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Effect of grey water application on physicochemical properties of tomato growing soil

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Abstract
A field study was conducted on "Effect of grey water application on physicochemical properties of tomato growing soil" during Rabi season of 2017 at RPCAU, Pusa Farm. Soil samples (0-15cm) were investigated for physical and chemical properties, *viz.*, bulk density, texture, porosity, pH, EC, organic carbon (OC), available nitrogen, phosphorous, potassium, sulphur, boron. Use of grey water significantly improves the soil properties like bulk density, pH, organic carbon, nitrogen, phosphorous, potassium, boron in soil. The concentration of nutrient like N, P, K and b was recorded highest viz. 389.0 kg ha^{-1}, 182.9 kg ha^{-1}, 176.7 kg ha^{-1} and 0.46 mg kg^{-1} respectively in 100% grey water applied soil. All chemical parameters and nutrient contents were found higher in grey water than ground water treated soil. Application of gray water can be a good choice for plant nutrient enrichment in farmland.

Keywords: Grey water, soil physical properties, soil chemical properties, tomato growing soil

Introduction
The increasing population, industries and agricultural activities require a great amount of water resulting in depletion of ground water day by day. Hence, farmers are now opting to use grey water in Irrigation of forest trees, agricultural crops and also for other industrial works only after complete processing. India is an agricultural country where water plays important roles. Many of the states of India are always dry such as Rajasthan, Maharashtra etc. In those area of crises, water is delivered by water tank. Agricultural crops are wasted in want of water. Due to the fact farmers tend to commit suicide. India's cultivation depends on rain. The economic conditions of majority of the farmers are very poor and they cannot afford heavy expenditure on irrigation, large scale tree cutting and improper management of rain water leads water crises. Rain water management are not proper, so whole water directly go into ocean In this situation, grey water can be a cheap and good alternative source of fulfilling the water demand for irrigation of agricultural crops. 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. It can also be valuable to landscape planners, builders, developers and contractors because of the design and landscaping advantages of on-site greywater treatment/management. After all, some of the nutrients like phosphorous, potassium and nitrogen making grey water a source of pollution for lakes, rivers and ground water which are excellent nutrient sources for vegetation when this particular form of waste water is made available for irrigation. Grey water contains significant amounts of nutrients like nitrogen and phosphorus. An average volume of greywater will produce approximately 45 g of nitrogen and 3 g of phosphorus per day. If managed properly, these nutrients could be beneficial to the however, reducing the amount of commercial fertilizer needed for garden and lawns. Chemical contamination found in bathroom greywater originates from shampoo, hair dyes, toothpaste and cleaning chemicals. Laundry water contains higher chemical concentration from soap powders and soiled clothes (Sodium phosphate, boron, ammonium nitrogen), and is high in suspended solids lint, turbidity and oxygen demand and if applied to untreated land could lead to environment damage, as well as posing a threat to public health. The importance of sustainable development cannot be overemphasized. The reuse of grey water is an example of sustainable development in practice through water conservation. The most obvious benefit of grey water reuse is water conservation. Domestic reuse of greywater will help the environment by reducing demand on higher quality water resource. Plant nutrient enrichment by application of gray water has found by various research. So, there is a need to study the effects chemical properties on soil for better management of gray water.

Materials and Methods

A short term experiment study was conducted in ongoing research project under AICRP on IWM at south Pangabri plot of Crop Research Center, Dr. Rajendra Prasad Central Agricultural University, Pusa, Samastipur, 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 soil of the experimental site belongs to order *Entisol*, suborder *Fluvents*, great group *Ustifluvent* and is taxonomically characterized as Calciorthents. The experiment was laid out in a Randomized Block Design (RBD) in three replications by taking different proportion of fresh water and grey water for irrigation purpose into consideration, seven different treatments were made which includes, Irrigation by 100% fresh water (T_1), Irrigation by 75% fresh water + 25% grey water(T_2), Irrigation by 50% fresh water + 50% grey water(T_3), Irrigation by 25% fresh water +75% grey water(T_4), Irrigation by 100% grey water(T_5), Alternate irrigation by fresh and grey water(T_6), Two irrigation by fresh water followed by one grey water(T_7). The seeds of tomato crop cultivar were sown in well pulverised raised nursery beds, and 25 days old seedlings were planted. Nutrient like N, P_2O_5 and K_2O were applied in the form of urea, di-ammonium phosphate (DAP) and muriate of potash (MOP). Tomato crops was fertilized @ 120, 80 and 80 kg of N, P_2O_5 and K_2O per hectare, respectively irrespective of the treatments. The crop was grown utilizing the soil moisture and subsequently irrigation was applied at 15days interval by mixing both normal and grey water as mentioned in the treatment details. For control of late blight in tomato Mancozeb @ 2g/liter was applied. Imidachlorpid @ 1ml/liter was applied for control of curling of leaf in tomato. Dimethoate EC @ 2ml/liter was also applied for control of fruit borer in tomato.

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 chemical properties. Bulk density was estimated by using core sampling method (Blake and Hartge, 1986) [15]. Soil texture is determined by international pipette method (Piper, 1966) [9]. The pH and electrical conductivity of soil was measured with the help of a pH meter, maintaining the soils, water ratio of 1:2 as described by Jackson (1973) [7]. The organic carbon content in soil samples was estimated by Walkely and Black (1934) method as suggested by Jackson (1973) [7]. Free calcium carbonate was measured by rapid titration method as suggested by Piper (1966) [9]. Available N, available P and available K of soil were measured by alkaline permanganate method (Subbiah and Asija, 1956) [12], ascorbic acid method (Olsen *et al*., 1954) [8], flame photometric method (Jackson, 1973) [7], respectively. Available S was tested through turbidimetric method (Chesnin and Yein, 1950) [6] and available boron in soil was determined by hot water soluble method (Berger and Truog, 1939) [4].

Results and Discussion

Results showed reatment 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. 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) [2]. 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. 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) [2]. All soil samples are characterized as loamy sand type based on proportion of sand, silt and clay. The pH of soil under different grey water treatments ranged between 8.30 and 8.93 (Table 1). 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. 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) [3]. The EC values varied from 0.153 to 0.717 dSm^{-1} and high EC values were obtained in all the treatments over control, which is considered safe for growth of all crops. 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 EC of irrigation waters. Similar results were reported by Pinto *et al*., 2010; Wiel-Shafran *et al.*, 2006 and Anwar, 2011 [14, 2]. 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. 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) [11]. Results revealed that highest N content was increased with application of 100% grey water T_5 (389.1 kg ha^{-1}) followed by T_4 375.2 and T_3 255.7 kg ha^{-1}. There were no significant differences in nitrogen has been analysed after harvest of plants for any of the treatments although there was a trend of higher N in soil irrigated with 100% grey water the control. Similar trend of the results were also obtained when lettuce crop were irrigated with grey water as reported by Wiel-Shafran *et al.* (2006) [14]. This might be due to the fact that detergent and quality of water also affect the amount of N accumulated in soil. Phosphorus of soil was significantly influenced by different grey water application with maximum p content obtained with 100% (T_5) followed by 75% grey water in combination with 25% fresh water (T_4) followed by T_3 50% grey water + 50% fresh water application. Wiel-Shafran *et al*. (2006) [14] suggested that this accumulation of P in soil is correlated to the concentrations present in the grey water. N and P where also higher in dark grey water compared to light grey water, due to kitchen grey water and phosphates from laundry detergents (Boyjoo *et al*., 2013) [5]. The potassium of soil under different grey water treatments ranged between 132.6 and 176.7 kg ha^{-1} over control (Table 1). It was noticed that T_5, T_4 and T_3 has significantly higher potassium content over control. The study also indicated that plot receiving 100% grey water recorded highest potassium content among all the treatments followed by T_4 and T_3. The sulphur content of soil under different grey water treatments ranged between 2.20 and 8.19 mg kg^{-1}. Perusal of the data in table indicated that T_2 has significantly higher sulphur compare to control (T_1). It was noticed that plot receiving 100% grey water yielded lowest sulphur content in the soil. This might be due to the fact that the excess of sulphur added via grey water may result in acidification of the soil may lead to lower content of sulphur in soils treated with 100% grey water. The boron content of soil under different grey water treatments ranged between 0.292 and 0.455 mg/kg. It was observed that plot receiving 100% grey water (T_5) showed highest B content followed by T_4 and T_3.The results indicated that there was significant increase in B content in all the treatment over control. This might be due to presence of various types of shampoos as well as one of the organic hard soaps used in bathroom. The highest level detected was 0.2 mg kg^{-1} in one organic shampoo.

Table 1: Physio-chemical characteristics of grey water treated soils.

Treatments	Bulk density (g/cc)	Pore Space (%)	Soil Texture	pH	EC (dSm^{-1})	Organic carbon (%)	Nitrogen (kg ha^{-1})	Potassium (kg ha^{-1})	Phosphorus (kg ha^{-1})	Sulphur (mg kg^{-1})	Boron (mg kg^{-1})
T_1	1.486	43.93	Loamy sand	8.30	0.153	0.359	311.6	132.6	120.0	6.64	0.292
T_2	1.406	46.94	Loamy sand	8.30	0.183	0.358	240.4	144.4	128.1	8.19	0.326
T_3	1.364	48.53	Loamy sand	8.50	0.237	0.375	355.7	162.2	143.3	3.57	0.376
T_4	1.380	47.91	Loamy sand	8.67	0.333	0.380	375.2	172.4	148.3	3.23	0.450
T_5	1.518	39.70	Loamy sand	8.93	0.717	0.471	389.1	176.7	182.9	2.20	0.455
T_6	1.365	48.49	Loamy sand	8.66	0.203	0.366	240.8	138.7	137.7	2.22	0.348
T_7	1.416	46.56	Loamy sand	8.40	0.160	0.332	273.1	149.8	137.6	3.14	0.382
SE(m) ±	0.044	1.667		0.102	0.019	0.028	39.75	7.48	14.6	0.44	0.077
CD(P= 0.05)	0.138	5.194		0.318	0.060	NS	NS	23.311	52.8	1.379	0.240
CV	5.350	6.277		2.073	11.669	13.049	22.049	8.418	17.765	18.419	30.896

Conclusion

In general high buildups of nutrients were taken place in soils due to application of grey water in comparison to other nutrients. Bulk density of soil was increased while pore spaces of the soil were decreased with application of grey water. The pH of soil under different grey water treatments ranged from 8.3 to 8.9 and the EC values in all the treatments were lesser than 0.153 dS m^{-1}, which is considered safe for growth of all crops. Irrigation with 100% grey water resulted overall higher concentration of all plant nutrients content in soil. Gray water can be used as efficient resource for plant nutrient supply, which can also help to reduce pollution and improves our soil.

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