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Effect of sewage water on quality parameters of marigold (*Tagetes erecta* L.) under polyhouse condition

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Abstract
Due to rapid industrial development activities and increasing population, the resources are declining throughout the world. So, there is a need to adopt recycle and reuse strategy. Due to increasing population high volume of wastewater is being produced in the cities. As the sewage water serves as the important source of nutrients and trace elements it can be utilized for the irrigation purpose. Sewage water supplying large amount of nitrogen and phosphorus and their beneficial effect on improving and maintaining good soil structure is well established. The present research was conducted to record the effect of sewage water on growth yield and quality parameter of marigold over a period of year 2020 – 2021 at College of Horticulture, Kolar during rabi season in the pots under polyhouse condition. The experiment laid out in Factorial Randomized Complete Block Design (FRCBD) with 2 factors and 10 treatments with three replications. The standard protocol was followed for recording the observation. It was observed that all the quality parameters *viz*., highest flower diameter (6.69 cm), maximum number of petals (239.63), maximum shelf life of flowers (4.01 days), flower weight (7.38g) and highest carotene content (25.26 g kg^{-1}) were significantly higher in the plants treated with 100% untreated sewage water (T_2).

Keywords: Sewage water, quality parameters, marigold, *Tagetes erecta* L. polyhouse condition

1. 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) [9]. 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) [8]. 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.

2. Material and Methods

This present research work was carried out at College of Horticulture, Kolar located at 13.13 ˚N, 78.13 ˚E. with an average elevation of 849 meters. The experimental details include the African marigold plants were potted under polyhouse condition at during rabi season. The experiment was laid out in factorial randomized complete block design with 2 factors and 10 treatments with three replications. The treatments details include Factor A: sewage water treatment (T) with T_1 (bore well water), T_2 (Untreated sewage water), T_3 (25% Bore well water + 75% Untreated sewage water), T4 (50% Bore well water + 50% Untreated sewage water) and T5 (75% Bore well water + 25% Untreated sewage water) and Factor B: marigold varieties (V) with V_1 Arka Bangara 2 and V_2 Maxima Yellow. Thirty days old healthy seedlings were transplanted to each pot. The pots (60 cm x 45 cm) were filled with 2:1:1 ratio of red earth, sand and FYM and added with recommended dose of fertilizers (125:60:60 kg NPK/ ha) and treatments were imposed and soil samples were collected for further studies. The growth, yield and quality parameters were also analysed.

3. Result and Discussion

3.1 Quality parameters

Quality parameters were recorded and presented in the Table 3. All the parameters were significantly observed at all stages of plant growth. It revealed that the highest flower diameter (6.69 cm), maximum number of petals (239.63) were noticed in untreated sewage water treatment (T_2) followed by T_4. Higher flower diameter was due to early first bud appearance and subsequently less number of days for 50 per cent flowering and thus more scope for development of bigger flower. Whereas maximum shelf life of flowers (4.01 days) was also recorded in T_2 which was on par with T_3, this may be due more flower diameter and weight of flower in these two treatments. It was also noted that higher flower weight (7.38g) and highest carotene content (25.26 g kg^{-1}) was also significantly higher in T_2 followed by T_3 this might be due to more flower diameter, more number of flowers and more number of petals in two treatments (T_2 and T_3) as compared with rest of the treatments. In contrast the lower quality parameters were observed in Control (T_1).

Among varieties Maxima Yellow has recorded highest value of flower diameter (5.53 cm), maximum number of petals (188.10), maximum shelf life (4.22 days), highest flower weight (6.55 g) and lowest value found in Arka Bangara 2. Whereas the varieties highest carotene content was recorded in (V_2) Arka Bangara 2 (22.48 g kg^{-1}) and lowest was recorded in Maxima Yellow.

The interaction data in Table 3. It indicates significant values on quality parameters. The highest flower diameter (7.36cm) and maximum number of petals (232.63) shelf life (4.10 days) and flower weight (8.13g) were observed in T_2V_1 interaction and lowest value was recorded in T_1V_2. In interaction T_2V_2 induced maximum carotene content 27.12 g kg^{-1} was noted and minimum carotene content was recorded in T_1V_1 interaction.

Table 1: Quality parameters in marigold varieties as influenced by the sewage water treatment level

Treatments (T)	Flower diameter (cm)	Number of petals	Flower weight (g)	Shelf life (days)	Carotene (g/kg of petal meal)
T_1 Bore well water (Control)	4.52	139.51	5.52	2.16	14.08
T_2 (100% Sewage Water)	6.69	239.63	7.38	4.01	25.26
T_3 (25% B.W+ 75% S.W)	5.15	171.56	6.37	3.66	22.72
T_4 (50% B.W+50% S.W)	5.48	148.23	6.08	2.81	22.78
T_5 (75% B.W+ 25% S.W)	5.32	152.11	5.96	2.20	19.32
S. Em±	1.00	0.37	0.37	0.09	0.60
CD (P=0.05)	0.33	1.13	0.12	0.29	1.82
Varieties (V)					
V_1 (Maxima Yellow)	5.53	188.10	6.55	4.22	19.18
V_2 (Arka Bangara)	5.22	152.32	5.98	3.64	22.48
S. Em±	0.63	0.24	0.23	0.06	0.38
CD (P=0.05)	0.21	0.71	0.07	0.18	1.15
Interaction (Treatments x Varieties)					
T_1V_1	4.64	146.53	5.85	2.33	13.34
T_1V_2	4.30	129.46	5.20	2.00	14.82
T_2V_1	7.36	247.60	8.13	4.10	23.40
T_2V_2	6.01	231.66	6.63	3.23	27.12
T_3V_1	4.76	221.66	6.53	4.03	21.29
T_3V_2	5.55	132.50	6.21	3.56	24.15
T_4V_1	5.62	162.66	6.20	3.33	20.99
T_4V_2	4.95	133.80	5.96	2.30	24.58
T_5V_1	4.80	162.06	6.03	2.30	16.90
$T_5 V_2$	5.19	142.16	5.90	2.10	21.73
S. Em±	1.42	0.53			
CD (P=0.05)	0.47	1.60			

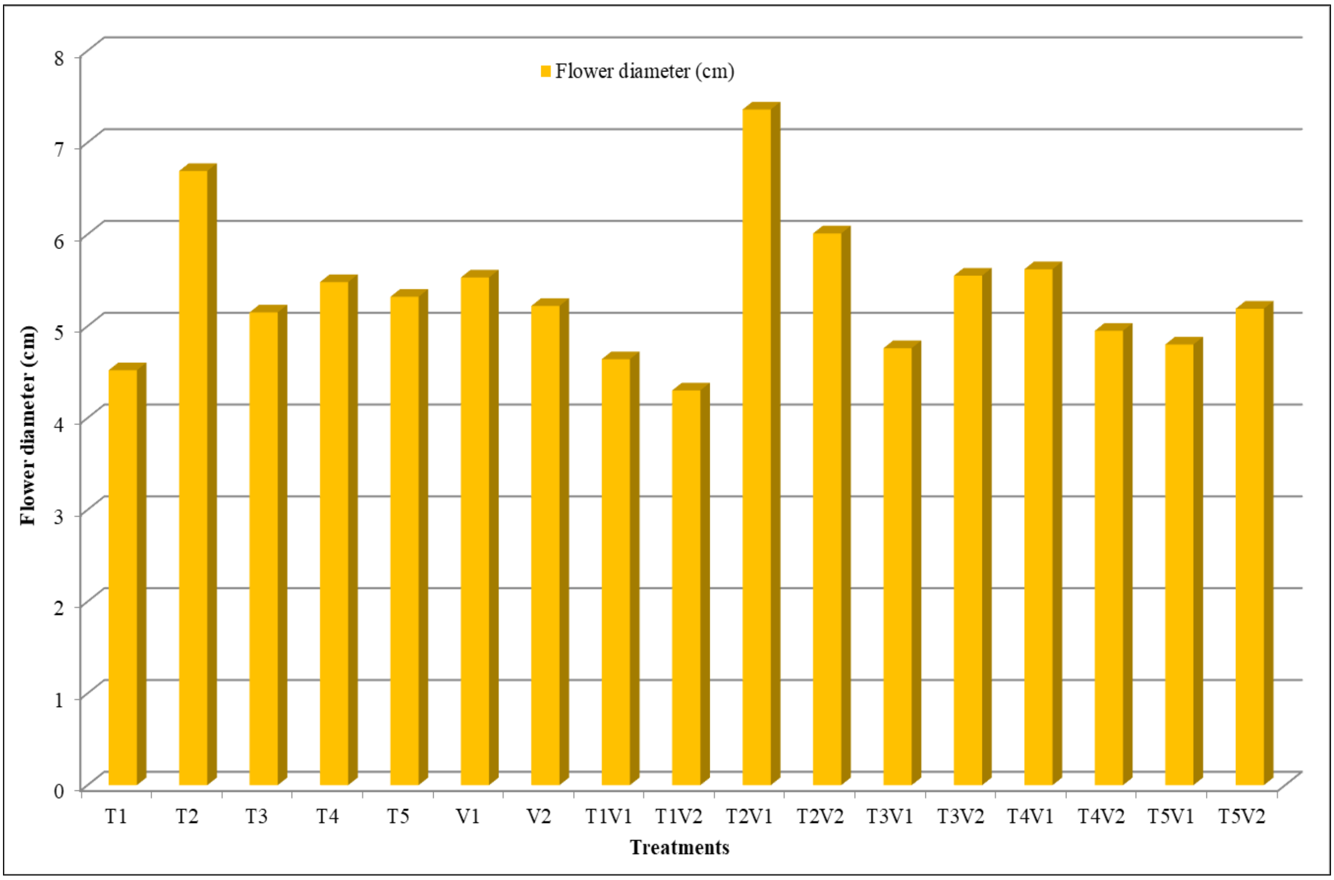

Fig 1: Flower diameter in marigold varieties (cm) as influenced by different sewage water treatment levels

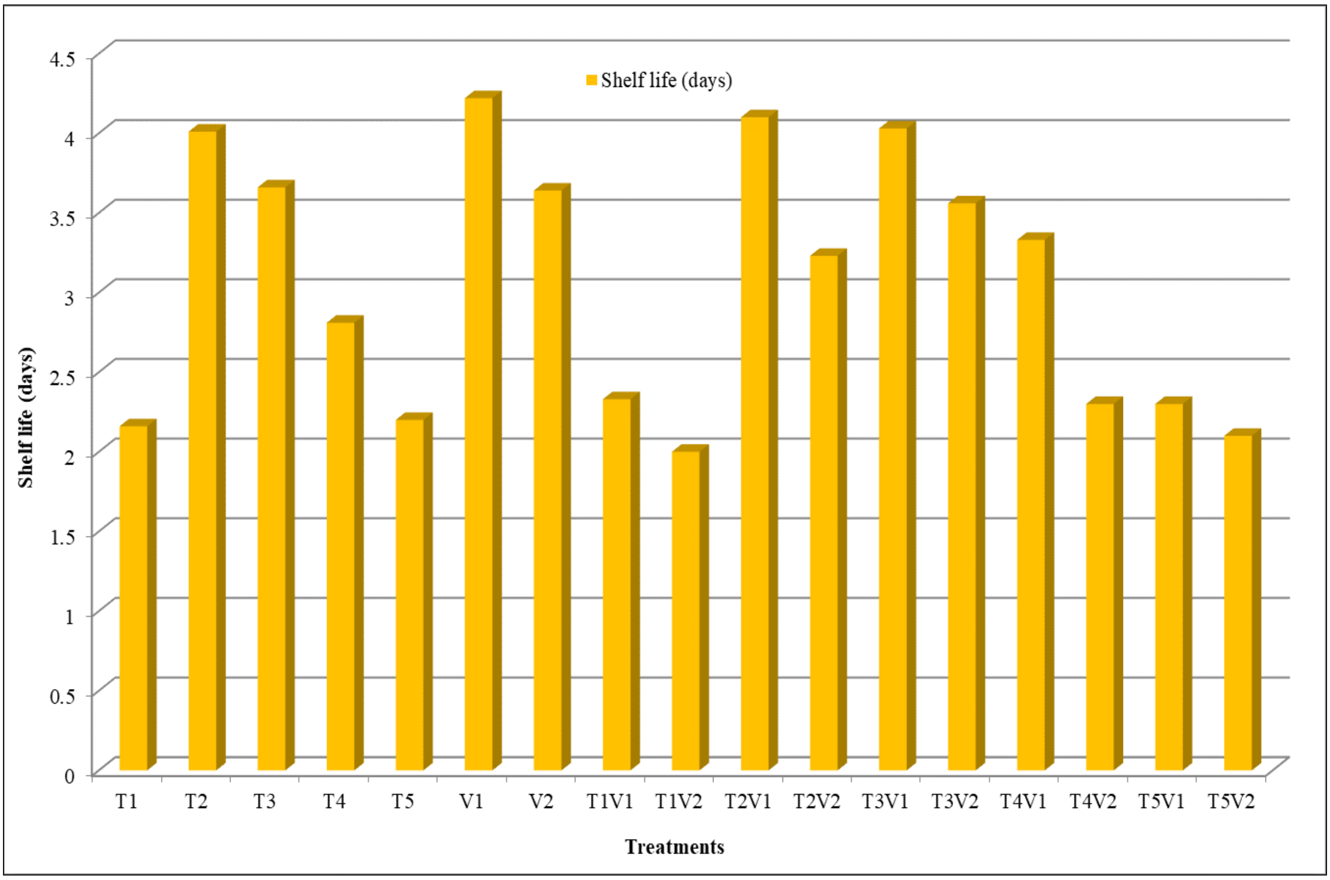

Fig 2: Shelf life in marigold varieties (days) as influenced by different sewage water treatment levels

Fig 3: Carotenoid extracted from Maxima Yellow and Arka Bangara plant

4. Conclusion
As there is increase in volume of waste water production, usage of the sewage water as the source of irrigation could be the better alternative way. 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 quality parameters *viz*., flower diameter, number of petals, flower weight, shelf life and carotene content.

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