

Application of treated municipal wastewater for crop irrigation

Sowmiya.S.S¹, Karthika.N²

1(Environmental Engineering, Egs pillay engineering college, Nagappattinam
Email: sowmiyasenthil4@gmail.com)

2(Environmental Engineering, Egs pillay engineering college, Nagappattinam
Email: karthika@egspec.org)

Abstract:

Water scarcity has led to increased interest in alternative irrigation sources such as treated municipal wastewater. This study evaluates the effectiveness of treated wastewater for irrigating a short-duration crop, okra (*Abelmoschus esculents*), compared with groundwater. Physico-chemical characteristics of both water sources were analysed, and their effects on soil nutrients, plant growth, and yield were assessed over a six-week period. Results indicated that treated wastewater contained higher levels of nitrogen, phosphorus, and potassium, leading to improved plant growth and a 20–22% increase in yield compared to groundwater irrigation. Soil fertility also improved significantly under wastewater irrigation. However, slightly elevated electrical conductivity suggests the need for long-term monitoring. The study concludes that treated municipal wastewater can be a sustainable irrigation alternative for short-duration crops with proper management.

Keywords — Wastewater reuse, Okra, irrigation, soil nutrients, sustainable agriculture.

I. INTRODUCTION

Water scarcity is a major global issue affecting agricultural productivity. Agriculture consumes nearly 70% of freshwater resources worldwide, making it essential to explore alternative water sources. Treated municipal wastewater has emerged as a viable option due to its availability and nutrient content. In India, rapid urbanization has led to increased wastewater generation, much of which remains underutilized. Reusing treated wastewater for irrigation can reduce dependence on groundwater while improving soil fertility. Okra (*Abelmoschus esculentus*) is a widely cultivated short-duration

vegetable crop that responds well to nutrient-rich irrigation. This study aims to evaluate the impact of treated municipal wastewater on okra growth, soil quality, and yield compared to groundwater irrigation.

II. LITERATURE REVIEW

General :

Wastewater reuse is becoming essential to meet; rising agricultural water demand (20–30%) projected rise by 2050).

In India, wastewater irrigation is underutilized; studies from Tamil Nadu, Gujarat, and Rajasthan

show positive results when effluent meets BIS IS:11624 standards.

Findings from Previous Studies on Wastewater

Irrigation:

Pedrero et al. (2010): TMW improved soil organic matter and reduced fertilizer needs by up to 30%.

Rusan et al. (2007): Long-term wastewater use increased soil N and P but also caused gradual salinity build-up.

Kumar et al. (2015): Okra yield increased by 18% with municipal effluent irrigation compared to groundwater.

Wang Jun-feng (2007): Studied soil changes, crop yield, and groundwater risks under controlled treated sewage irrigation.

Angela Libutti & Gatta (2018): Summarized impacts on soil chemistry, crop yield, and pathogen risks.

Singh et al. (2014): Okra irrigated with treated effluent showed faster germination and higher chlorophyll content.

Sharma et al. (2018): Wastewater-irrigated okra reached flowering 4–5 days earlier due to higher nitrogen availability.

III. MATERIALS AND METHODOLOGY

A. Study Area and Experimental Design

The study was conducted using two experimental plots (3 m × 3 m each):

Plot A: Irrigated with treated municipal wastewater.

Plot B: Irrigated with groundwater used.

B. Water Sampling and Analysis

Water samples were collected and analysed using standard methods (APHA, 2017) for parameters including pH, EC, TDS, BOD, COD, and nutrients.

C. Soil Analysis

Soil samples were collected before and after the experiment to determine changes in nutrient content (N, P, K) and organic matter.

D. Crop Cultivation

Okra seeds were sown with standard spacing. Irrigation was applied twice weekly using equal volumes of water in both plots.

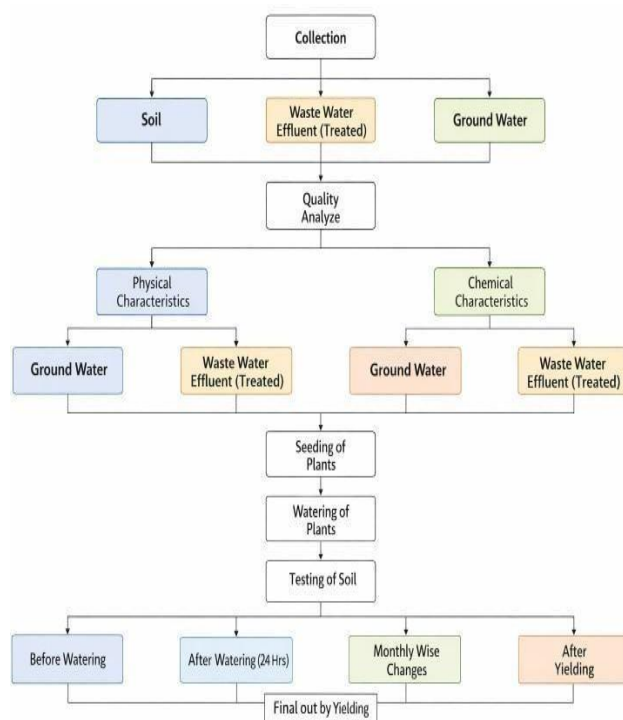


Fig. 1 Flowchart for methodology of crop irrigation

E. Growth Parameters

Plant height, number of leaves, and yield were recorded at weekly intervals up to six weeks.

IV. RESULTS AND DISCUSSIONS

A. Water Quality Analysis

Treated wastewater showed higher nutrient concentrations compared to groundwater. Key parameters remained within permissible irrigation limits.

TABLE I
WATER QUALITY ANALYSIS

Parameter	Wastewater	Groundwater
pH	7.3	7.0
EC(dS/m)	1.1	7.5
TDS(mg/L)	650	450
Turbidity(NTU)	4.8	1.2
BOD(mg/L)	18	2
COD(mg/L)	42	6
Nitrogen(mg/L)	18.5	4.1
Potassium(mg/L)	12.8	3.5
Phosphorus(mg/L)	4.3	1.0
Iron(mg/L)	0.2	0.05
zinc(mg/L)	0.15	0.01

The higher nutrient content supports improved plant growth but requires monitoring of salinity.

B. Soil Nutrient Changes

Soil samples from both plots were analyzed before and after irrigation.

TABLE II.
CHANGE IN SOIL NUTRIENT CONTENT

Parameter	Initial	AfterWW	AfterGW
Nitrogen (kg/ha)	220	245	228
Phosphorus (kg/ha)	18	22	19
Potassium (kg/ha)	185	200	188

C. Plant Growth Performance

Plant growth parameters were recorded at 1,2, and 6 weeks.

TABLE III
AVERAGE PLANT HEIGHT

Week	Wastewater (cm)	Groundwater (cm)
1	7.4	6.8
2	15.8	13.9
6	68.2	59.5

Plants irrigated with wastewater showed better growth due to nutrient availability.

D. Yield Analysis

TABLE IV.
CHANGE IN SOIL NUTRIENT CONTENT

Irrigation Type	Yield (kg/plot)
Wastewater	14.8
Groundwater	12.2

Yield increased by approximately 21% with wastewater irrigation.

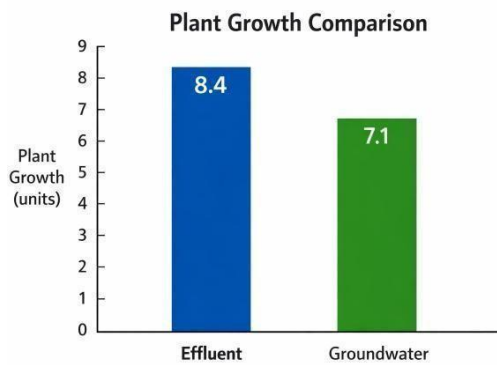


Fig. 2 Growth of plants graphical representation at week One

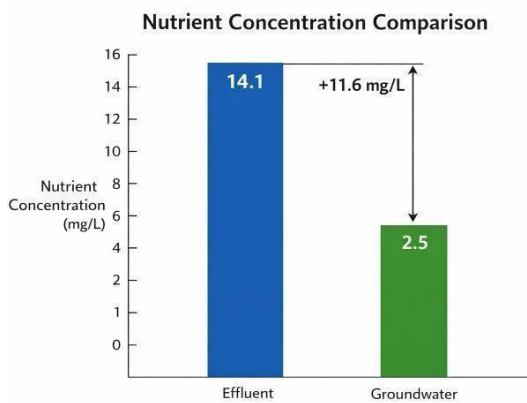


Fig. 3 Nutrient analysis graphical representation

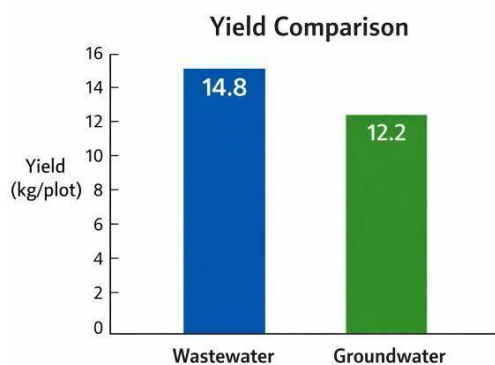


Fig. 4 Yield analysis graphical representation

E. Discussion

The results confirm that treated municipal wastewater enhances crop growth and yield due to its nutrient-rich composition. These findings align with previous studies reporting improved agricultural productivity using wastewater irrigation. However, long-term use may lead to salinity build up, requiring periodic monitoring. The overall results align with findings from past studies (e.g., Qadir et al., 2010; Pedrero et al., 2013) that have reported productivity benefits from treated wastewater reuse.

IV. CONCLUSION

Treated municipal wastewater can be effectively used for irrigating short-duration crops such as okra. It improves soil fertility, enhances plant growth, and increases yield. With proper treatment and monitoring, wastewater reuse offers a sustainable solution to water scarcity in agriculture. This study assessed the application of treated municipal wastewater for irrigating a short term crop and compared its effects with conventional groundwater irrigation.

The main findings include:

Treated wastewater met irrigation water quality standards and had higher nutrient levels compared to municipal wastewater for irrigating a short-term crop (Okra) and compared its effects with conventional standards and had higher nutrient levels compared to groundwater.

Soil nutrient content improved after wastewater irrigation, with increased organic matter and available nitrogen, phosphorus, and potassium.

Yield improvement of 21% demonstrates the potential for wastewater reuse in agriculture.

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