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Impact of untreated and treated sewage water on nutrient content of soil and marigold plant (*Tagetes erecta* L.) under polyhouse condition

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Abstract
Marigold is one of the commercial loose flower crops which belongs to Asteraceae family. It is popular for its ease of cultivation and wide adaptability to varied agro climatic conditions. Rapid industrialization and urbanization has led to the increase in the volume of the waste water generation. Therefore, utilization of the sewage water for the irrigation could be the alternative way for this. As the sewage water also provides the nutrients and the other trace elements. The present work done at College of Horticulture; Kolar situated in the Eastern dry agro climatic Zone. Due to scattered rainfall pattern and depletion of ground water, irrigation is becoming highly challenging in these areas. In this regard use of sewage water in horticulture crops with proper scientific study will helpful to solve the growing problem. The experimental details include the African marigold (Maxima Yellow, Arka Bangara 2) plants were potted under polyhouse condition during rabi season and laid out in Factorial Randomized Complete Block Design (FRCBD) with 2 factors and 10 treatments with three replications. It was noted that the highest soil EC at harvesting stage was recorded in T_5. Among all the treatments 100 percent untreated sewage water (T_2) treatment added highest soil and plant nitrogen, phosphorus and potassium content. Also, highest soil and plant calcium, magnesium and sulphur content and also the soil and plant micronutrients like zinc, iron, copper and manganese content was also found highest with the application of 100 percent untreated sewage water. The maximum count of total bacteria and maximum total fungi count was also found in (T_2) 100 percent untreated sewage. Among varieties maximum nutrients content observed in Maxima Yellow.

Keywords: Treated sewage water, nutrient content, soil, marigold plant, *Tagetes erecta* L.

Introduction
Marigold (*Tagetes erecta* L.) is one of the most commonly grown commercial flower crops in India. It belongs to the family Asteraceae. The two main popularly grown species in marigold are *Tagetes erecta* L. and *Tagetes patula* L. which have their origin in Mexico and South Africa, respectively. *Tagetes erecta* L. is popularly known as "African marigold" while *Tagetes patula* L. as "French marigold". (Swathi and Naik, 2017) [10]. Marigold has got considerable choice among the gardeners and flower growers on account of its ease in cultivation and wide adaptability in varied agro climatic conditions. Sustainable flower production requires optimal nutritional management to attain a high ornamental value of plant and to reduce production costs (Polara *et al*., 2014) [7]. Marigold has a great demand as loose flowers, and is widely used for making garlands and for decorative purposes. Apart from this, it's extracted colour used as colorant in the food and animal feed industry.

Rapid industrial developmental activities and increasing population growth had declined the resources day by day throughout the world. The population increase has not only increased the fresh water demand but also increased the volume of wastewater generated. Therefore, there is an urgent need to conserve and protect fresh water and to use the water of lower quality for irrigation. Various studies confirm that treated sewage water can be useful as an additional water resource for irrigation (Palese *et al*., 2009; Mehrdadi *et al*., 2007) [6, 5]. Disposal of sewage waste water is a problem of increasing importance throughout the world. At present 17.4 million cubic liters of raw sewage is generated per day in urban areas of the country (Mara *et al*., 2007) [4].

Sewage water is used as a source of irrigation as well as a source of plant nutrients and trace elements allowing farmers to reduce and even eliminate the use of chemical fertilizers and as an organic matter that serves as a soil conditioner and humus replenisher (Bakhsh and Hassan 2005) [1]. The present work done at Kolar district situated in the Eastern dry agro climatic Zone. It experiences a semi-arid climate. Due to scattered rainfall pattern and depletion of ground water, irrigation is becoming highly challenging. In this regard use of sewage water in horticulture crops with proper scientific study will helpful to solve the growing problem. In this regard, a study entitled "Effect of sewage water on growth, yield and quality of marigold (*Tagetes erecta* L.)" was carried out.

Fig 1: General view of research plot

Results and Discussion
Soil analysis
Soil pH and EC

The initial soil pH (6.86) and initial soil EC (0.83 dS m^{-1}) recorded before transplanting and harvesting stages (90 days after transplanting) are presented in the Table 1. The soil pH and EC differed significantly among all the different treatments of sewage water. The lowest soil pH (6.74) was obtained in 100 percent untreated sewage water (T_2). The highest soil EC (1.46 dS m^{-1}) at harvesting stage was recorded in T_5 and which was on par with T_2 (1.45 dS m^{-1}). However, the highest pH (7.23) and lowest soil EC of (0.82 dS m^{-1}) was observed in control.

Among the soil parameters, the lowest soil pH and high soil EC was obtained in 100 percent untreated sewage water (T_2), this can be attributed to more acidic nature of sewage water and the quantity of sewage water applied in this treatment was more as compared with rest of the treatments. Whereas, the highest soil EC may be due to higher salt content and mineralization of sewage water, there was increase in soil EC with increase in dose of sewage sludge application.

Available NPK (kg ha^{-1})

The availability of NPK increased with increase in dose of sewage water and with advancement in crop age data recorded at harvesting stage given in Table 1. The highest soil nitrogen content (712.72 kg ha^{-1}) was observed in 100 percent untreated sewage water treatment (T_2) and followed by T_3 and T_4. Among all the treatments, (T_2) 100 percent untreated sewage water treatment added highest soil phosphorus content (66.95 kg ha^{-1}) followed by T_3 and T_4. Similar trend was followed even in potassium as that of nitrogen and phosphorous, the availability of soil potassium increased as the crop age advanced along with rate of sewage water application. The highest soil potassium content (663.45 kg ha^{-1}) was observed in 100 percent untreated sewage water treatment (T_2) followed by T_3 and T_4. The lowest NPK was observed in Control (T_1).

The availability of NPK increased with increase in dose of sewage water and with advancement in crop. The highest N content was due to more nitrogen content of sewage water and its availability with more sewage water application. High P content can be attributed to higher phosphorus availability from sewage water similar to nitrogen. High K was due to more potassium content of sewage water. Relatively high percent of organic carbon in sewage sludge increased the cation exchange capacity, which helped to retain essential plant nutrients within the rooting zone (Soon, 1981) [8].

Available Ca, Mg (m eq/100 g) and S (ppm)

The available Ca, Mg and S content of soil applied with sewage water at the harvesting stage was given in Table 1. Highest soil calcium content (6.16 meq/100 g), The highest soil magnesium content (3.41 meq/100 g) and the highest Sulphur content (28.63 ppm) was recorded in soil which was applied with 100 percent sewage water (T_2) followed by T_3 and T_4. In contrast the lowest Calcium (2.70 meq/100 g), lowest magnesium (1.68 meq/100 g) and lowest sulphur content (18.41 ppm) was observed in Control (T_1).

Among secondary macro nutrients, high Ca, Mg and S was obtained in 100 percent untreated sewage water (T_2), it was due to more Ca, Mg and S content of sewage water and its availability with more sewage water application. The calcium, magnesium and sulphur content of sewage effluent has increased by 35 percent compared to tube well water samples. This increase may be due to the addition of certain compounds (which imparts hardness) after domestic use of the water (Kiran *et al*., 2012) [2].

Available micronutrients (mg kg^{-1}).

The available micronutrient content of soil with sewage water at harvesting stage is given in Table 2. The highest soil zinc content (30.60 mg kg^{-1}), highest soil iron content (53.33 mg kg^{-1}), highest soil copper content (4.16 mg kg^{-1}) and highest soil manganese content (21.43 mg kg^{-1}) was observed in 100 percent untreated sewage water treatment (T_2) followed by T_3 and T_4. In contrast lowest Zinc (8.24 mg kg^{-1}), lowest Iron (17.05 mg kg^{-1}), lowest copper (1.51 mg kg^{-1}) and lowest Manganese (8.90 mg kg^{-1}) was observed in Control (T_1).

Among micronutrients, increased soil micro nutrients were noticed in 100 percent untreated sewage water (T_2). This might be due to more Zn, Fe, Cu and Mn content of sewage water and its availability with more sewage water application.

Table 1: Soil pH, EC, available N, P, K, and Ca, Mg, S as influenced by sewage water treatment levels

Treatments (T)	pH	EC (dS m^{-1})	Nitrogen (kg ha^{-1})	Phosphorous (kg ha^{-1})	Potassium (kg ha^{-1})	Calcium (meq/100 g)	Magnesium (meq/100 g)	Sulphur (ppm)
T_1 Bore well water (Control)	7.23	0.82	262.63	32.76	239.46	2.70	1.68	18.41
T_2 (100% Sewage Water)	6.74	1.45	712.72	66.95	663.45	6.16	3.41	28.63
T_3 (25% B.W+ 75% S.W)	7.19	0.98	600.20	58.40	557.44	4.71	2.93	24.58
T_4 (50% B.W+50% S.W)	7.15	1.25	487.67	49.85	451.45	4.26	2.71	22.46
T_5 (75% B.W+ 25% S.W)	7.19	1.46	375.15	41.30	345.45	3.70	2.38	21.51
S. Em±	0.01	0.12	2.37	0.79	1.48	0.03	0.03	0.06
CD (P=0.05)	0.03	0.36	5.02	1.68	3.13	0.10	0.09	0.20

Table 2: Soil micronutrients as influenced by sewage water treatment levels

Treatments (T)	Zinc (mg kg^{-1})	Iron (mg kg^{-1})	Copper (mg kg^{-1})	Manganese (mg kg^{-1})
T_1 Bore well water (Control)	8.24	17.05	1.51	8.90
T_2 (100% Sewage Water)	30.60	53.33	4.16	21.43
T_3 (25% B.W+ 75% S.W)	24.33	36.00	3.06	18.40
T_4 (50% B.W+50% S.W)	18.02	31.46	2.57	13.03
T_5 (75% B.W+ 25% S.W)	10.57	22.95	2.35	11.38
S. Em±	0.09	0.12	0.03	0.09
CD (P=0.05)	0.27	0.36	0.10	0.28

Table 3: Plant uptake of N, P, K, Ca, Mg and micronutrients in marigold varieties as influenced by sewage water treatment levels

Treatments (T)	Nitrogen uptake (%)	Phosphorus uptake (%)	Potassium uptake (%)	Calcium uptake (%)	Magnesium uptake (%)	Boron (ppm)	Copper (ppm)	Iron (ppm)	Zinc (ppm)
T_1 Bore well water (Control)	1.10	0.40	3.93	0.22	0.47	129.06	3.98	23.36	62.40
T_2 (100% Sewage Water)	2.22	0.73	4.53	0.27	0.59	157.18	7.75	88.68	175.88
T_3 (25% B.W+ 75% S.W)	2.08	0.54	4.09	0.25	0.56	147.96	5.98	61.86	127.41
T_4 (50% B.W+50% S.W)	1.67	0.41	3.96	0.23	0.48	129.16	4.10	24.58	71.28
T_5 (75% B.W+ 25% S.W)	1.52	0.50	3.86	0.27	0.50	148.01	5.96	57.40	127.31
S. Em±	0.08	0.22	0.22	0.15	0.08	0.42	0.06	0.23	0.44
CD (P=0.05)	0.24	0.67	0.67	0.46	0.25	1.28	0.20	0.70	1.32
Varieties (V)									
V_1 (Maxima Yellow)	1.89	0.55	4.33	0.27	0.57	148.78	5.98	53.56	118.76
V_2 (Arka Bangara)	1.55	0.48	3.81	0.23	0.47	135.78	5.12	48.80	106.96
S. Em±	0.05	0.03	0.14	0.09	0.05	0.27	0.04	0.14	0.27
CD (P=0.05)	0.15	0.11	0.42	0.29	0.15	0.81	0.13	0.44	0.83
Interaction (Treatments x Varieties)									
T_1V_1	1.17	0.43	4.05	0.21	0.42	163.06	4.43	25.06	78.16
T_1V_2	1.04	0.39	3.86	0.25	0.52	151.30	3.53	24.10	64.40
T_2V_1	2.42	0.78	4.75	0.30	0.55	154.26	6.26	90.60	180.63
T_2V_2	2.03	0.69	4.32	0.25	0.43	141.66	5.70	60.30	120.56
T_3V_1	2.24	0.58	4.36	0.27	0.63	136.30	8.13	63.43	134.26
T_3V_2	1.93	0.50	3.82	0.22	0.54	122.03	7.36	86.76	171.13
T_4V_1	1.91	0.46	4.27	0.25	0.51	136.40	4.60	25.93	67.20
T_4V_2	1.43	0.34	3.58	0.29	0.61	121.73	3.60	20.80	57.60
T_5V_1	1.73	0.53	4.22	0.23	0.58	153.86	6.50	62.76	133.53
T_5V_2	1.31	0.48	3.49	0.20	0.43	142.16	5.43	52.03	121.10
S. Em±	0.11	0.08	0.31	0.22	0.11	0.60	0.09	0.33	0.62
CD (P=0.05)	0.34	0.25	0.95	0.66	0.35	NS	NS	0.99	1.86

Plant analysis

Nitrogen, Phosphorous and Potassium uptake (%)

The NPK uptake by marigold plants (%) was estimated and is presented in Table 3. Which was significantly different among the treatments. The highest nitrogen uptake (2.22%) was noticed in T_2 followed by T_3 and T_4, The lowest nitrogen uptake (1.10%) was observed in Control (T_1).

The highest phosphorus uptake (0.73%) was also recorded in 100 untreated sewage water (T_2) followed by T_3 and T_4. The lowest phosphorus uptake (0.40%) was observed in Control (T_1). Whereas, the highest Potassium uptake (4.53%) was recorded in 100 percent untreated sewage water (T_2) followed by T_3 and T_4. The lowest Potassium uptake (3.93%) was observed in control (T_1). Among the varieties highest nitrogen uptake (1.89%), highest phosphorus uptake (0.43%), highest potassium uptake (4.33%) was observed in Maxima Yellow and lowest value recorded in Arka Bangara 2 (Table 3).

The maximum nitrogen uptake (2.42%) was recorded in T_2V_1 and minimum nitrogen uptake was recorded in T_1V_2 (1.04%). The maximum phosphorus uptake (0.78%) was recorded in T_2V_1 and minimum phosphorus uptake was recorded in T_4V_2 (0.34%). The maximum Potassium uptake (4.75%) was recorded in T_2V_1 and minimum Potassium uptake was recorded in T_5V_2 (3.49%).

Table 4: Total bacteria, fungi and actinomycetes in soil as influenced by sewage water treatment levels

Treatments (T)	Total bacteria (CFU X 10^6 g^{-1} soil)	Total fungi (CFU X 10^4 g^{-1} soil)	Total actinomycetes (CFU X 10^4 g^{-1} soil)
T_1 Bore well water (Control)	4.02	1.20	1.31
T_2 (100% Sewage Water)	5.80	2.56	1.71
T_3 (25% B.W+ 75% S.W)	5.38	2.50	1.37
T_4 (50% B.W+50% S.W)	4.81	2.44	1.51
T_5 (75% B.W+ 25% S.W)	4.60	2.24	1.58
S. Em±	0.04	0.01	0.01
CD (P=0.05)	0.12	0.02	0.02
Varieties (V)			
V_1 (Maxima Yellow)	5.30	2.26	1.45
V_2 (Arka Bangara)	4.55	2.11	1.54
S. Em±	0.02	0.006	0.006
CD (P=0.05)	0.08	0.02	0.02
Interaction (Treatments x Varieties)			
T_1V_1	4.52	1.24	1.76
T_1V_2	3.53	1.16	1.65
T_2V_1	6.26	2.60	1.36
T_2V_2	5.34	2.52	1.26
T_3V_1	5.94	2.57	1.62
T_3V_2	4.83	2.43	1.54
T_4V_1	5.07	2.55	1.55
T_4V_2	4.56	2.34	1.46
T_5V_1	4.71	2.35	1.42
T_5V_2	4.49	2.14	1.33
S. Em±	0.06	0.01	0.01
CD (P=0.05)	0.18	0.04	N.S

Ca and Mg uptake (%)

The highest Calcium uptake (0.27%) and highest Magnesium uptake (0.59%) was recorded in 100 percent untreated sewage water treatment (T_2) followed by T_3 and T_4. The lowest Calcium and magnesium uptake was observed in Control (T_1). Among varieties highest Calcium uptake (0.27%) and highest magnesium uptake (0.55%) observed in Maxima Yellow and lowest value recorded in Arka Bangara 2 (Table 3). The maximum Calcium uptake (0.30%) was recorded in T_2V_1 and minimum Calcium uptake was recorded in T_5V_2 (0.20%). The maximum Magnesium uptake (0.63%) was recorded in T_3V_1 and minimum Magnesium uptake was recorded in T_1V_1 (0.42%).

Micronutrients uptake (ppm)

The effect of sewage on micronutrient content uptake is given in table 3. The highest Boron uptake (157.18 ppm) was recorded in 100 percent untreated sewage water treatment (T_2) and followed by T_5 and T_3. The highest Copper uptake (7.75 ppm), highest Iron uptake (88.68 ppm) and highest Zinc uptake (175.88 ppm) was recorded in 100 percent untreated sewage water (T_2) which was followed by T_3 and T_5. The lowest boron (129.06 ppm), copper (3.98 ppm), iron (23.36 ppm) and zinc (62.40 ppm) uptake was observed in Control (T_1).

Among the varieties highest Boron uptake (148.78 ppm), highest Copper uptake (5.98 ppm), highest Iron uptake (53.56 ppm) and also the highest zinc uptake (118.76 ppm) was observed in Maxima Yellow and lowest value recorded in Arka Bangara 2 (Table 3). Among interaction the result found was non significant for boron and copper uptake. The maximum Iron uptake (90.60 ppm) and also the zinc uptake (180.63 ppm) was recorded in T_2V_1 and minimum Iron uptake (20.80 ppm) and zinc uptake (57.60 ppm) was recorded in T_4V_2.

The more availability of nutrients was obtained in 100 percent untreated sewage water (T_2)**,** this was due to more availability of nitrogen in soil as compared to rest of the treatments. Sewage water irrigation was found to act as a supplement to soil fertility by adding organic matter and mobile compounds of nutrients. High P might be due to more availability of phosphorus in the soil and favourable soil pH for phosphorus availability at these treatments. Whereas High K was due to more availability of potassium in the soil. High Ca and Mg was due to more availability of Ca and Mg in the soil. The highest micronuteints content was also noticed in plant analysis, this was due to more availability Zn, Fe, Cu and Mn in the soil. Finally the increase in bacterial, fungal and actinomycetes population was also noticed in the 100 percent untreated sewage water application, this might be due to mineralization of organic matter (Stepniewska *et al.*, 2007) [9].

Total bacteria, fungi and actinomycetes (CFU per g of soil)

Data on bacterial, fungal and actinomycetes populations of the soils (Table 4) showed that number of bacterial and fungal colonies increased significantly with sewage water irrigation, maximum being in sewage irrigated soils followed by partial sewage irrigated soils and least in bore well water irrigated soils. The maximum count of total bacteria (5.80 X 10^6 CFU), maximum count of total fungi (2.56 X 10^4 CFU) count found in (T_2) 100 percent untreated sewage water followed by treatment T_3 and T_4. Also, the maximum count of total actinomycetes count (1.71 X 10^4 CFU) was observed in 100% untreated sewage water (T_2), followed by treatment T_5 and T_4. The minimum bacterial, fungal and actinomycetes count was observed in control (T_1).

Among the varieties highest bacterial count (5.3 X 10^6 CFU) and highest fungi count (2.66 X 10^4 CFU) observed in Maxima Yellow (5.3 X 10^6 CFU) and lowest value recorded in Arka Bangara 2. In contrast to this the highest actinomycetes count (1.54 X 10^4 CFU) was recorded in Arka Bangara 2 and minimum recorded in Maxima Yellow.

The maximum bacterial count (6.26 X 10^6 CFU) and maximum fungi count (2.60 X 10^4 CFU) was recorded in T_2V_1 and minimum bacterial count (3.53 X 10^6 CFU) and fungal count

(1.16 X 10^4 CFU) was recorded in T_1V_2. Whereas, total actinomycetes count was found to be non-significant in the interaction.

Conclusion
Usage of the sewage water as the source of irrigation could be the better alternative way. As it contains the huge amounts of macro and micro nutrients which are required for the proper growth and development of plants. Which thereby reduces the quantity of the nutrients application and also reduced the cost of cultivation. Inferences about the usage of sewage water can be drawn from the findings of the current experiment that 100% sewage water usage in marigold varieties increased the soil and plant nutrient content of macro and micro nutrients also increased the bacterial and fungal count.

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