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# Impact of sensor-based wastewater irrigation on chemical soil health in chrysanthemum (*Chrysanthemum morifolium*)

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Every continent today experiences water scarcity, which makes meeting the UN's sustainable development goals extremely difficult (UNESCO 2020). Many nations have made investments in wastewater treatment and reuse in response to rising demand and limited freshwater supply (Jones *et al*. 2021). The increasing generation of wastewater with low treatment capacity pose huge problem of its disposal. Because of this, large amount of wastewater being discharged either into groundwater or water body/natural drainage thereby increasing pollution of water bodies (Kaur *et al*. 2012). Chrysanthemum (*Chrysanthemum morifolium* Ramat.) was chosen as trial crop for this experiment. Studies on wastewater irrigation in flower crops in Indian condition are very less (Gurjar *et al*. 2018). Hence, greater research efforts are needed for location and situation specific recommendation of package of practices using sensor based irrigation scheduling for commercial cultivation of chrysanthemum. So, this study was performed to evaluate the short-term impact of sensor-based wastewater irrigation scheduling on chemical soil health in chrysanthemum.

A field study was carried out to assess short-term impact of sensor-based wastewater irrigation scheduling on chemical soil health in chrysanthemum at Water Technology Centre, ICAR-Indian Agricultural Research Institute, New Delhi, during 2019–20. The GPS coordinates of research farm are having latitude (28° 37' 22" to 28° 39' 00" N) and longitudes (77° 8' 45" to 77°10' 24" E) with an average altitude of 225 metre above MSL. Soils was sandy loam (0–30 cm). Soil *p*H (7.65) and EC (0.29 dS/m) were found optimum. Mean OC of soil (0.32%) and soil available NPK was 128.71 kg/ha, 26.55 kg/ha and 283.61kg/ha, respectively. The bulk density of 0–30 cm soil depth was 1.52 Mg/m$^3$. The maximum water holding capacity of soil was 21.96%. Six treatments, viz. $T_1$, GWI scheduling at 25% MAD; $T_2$, GWI scheduling at 50% MAD; $T_3$, GWI scheduling at 75% MAD; $T_4$, WWI scheduling at 25% MAD; $T_5$, WWI scheduling at 50% MAD; $T_6$, WWI scheduling at 75% MAD with four replications were laid out in randomized block design (RBD). Irrigation scheduling in different treatments were based on MAD, which is soil indicator based approach. FDR sensor based irrigation scheduling at 3 levels of MAD (25%, 50% and 75%) values of soil moisture was used. Amount of water to be applied (l/plot) was quantified by multiplying the area of plot and refill/ irrigation depth. As per experimental plot size (2.25 m$^2$), refill amount/depth and amount of water applies for each 25, 50 and 75% MAD values were 1.58, 3.15, 5.04 cm/30 cm and 35.55, 70.87, 109.35 l/plot, respectively. In total 14, 11 and 8 irrigations are given at 25, 50 and 75% MAD levels with different dates as and when the specific MAD level reaches in that particular plot. EnviroSCAN probe was used to quantify soil moisture at amplification of 10 cm of surface soil to 2 m using DDI-I2 interface. EC and *p*H of soil were quantified by using a conductivity bridge and glass electrode, respectively (Jackson 1973). Soil OC was quantified by dichromate oxidation method and nitrogen analyzer for available nitrogen (Subbiah and Asija 1956). 0.5 M $NaHCO_3$ is used for extracting samples to determine available P in soil and UV visible spectrophotometer is used for determining phosphorus calorimetrically using molybdate. For determining available K, ammonium acetate (1N) for extraction followed by flame photometer (Jackson 1973). Soil micronutrients and heavy metals content were quantified by ICP-MS (Lindsay and Norvell 1978). After analysis of all soil health indicators the mean values were determined. The data for each parameter was analyzed through the ANOVA technique as applicable to RBD (Gomez and Gomez 1983).

*Short term impact on soil* p*H, EC, OC and available NPK content*: Results (Table 1) shows soil *p*H ranges from 7.15–7.30 (slightly alkaline). Soil EC under all treatments ranges from 0.29–0.31 dS/m at depth of 0–15 cm. Soil OC ranges from 0.29–0.36% under all irrigation treatments at 0–15 cm soil depth. In WWI plots maximum

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Table 1 Impact of FDR sensor based application of wastewater irrigations on soil *p*H, EC, OC and available NPK contents at 0–15 cm depth after harvest of chrysanthemum (2019–20)

| Treatment | *p*H (1:2.5) | EC (1:2.5) (dS/m) | OC (%) | Available N (kg/ha) | Available P (kg/ha) | Available K (kg/ha) |
|---|---|---|---|---|---|---|
| T1 | 7.30 | 0.29 | 0.29 | 121.14 | 26.06 | 280.33 |
| $T_2$ | 7.25 | 0.29 | 0.29 | 124.72 | 26.82 | 287.97 |
| $T_3$ | 7.15 | 0.30 | 0.30 | 127.06 | 27.33 | 292.97 |
| $T_4$ | 7.28 | 0.30 | 0.35 | 146.75 | 31.56 | 297.95 |
| $T_5$ | 7.30 | 0.31 | 0.36 | 152.72 | 32.84 | 310.67 |
| $T_6$ | 7.23 | 0.31 | 0.35 | 148.80 | 31.10 | 302.31 |
| SE(m) | 0.10 | 0.00 | 0.00 | 1.14 | 0.25 | 2.44 |
| CD (P=0.05) | NS | NS | 0.008 | 3.48 | 0.75 | 7.41 |

Refer to methodology for treatment details.

OC (0.36%) was in ($T_5$). Available soil N content ranges from 121.14 to 152.72 kg/ha. Significantly higher content of available N at 0–15 cm (152.72 kg/ha) was found in $T_5$. Same trends were observed with available P (32.84 kg/ha) and K (310.67 kg/ha) content in soil. Available P content ranges from 26.06 to 32.84 kg/ha. Available K content in soil varies from 280.33 to 310.67 kg/ha. EC of the treated wastewater (TWW)-irrigated soils increased due to increase in salinity (Ibrahimi *et al*. 2022). Gurjar *et al*. (2018) found higher content of OC in wastewater irrigated plot soils. The increased content of soil OC because of presence of higher amount of soil organic matter in TWW resulted in higher vegetative growth (Abd-Elwahed 2018). TWW irrigation considerably boosted the total N by 22 to 90%, most likely as a result of the biodegradation of carbon compounds in wastewater (Rezapour *et al*. 2017). Available P and K contents were generally found to be greater in TWW-irrigated plots than in groundwater irrigated plots (Ibrahimi *et al*. 2022). As farmers do not provide nutrient inputs at the research sites, the TWW was primarily responsible for providing these nutrients (Liang *et al*. 2021). Gurjar *et al*. (2018) reported greater amount of NPK in tuberose irrigated under wastewater. TWW application increased the P and K contents of the soils compared to ground watered soils (Jahany and Rezapour 2020).

*Short term impact on content of micronutrients in soil*: Results (Table 2) shows that significantly greater amount of available copper (1.25 mg/kg) was observed in $T_4$ treatment. Available iron content (9.03 mg/kg) was observed significantly more in $T_4$. Significantly larger amount of available manganese (14.61 mg/kg) in soil was observed in $T_5$. Significantly greater amount of available zinc (2.40 mg/kg) in soil was observed in $T_4$. This might be due to occurrence of greater content of these micro-nutrients compared to groundwater (Gurjar *et al*. 2018). The presence of these micronutrients in the TWW may directly correlate with the greater concentration of micronutrients in the TWW-irrigated soils (Khawla *et al*. 2019). Furthermore, application of higher quantity ($T_5$: Mn) with more number of irrigation or frequent irrigation, ($T_4$: Cu, Fe and Zn) might be the reason for significantly greater amount of micronutrients in wastewater irrigated plots than groundwater (Gurjar *et al*. 2018). TWW considerably increases nutrients in the form trace metals (Fe, Mn, Zn, and Cu), thereby successfully improving soil fertility and crop productivity (Tahtouh *et al*. 2019).

*Short term impact on content of heavy metals in soil*: Results (Table 3) shows content of heavy metals (Ni, Cr, Cd and Pb) in soils ranges from 0.36 to 0.60, 0.51 to 0.73, 0.02 to 0.03 and 0.51 to 1.76 mg/kg, respectively. Considerably greater amount of Ni (0.60 mg/kg), Cd (0.03 mg/kg) and Pb (1.76 mg/kg) was observed in $T_4$. Highest content of Cr (0.73 mg/kg) was observed in $T_5$. These results are comparable to those reported by (Ghosh *et al*. 2012). All heavy metals were substantially more abundant after wastewater irrigation than in groundwater irrigated soils. This pattern was seen across all soil types, suggesting that wastewater irrigation caused the heavy metals to accumulate in these soils and enrich them (Jahany and Rezapour 2020).

It can be concluded that short term wastewater application in significantly enhanced the content of primary nutrients and micronutrients in the soils. Overall, short term wastewater application has beneficial effects on soil health of chrysanthemum. Though, there is need to regularly

Table 2 Impact of FDR sensor based application of wastewater irrigations on available micronutrients contents in soil at 0-15 cm depth after harvest of chrysanthemum (2019–20)

| Treatment | Cu (mg/kg) | Fe (mg/kg) | Mn (mg/kg) | Zn (mg/kg) |
|---|---|---|---|---|
| $T_1$ | 1.04 | 7.52 | 8.48 | 1.53 |
| $T_2$ | 1.02 | 7.38 | 8.75 | 1.50 |
| $T_3$ | 0.99 | 7.17 | 8.67 | 1.46 |
| $T_4$ | 1.25 | 9.03 | 14.35 | 2.40 |
| $T_5$ | 1.22 | 8.80 | 14.61 | 2.36 |
| $T_6$ | 1.21 | 8.68 | 13.15 | 2.28 |
| SE(m) | 0.00 | 0.07 | 0.15 | 0.03 |
| CD (P=0.05) | 0.03 | 0.21 | 0.44 | 0.08 |

Refer to methodology for treatment details.

Table 3 Impact of FDR sensor based application of wastewater irrigations on available (DTPA) heavy metals contents in soil at 0-15 cm depth after harvest of chrysanthemum (2019–20)

| Treatment | Ni (mg/kg) | Cr (mg/kg) | Cd (mg/kg) | Pb (mg/kg) |
|---|---|---|---|---|
| $T_1$ | 0.40 | 0.62 | 0.02 | 0.85 |
| $T_2$ | 0.36 | 0.57 | 0.02 | 0.57 |
| $T_3$ | 0.40 | 0.51 | 0.02 | 0.51 |
| $T_4$ | 0.60 | 0.71 | 0.03 | 1.76 |
| $T_5$ | 0.54 | 0.73 | 0.03 | 1.65 |
| $T_6$ | 0.54 | 0.67 | 0.03 | 1.47 |
| SE(m) | 0.002 | 0.001 | 0.00 | 0.002 |
| CD (P=0.05) | NS | NS | NS | NS |

Refer to methodology for treatment details.

monitor the health of wastewater irrigated soils and quality of wastewater.

## SUMMARY

A field experiment was conducted to study the short-term impact of sensor-based wastewater irrigation scheduling on chemical soil health in chrysanthemum (*Chrysanthemum morifolium* Ramat.) at Water Technology Centre, ICAR-Indian Agricultural Research Institute (IARI), New Delhi during 2019–20. Experiment was conducted with following 6 treatments, viz. $T_1$, Groundwater irrigation (GWI) at 25% Maximum Allowable Depletion (MAD), $T_2$, GWI at 50% MAD, $T_3$, GWI at 75% MAD, $T_4$, Wastewater irrigation (WWI) at 25% MAD, $T_5$, WWI at 50% MAD, $T_6$, WWI at 75% MAD and was laid out in a randomized block design (RBD) in open field condition with 4 replications. Soil samples and quality of groundwater and wastewater were assessed during and after the experiment to quantify the chemical properties (*p*H, EC and OC), primary nutrients (NPK), micronutrients (Fe, Mn, Cu and Zn) and heavy metals (Ni, Pb, Cr and Cd). Results shows that *p*H and EC remains the same. Organic carbon, primary nutrient and micronutrients content significantly increased in wastewater irrigated soils and best result was observed in $T_5$. Moreover, the content of heavy metals (Ni, Cr, Cd and Pb) in soils was significantly not changed with different wastewater irrigation treatments. Wastewater irrigation have beneficial impacts on soil chemical parameters in terms of higher amount of organic matter, primary and micronutrients in soil.

## REFERENCES

Abd-Elwahed M S. 2018. Influence of long-term wastewater irrigation on soil quality and its spatial distribution. *Annals of Agricultural Sciences* **63**(2): 191–99.

Ghosh A K, Bhatt M A and Agrawal H P. 2012. Effect of long-term application of treated sewage water on heavy metal accumulation in vegetables grown in Northern India. *Environmental Monitoring and Assessment* **184**: 1025–36. https://doi.org/10.1007/s10661-011- 2018-6.

Gomez K A and Gomez A A. 1983. *Statistical Procedure for Agricultural Research,* pp 20–8. John Wiley and Sons, New York, United States of America.

Gurjar D S, Kaur R and Singh K P. 2018. Impact of wastewater irrigation on vegetative growth, flowering characteristics, keeping quality and productivity of tuberose (*Polianthes tuberosa*). *Indian Journal of Agricultural Sciences* **88**(4): 584–89.

Ibrahimi K, Attia K B, Amami R, Américo-Pinheiro J H P and Sher F. 2022. Assessment of three decades treated wastewater impact on soil quality in semi-arid agroecosystem. *Journal of the Saudi Society of Agricultural Sciences* **21**(8): 525–35.

Jackson M. L. 1973. *Soil Chemical Analysis*. Pentice hall of India Pvt. Ltd., New Delhi, India. **498**: 15–54.

Jahany M and Rezapour S. 2020. Assessment of the quality indices of soils irrigated with treated wastewater in a calcareous semi-arid environment. *Ecological Indicators* **109**: 105800.

Jones E R, Van Vliet M T, Qadir M and Bierkens M. F. 2021. Country-level and gridded estimates of wastewater production, collection, treatment and reuse. *Earth System Science Data* **13**(2): 237–54.

Kaur R, Wani S P. Singh A K and Lal K. 2012. Wastewater production, treatment and use in India. (In) *National Report presented at the 2nd regional workshop on Safe Use of Wastewater in Agriculture,* pp. 1–-3.

Khawla K, Besma K, Enrique M and Mohamed H. 2019. Accumulation of trace elements by corn (*Zea mays*) under irrigation with treated wastewater using different irrigation methods. *Ecotoxicology and Environmental Safety* **170**: 530–37.

Liang X, Rengasamy P, Smernik R, Mosley and L M. 2021. Does the high potassium content in recycled winery wastewater used for irrigation pose risks to soil structural stability? *Agricultural Water Management* **243**: 106422. https://doi.org/10.1016/j.agwat.2020.106422

Lindsay W L and Norvell, W. 1978. Development of a DTPA soil test for zinc, iron, manganese, and copper. *Soil Science Society of America Journal* **42**(3): 421–28.

Rezapour S, Kalashypour E and Asadzadeh F. 2017. Assessment of the quality of salt-affected soils after irrigation and cultivation in semi-arid condition. *International Journal of Environmental Research* **11**: 301–13.

Subbiah B V and Asija G L. 1956. A rapid procedure for determination of available nitrogen in soils. *Current Science* **25**: 259–60.

Tahtouh J, Mohtar R, Assi A, Schwab P, Jantrania A, Deng Y and Munster C. 2019. Impact of brackish groundwater and treated wastewater on soil chemical and mineralogical properties. *Science of the Total Environment* **647**: 99–109. https://doi.org/10.1016/j.scitotenv.2018.07.200.

Water U N. 2020. Water and climate change. The United Nations World Water Development Report; UNESCO: Paris, France.