6].

(iii) Organic carbon (%)

The organic carbon content in soil samples was estimated by Walkely and Black (1934) [14] method as suggested by Jackson (1973) [6].

Physical Properties

(iv) Bulk density

The core sampler was pressed into the soil in such a way that soil is collected by core from the centre of surface soil depth (0-15 cm). Soil samples were dried in oven at 105^0C for 24 hrs. Bulk density (g cm^{-3}) was calculated by dividing the weight of dried soil by the volume of core used (Blake, 1986) using the following formula.

$$\text{Bulk density (g cm}^{-3}) = \frac{\text{Weight of oven dry soil (g)}}{\text{Volume of soil (cm}^3)}$$

The volume of the soil was taken as the inner volume of the core sample, which was, in turn, calculated by $\pi r^2 h$

Where,

r = radius,

h = height of the core.

Soil porosity

The soil porosity was calculated using the bulk density (BD) and particle density (PD, 2.65 Mg m^{-3}) according to the following equation:

$$Porosity (\%) = (1-BD/PD)$$

Result & Discussion

Grey water characteristics

Grey water was collected from ditch located behind the Boy's hostel, Pusa and tested for various parameters are presented in table 1.The values of EC of the grey water and ground water were 0.68 and 0.96 value, however indicated that grey water was found more alkaline than fresh water and also contained more dissolved salts. Higher concentration of grey water contributes to higher Electrical Conductivity (EC). The EC of aqueous solution indicated the presence of salt and hence the salinity of the soil. Similar types of results were also obtained by (Mishra *et al.*). Sodium content in grey and ground water was found 4.01 and 8.89 me/l, however indicated that grey water contain much more Na than ground water. Similarly, grey water also contains high calcium and magnesium concentration (i.e. 7.77 me/l) than ground water i.e. (5.40 me/l)). The concentration of CO_3^{--} + HCO_3^{-} of the grey water and ground water were 5.62 and 4.34 me/l, respectively. The concentration of chloride of grey water was found much higher i.e. 9.84(me/l) than that of fresh water (i.e. 4.20 me/l). These might be due to the fact that salts present (washing powder) in grey water dissociated in cations such as, sodium, calcium, magnesium, and potassium and anions of sulphate, phosphate, nitrate, chloride and carbonate etc. The values of SAR in grey water and ground water were 3.29 and 2.34, respectively. The Sodium Adsorption Ratio (SAR) was higher due to presence of laundry, kitchen and bathroom water. The high laundry SAR values may be a result of the type of detergents or soaps used. SAR is an indicator of the salinity of the wastewater and is used for predicting the possible diverse effects of monovalent cations (sodium) in soils. Hence, high SAR values of the grey water validates the need to apply freshwater to the grey water towers as a control measure against soil damage (clogging) (Kulabakoa *et al.* 2011) [7].

The data in the table also indicated that turbidity in grey water i.e. 273.0 Nephlometric Turbidity unity was found much higher than that of ground water (27.0 NTU). The TDS values in ground and grey water were 435 and 614 me/l.

Table 1: Characteristics of Grey water and Ground water

S. No.	Parameters	Ground water	Grey water
1	pH	7.80	8.80
2	EC (dSm^{-1})	0.68	0.96
3	Na (me/l)	4.01	8.89
4	Ca^{++} Mg^{++} (me/l)	5.40	7.77
5	Cl^- (me/l)	4.20	9.84
9	$CO_3^{--} + HCO_3^-$ (me/l)	4.34	5.62
10	SAR	2.34	3.29
11	TDS (mg/l)	435.0	614.4
12	Turbidity (NTU)	27.0	272.0

Soil pH

The pH of soil under different grey water treatments ranged between 8.30 and 8.93 (Table 2). It was obvious from the table that soil pH of T_5 was found maximum in the plot where received 100 % grey water followed by T_4 irrigated with 75 % grey water in combination with ground water and followed by alternate irrigation with grey and ground water T_6 thrice. The results also revealed that T_5, T_4 and T_6 have significantly higher pH over control (T_1) due to irrigation of the grey water in the tomato crop. T_3 and T_7 have recorded higher pH compared to T_1 but, not significantly higher. Similar increase of pH was found by Qishlaqi *et al.* (2008) [10]. This might be due to the fact that grey water caused higher bicarbonate (HCO^-_3) concentration in soil which could rise the pH. HCO^-_3 raises the pH by causing Ca^{++} and Mg^{++} ions to form insoluble minerals leaving Na^+ ion incomputable in solution (Bauder *et al.*, 2014) [2].

Electrical conductivity

The EC values varied from 0.153 to 0.717 dSm^{-1} and high EC values were obtained in all the treatments over control (Table 2), which is considered safe for growth of all crops. The data in the table indicated that electrical conductivity of soil was significantly influenced by different grey water treatment over control. Amongst the treatments it was noticed that T_5, T_4 and T_3 have significantly higher EC values than that of control. It was also observed that 100% grey water (T_5) recorded highest EC values among all the treatments followed by 75% + 25% ground water (T_4) and alternate irrigation (T_6). The results indicated that higher EC values may be due to because of higher concentration of detergent leading to higher pH and EC of irrigation waters. Similar results were reported by (Pinto *et al*., 2010; Wiel-Shafran *et al*., 2006; Anwar, 2011) [9, 15, 1].

Organic carbon

Soil organic carbon is key to soil property. Soil organic carbon varied from 0.332 to 0.471 % with maximum content in soils treated with 100% grey water application (0.471 %) followed by 75% grey water in combination with 25 % ground water application (0.380 %) are presented in (Table 2). The data in the table also indicated that soil organic carbon increased slightly but they were not significantly influenced by grey water treatments. However, the results suggested that grey water irrigation would lead to direct effects on soil chemistry, such as elevated pH, excessive salinity, or a build-up of organic compounds, and to indirect effects, most notably the modification of microbial activity in the soil due to the increased availability of organic carbon in grey water constituents (Roesner *et al*. 2006) [13].

Table 2: Chemical characteristics of grey water treated soils

Treatments	pH	EC (dSm^{-1})	Organic carbon (%)
T_1	8.30	0.153	0.359
T_2	8.30	0.183	0.358
T_3	8.50	0.237	0.375
T_4	8.67	0.333	0.380
T_5	8.93	0.717	0.471
T_6	8.66	0.203	0.366
T_7	8.40	0.160	0.332
SE(m) ±	0.102	0.019	0.028
CD (P= 0.05)	0.318	0.060	NS
CV	2.073	11.669	13.049

Bulk density

Lower value of bulk density is better for plant growth and nutrient uptake by of plant. Treatment T_5 recorded highest bulk density value amongst all the treatments followed by T_7, T_1, T_2, T_4, T_3, T_6 varied from 1.364 to 1.518 g/cc (table 3). Lowest value were recorded in T_4 followed by T_3, and T_6. The results revealed that the bulk density decrease application of with grey water. This is because the grey water washed out the fine particles. (Anwar 2011) [1].

% Pore Space

Increased per cent pore space relates to increased water and air retention ability of soil. Treatment T_3 recorded for highest value of pore space among all the treatment followed by T_6, T_2, T_7, T_4, T_1, T_5 and varied from 39.70 to 48.53 %pore space of soil (table 3). As percent unit pore space is negatively correlated with bulk density therefore, percent pore space has increased in the treatments having lower bulk density (Anwar 2011) [1].

Table 3: Soil physical parameters

	Bulk density (g/cc)	% Pore Space
T_1	1.486	43.93
T_2	1.406	46.94
T_3	1.364	48.53
T_4	1.380	47.91
T_5	1.518	39.70
T_6	1.365	48.49
T_7	1.416	46.56
SE(m) ±	0.044	1.667
CD (P = 0.05)	0.138	5.194
CV	5.350	6.277

Conclusion

pH, EC and organic carbon was highest in treatment receiving 100% grey water. Bulk density of soil was increased while pore space of the soil were decreased with application of grey water.

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