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# Effect of Wastewater Irrigation on Crop Production

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**Abstract**

The three most crucial pillars of human existence in India or anywhere else in the world are energy, food, and water security. Water is a crucial natural resource for producing food and energy. The international scientific community is working to address sustainable crop production and the scarcity of fresh water. According to estimates, approximately 80% of groundwater in India is used for agricultural irrigation. The study highlights the farmers' perceptions towards wastewater reuse. In this changing scenario, Wastewater (WW) plays an important role in sustainable agriculture by mitigating the water demand for agricultural crop production. WW is rich in plant nutrients, which are necessary for increased crop yield and higher-quality food grains. WW irrigation is expected to increase in the future due to urbanization and water shortages. While using WW for agriculture is not ideal, it has become a necessity in many regions. Long-term use of WW for crop production decreased both sustainable crop yield and soil biodiversity. To ensure the sustainable use of sewage water, effective treatment through STPs, regular monitoring of sewage-irrigated fields, and public awareness campaigns are essential. This study explores the status, challenges, and opportunities presented by WW irrigation for farmers in crop production. It advocates for a balanced approach that prioritizes sustainable practices, effective treatment, and public engagement to ensure the responsible and beneficial use of this valuable resource.

**Keywords:** Crop production, physicochemical characteristics, socio economic impact, WW irrigation, yield

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## Introduction

The three most crucial pillars of human existence in India or anywhere else in the world are energy, food, and water security. The relationships between water, food, and energy are fundamental to the formation and preservation of sustainable economies and environments. As the global population approaches 8 billion, there will be a greater need for basic services due to factors like rising aspirations for higher living standards and more thoughtful management of the essential resources needed to provide those services. These needs have also become more pressing and evident. A growing population, continuous migrations of people from rural to urban areas, rising incomes, a greater desire to spend those incomes on goods that require a lot of energy and water or on different diets, international trade, urbanization, and climate change are some of the factors contributing to the ongoing growth in demand for all three resources. Water is one of the most important natural resources for producing food and energy. Water is an essential component of all living things, making up between 50 and 97 per cent of plant and animal bodies as well as around 70 per cent of human bodies. However, it is one of the world's most mismanaged natural resources [1]. The Arabian Sea, Indian Ocean, and Bay of Bengal round India's large 12-river basin [2]. Only 4 per cent of fresh water is available in India, home to more than 18 per cent of the world's population [3]. According to estimations, agriculture uses more than 80 per cent of groundwater, primarily for irrigation [4]. India's groundwater irrigation sector has several difficulties, such as rapidly depleting aquifers, falling water tables, and worsening water quality as a result of overexploitation. These problems are made worse by unequal resource allocation, insufficient regulation, and climate change. Resources are further strained by a lack of crop variety and water-efficient farming practices. In order to address the fresh water deficit and sustainable agricultural production, a significant question came up in front of the international scientific community. Many scientists are working to find a solution to this issue and develop innovative approaches to water conservation.

Wastewater (WW) is a crucial component of sustainable agriculture in this evolving landscape, helping to reduce the amount of water needed to produce crops. WW stands for sewage, home, and industrial effluent in this context. Around 20 million hectares of agricultural land globally already utilize WW irrigation [5]. In developing nations like

India, peri urban regions frequently handle sewage or industrial waste. The agriculture production scenario around the megacity is becoming worse every year. This includes a significant number of plant nutrients in addition to irrigation water [6]. Untreated WW is commonly used in both developing and wealthy nations, including Mexico and China.

## Availability of Fresh Water for Crop Production

Although people across the world mishandle their natural resources, civilization began on the banks of rivers, where they worshipped Lord Water. India's agricultural sector is highly dependent on the monsoon season, since the erratic rainfall determines both the quantity and quality of crops produced. The amount of fresh water that is available for usage is 2.7 per cent worldwide; the remaining amounts are found in lakes, rivers, the atmosphere, soil moisture, and plants. In addition, about 75.2 per cent of fresh water is frozen in the form of ice caps in polar areas, and 22.6 per cent is found as groundwater. When using water, people are neglecting water management techniques. People are squandering water and utilizing excessive irrigation on a daily basis as a result of ignorance.

## Availability and Use of Wastewater

Excessive extraction has resulted in a significant drop in groundwater levels up to 200 meters in certain locations. The Central Ground Water Board (CGWB) research also indicated that in most Indian locales, the water table is dropping at a rate of one meter per year. Reducing this drop rate in the next few years will be significant for researchers and policymakers. Humans utilize tainted water for a variety of purposes. As a result of fierce rivalry between industry for the surface and groundwater resources in the surrounding agriculture. Because no other options are available, many farmers in peri-urban and metropolitan regions are even forced to irrigate their fields with WW. It is not our desire to utilize WW for agriculture; rather, it is our constraint or pressure to do so. Due to the dryness of groundwater and natural streams, low-quality water must be used. Because of their low reading levels, farmers frequently use the WW and lack awareness. Some of the river tributaries are converted into WW channels and people believe that it benefited crop production. The researchers surveyed the many WW channels in the adjoining area of peri urban; really surprised that farmers are using WW in mushroom pump sets to extract fresh water from the well. Expansion in domestic water supply, it also increased the WW generation in equal proportion.

The average yield for paddy from various places compared to irrigation water from bore wells, the researcher claimed that WW irrigation had a major impact on yield. The high EC, sodium content, and alkaline pH are to blame for the yield's slight decline; these factors may also have affected the absorption of other nutrients. While there may be a noticeable amount of plant-essential nutrients in the WW, organic carbon and other elements like Na, TDS, heavy metals, and EC must be addressed to prevent long-term detrimental effects on crop productivity [7].

## Status of WW - Worldwide

Presently, around 380 billion $m^3$ (or 380 trillion liters) of WW are produced annually worldwide. Among these, although the percentage varies by location, more than 80 per cent of all WW produced is released into the environment without receiving proper treatment [8]. Over 20 million hectares of agricultural land globally already employ WW irrigation [5]. The United Nations study states that high-income nations typically treat around 70 per cent of the WW produced by their cities and industries. In higher middle-income nations like India, the ratio falls to 38 per cent, while in lower middle-income nations, it reduces to 28 per cent. Merely 8 per cent of people in low-income nations receive medical care of any type.

## Status of Wastewater - India

The Central Pollution Control Board (CPCB) reports that in 2021-2022, India's metropolitan regions produced 72,368 million liters of sewage per day (MLD) [9]. This is about twice as much WW as is produced in rural regions. Approximately 73000 hectares of land in India are irrigated using WW [10]. India's capacity to treat sewage, however, is far less than the quantity of WW produced. The nation had an operational capacity of 26,869 MLD and a sewage treatment capacity of 31,841 MLD as of March 2023. Only 28 percent of India's WW production is treated [9]. 72 per cent of the population is untreated.

## Status of Wastewater - Tamil Nadu

More than 5,599 MLD of sewage is produced in Tamil Nadu's urban centers [9]. Reclaimed WW with a treatment capacity of around 80.50 MLD is utilized in industry and agriculture. There are 891 sewage treatment plants in Tamil

Nadu. The state possesses the infrastructure necessary to treat 2,603.9 MLD of WW (which is presently operating at 797.3 MLD; the remaining 2,603.9 MLD is either under construction, pending permission, underutilized, or in the proposal stage).

## Status of Wastewater - Annamalai Nagar, Chidambaram

In Lalpuram Village, Chidambaram, a 9.44 MLD (or 5.20 MLD in operation) sewage treatment plant (STP) using activated sludge processing (ASP) technology was built. Annamalai University is a unitary university located in Chidambaram, Tamil Nadu, India, spanning 950 acres (3.8 $km^2$). Every year, over 30,000 students receive an education, of whom approximately 9,000 live in dorms. Additionally, Annamalai University utilizes around 1 lakh liters of water a day to cover the needs of the fodder farm and gardens, producing approximately 9 lakh liters of WW per day from its 14 dorms [11].

## Farmers' Perception towards Wastewater Reuse

In western Iran, the researcher investigated farmers' acceptance of and readiness to pay for the use of treated WW for agricultural irrigation [12]. Farmers' willingness to use treated WW for crop irrigation can be effectively increased by the use of suitable incentives, such as price reductions for treated WW based on quality, testing for physico-chemical properties and microbial contamination of treated WW, and extension training programs. Numerous researches looked into how farmers perceived the quality of the water and how they felt about using it again for irrigation. Reclaimed water, or treated WW, is a useful resource that may be used for irrigation. However, the water's sometimes mediocre quality can cause problems for farmers. The quality of reclaimed water may influence farmers' opinions, but other factors should be taken into account as well, such as their ability to handle the problems that come with using it for agriculture (salinity, damage to irrigation systems, produce marketing), their perceived and actual ability to control where and when to use reclaimed water, and their ability to affect the quality of the water that is delivered to the farm.

"The research done in 2017 by Blanca and Navarro [13] details the advantages and disadvantages of using WW for agricultural production in terms of human health". It is concluded that sound policies must be established to preserve advantages (livelihoods and food security) affordably and realistically while controlling health and environmental risks in a way that allows the situation to gradually improve. This is necessary to address the current and future effects of the extensive use of WW irrigation in low-income regions. The effluent standards for sewage treatment plants are displayed in the following table. WW therefore provides an alternate supply of irrigation, particularly for agriculture, which uses the most water worldwide. After appropriate treatment, WW may be utilized for fruits, vegetables, and other agricultural products. Produce from agriculture generated using WW irrigation is suitable for human and animal use. While farmers are shown a readiness to embrace this new technology, there is still a need to raise awareness of its use in rural areas.

**Table 1** Effect of long-term impact of WW irrigation on sustainable crop yield and soil biodiversity

| Effect | Study area | Result | Reference |
|---|---|---|---|
| Soil salinity and crop yield | Loess Plateau, China | WW irrigation increased soil EC 3.5 times more than fresh water irrigation. This caused a 10-15% decline in wheat and maize production over time. | [19] |
| Heavy metal accumulation | Dry tropical area of India | After 20 years of WW irrigation, concentrations of Cd, Pb, and Ni in soil increased by 36%, 29%, and 21%, respectively, resulting in a 5-8% loss in rice productivity. | [20] |
| Soil structure degradation | Tunisia | After four years of treated WW irrigation, soil bulk density increased by 10% and porosity fell by 8%, resulting in lower olive tree growth and fruit output. | [21] |
| Antibiotic resistance and biodiversity | China | Long-term WW irrigation increased antibiotic resistance genes in soil bacteria by two to thrice, potentially lowering total microbial diversity. | [22] |
| Soil enzyme activities | Mallorca, Spain | After 30 years of reclaimed water irrigation, soil dehydrogenase activity reduced by 25%, indicating a decline in total soil microbial activity. | [23] |

## Long-Term Wastewater Irrigation

Long-term WW irrigation has arisen as a key method in water-scarce areas, with both advantages and disadvantages for agricultural systems. Studies have demonstrated that the minerals included in WW can boost soil fertility and agricultural production. There are 10-15% increase in maize yields under long-term WW irrigation compared to fresh water irrigation [14]. However, the buildup of heavy metals in soils is a big worry. The researcher discovered that the higher amounts of cadmium, lead, and zinc in soils after 20 years of WW irrigation, possibly jeopardizing food safety and human health [15]. Furthermore, long-term WW usage can impact on sustainable crop yield and soil biodiversity as furnished in **Table 1**. The researcher found that 50% drop in soil hydraulic conductivity following continuous WW application, which was ascribed to the buildup of suspended particles and organic matter. The inclusion of new pollutants in WW, such as medicines and personal care items, creates additional issues [16]. "Pan *et al*. [17] found antibiotics in crops irrigated with WW, raising concerns about antimicrobial resistance". Regardless of these dangers, appropriate WW treatment and management can help to alleviate many of them. The wetlands may successfully eliminate up to 99% of harmful bacteria from WW before irrigation [18]. These findings emphasize the complexities of long-term WW irrigation and the importance of extensive monitoring and adaptive management measures to ensure its long-term use in agriculture.

## Conclusion

In conclusion, utilizing treated WW for the cultivation of non-edible crops, such as fiber and oil plants, can be a cost-effective strategy in regions experiencing water scarcity. In peri-urban regions, WW is often used for agricultural crop cultivation, particularly for the production of vegetables. These WW provide plants with increased levels of nutrients and trace levels of harmful metals which had the opposite effect of lowering crop quality and soil health. Based on these results, it can be concluded that proper management of WW irrigation and periodic monitoring of soil and plant quality parameters are required to ensure successful, safe, long-term WW irrigation.

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