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Wastewater Use: A Debatable Scenario and their Impacts on Crop Production

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ABSTRACT

About 90% of freshwater is used in agriculture for crop production and the world is already facing a scarcity of fresh water resources. Changing climate and rainfall pattern urge crops to demand more water while wastewater is excessively available and produce in huge amount which holds a maximum amount of organic matter and nutrients. Freshwater scarcity and demand for more food production urge farmers to use wastewater. Wastewater use has some pros and cons, in pros the addition of organic matter to soil bodies, while in cons are reduction in germination, growth, and yield. Wastewater helps farmers increment soil organic matter, total available macro and micronutrients. The negative effect is due to the addition of toxic material to soil bodies such as heavy metals, and it can't be reduced crop yield if it remains below the toxic limits. But the current scenario of wastewater uses and their positive and negative effects on the yield of crops are still under debate due many researchers showed that crop yield is reduced, and some mentioned that the crop yield increases or effects are insignificant. In this article, discussions are made about the impacts of wastewater irrigation and their correlation to seeds germination, plant growth and yield.

Keywords: *Wastewater, heavy metals, organic material, microbial biomass, inorganic nutrients, crop production.*

INTRODUCTION

Increasing population, hidden hunger, malnutrition, scarcity of water resources and sudden climate changes are in concern of researchers, but increasing population with hidden hunger demands high quality and quantity of food while water resources are depleting day by day. Due to different environmental (salinity, heavy metals pollution, changes in rainfall pattern i.e.) and different socio-economic concerns (wastewater use, insufficient fertilizer application, i.e.) decrease, the yield of different crops.

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Demands for more food production and unavailability of fresh water while on the other hand, more production and availability of wastewater; both these factors urge farmers to use of wastewater for crop production. Use of the wastewater for agricultural production is increasing on a daily basis in arid and semi-arid regions. Agricultural production demanding more water due to climate change (Ali et al., 2022). Jalali et al. (2007) described that the unavailability of freshwater near urban areas increases the use of wastewater. In the scarcity of fresh water reliable source is the use of wastewater; if it handles with care and proper management practices are done, then positive aspects are achieved (WHO, 2006). Furthermore, wastewater used regularly that introduces the heavy metals to soil environment, and if the soil remains below the toxic limits, and monitored regularly as a result more seed germination, crop growth and crop production are achieved than treated wastewater or freshwater (Makhadmeh et al., 2021).

Raw or partially treated wastewater is used over 20 million hectares in 50 different countries without considering any positive or negative aspects by farmers due to their availability (Hussain et al., 2001; & Scot et al., 2004). Aghtape et al. (2011) described that wastewater use increases crop germination, growth and production without deteriorating the soil environment if their induced contaminants remained below the hazardous level. Horsewell et al. (2003) studied that wastewater use is valuable if applied in controlled conditions and monitored in the soil environment for crop production because it provides the organic material with inorganic nutrients.

Impacts of wastewater

The process of fast degradation by plant consumption and movement in the soil system results in the deficiency of micronutrients (Ali et al., 2021). Candela et al. (2007) described that beneficial impacts of wastewater reduces the amount of commercial fertilizer use for agricultural crop production. Rai et al. (2011) studied that wastewater use produces many beneficial changes in soil potential, and also increment in the total organic and inorganic nutrients such as magnesium was observed. The concentration of many metals such as lead (Pb), cadmium (Cd), copper (Cu) and nical (Ni) increased to impressive level but not reach to effects the physio-chemical properties and plant growth (Ramirez et al., 2002).

Many researchers described that wastewater increases the level of macronutrients (N, K & P) besides of additional micronutrients such as iron (Fe) and sodium (Na) (Panicker, 1995; & Mojiri, 2011) while Garg and Kaushik (2006) studied that untreated wastewater contain higher amount of exchangeable calcium (Ca) and potassium (K) in comparison with fresh or groundwater. Liu and Hynes (2010) conducted an experiment on microbial assets of soil after using wastewater, and the results show that overall increment in microbial growth or biomass with their multiplication.

Wastewater provides a confidential amount of organic matter to soil with higher exchangeable calcium contents, while organic matter addition fluctuates the higher CEC values of the soil due to extra loading of calcium not due to the clay contents in soil (Qishlaqi et al., 2008). The upper layer wastewater irrigated soil receives a higher amount of exchangeable calcium and their concentration decreased with dept. The total amount of macronutrients is higher in soil irrigated with wastewater as compared to freshwater. Sushil et al. (2019) described that calcium (Ca), magnesium (Mg) and sulphur (S) value prominently in wastewater-irrigated soil.

Wastewater irrigation and seeds germination

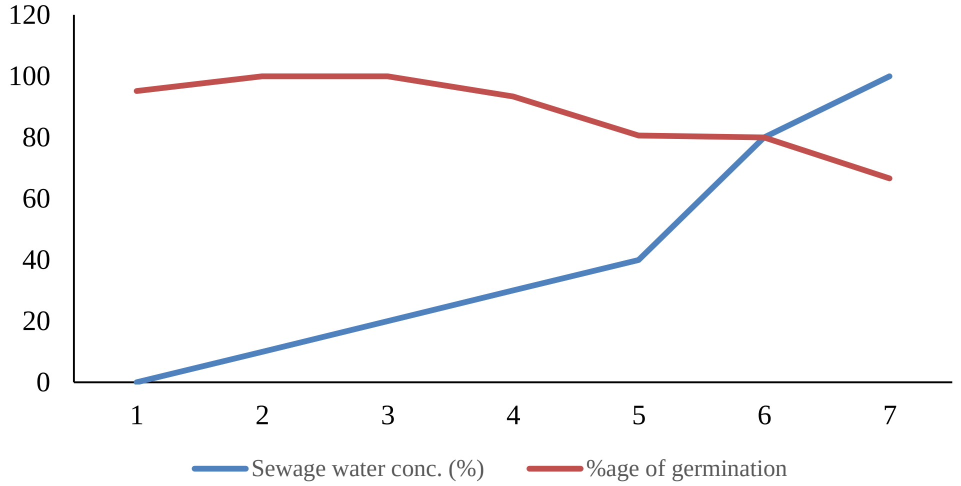
Dash (2012) in their experiment of rate of seeds germination by using wastewater as an irrigation source, concluded that rate of seeds germination increase by wastewater use upto 50% and thereafter decreases. The treatment with polluted water reduced the germination of rice and wheat due to higher level of salinity, causing element produced the osmotic stress to seed germination of wheat and rice. The use wastewater for the production of wheat and rice is discouragable in higher concentration due to their negative impacts.

Khan et al. (2011) in his experiment resulted that use of the industrial wastewater for crop production is not suitable because it reduced the germination of many crop seeds. Nagda et al. (2006) found that the use of industrial effluents for germination is discouragable due to their negative impacts. Mainly heavy metal contents are added through the anthropogenic activities such as industrial or domestic production (Ali et al., 2022a). Wastewater contains salts and toxic material, these material added in the soil due their excessive and long term use because higher salt content create osmotic imbalance in soil environment that leads to the retardation in the germination of crops.

Ajmal and Khan (1983) founded that lower concentration of industrial effluents increases seed germination upto 100% but effluents with higher hazardous material reduced the germination kidney bean and millet. Khan and Sheikh (1976) conducted an experiment and resulted that significant delay in the germination of *Capsicum annum* seeds due to the use of sewage water. This is due to higher salinity producing osmotic pressure resulting in the toxicity spreading within the seed. Mostly untreated water is added to nearly water bodies or directly put into the agricultural field by farmers in place of irrigation this untreated water has both toxic and fertilizer values.

Sinha and Paul (2013) were studied that wastewater effects on seed germination of *Cicer arietinum* in which results shows that sewage water concentration is inversely proportional to seed germination. Mainly accumulated heavy metals in soil renders the seed germination, growth and crop production.

Different concentrations of sewage water and their relation to germination (Sinha and Paul, 2013).



An experiment was conducted in Quetta city on wastewater use and their effects on seed germination and seedling growth of lettuce and results reveled that industrial effluents in lower concentration increases the seed germination and seedling growth but increase in the percentage of wastewater reduced the seeds germination to minimum level (Bazai & Achakzai, 2006).

Wastewater irrigation and crop growth

Agricultural production systems consume 90% of the freshwater, but different techniques, such as drip or foliar spray, are applied to save freshwater resources from depletion. Wastewater use after treatment or with care and monitoring produces positive aspects on crop production. Naddafi et al. (2005) conducted an experiments and resulted that use

of pond effluents in stabilized mechanism produce more positive impacts on crop growth and yield than river water. Also, river water may produce lower quality and quantity of crops due to higher salt contents than pond effluents. It is revealed that crop produced by using the treated pond effluents produce more qualitative and quantitative products than produce on river water plot.
Begum et al. (2011) resulted that in normal soil irrigated with fresh water produce highest straw yield than mixed and the least straw yield observed in the raw wastewater irrigated soil. Similarly, in the case of polluted soil, fresh water produces the highest straw yield than mixed and least observed in raw wastewater irrigated soil. Chakrabarti and Chakrabarti (1988) concluded that use of raw or diluted sewage water produces no significant results in increment or reduction of wheat straw yield.

Effect of sewage water irrigation on vegetative yield of wheat plant (Chakrabarti & Chakrabarti, 1988)

Treatments	Vegetative yield (t ha^{-1})
Normal (Control)	6.93
50%	5.81
66%	5.67
100%	6.30

Production of vegetables (cucumber, carrot, lettuce and tomato) by treated effluents produce more production than freshwater (Alizadeh & Naghibi, 1996). Zadhoosh (1996) stated that soil irrigated with wastewater add higher level of organic manure that is equal to 25 tons of farm yard manure (FYM). Abedi and Najafi (2001) resulted that raw wastewater used to produce wheat, more growth and production was observed. Different studies show that stress either by wastewater or other sources reduces the protein contents, but increase in protein content was observed (Hsu & Kao, 2003; & Guo et al., 2007).

Bamniya et al. (2010) discussed that total carbohydrates are higher in plants irrigated with normal water as compared to wastewater and also got similar results in the case of total chlorophyll contents. Chlorophyll a was affected at higher concentration of contaminants compared to chlorophyll b, and it may break down due to inhibition by contaminants or stress. Also discussed that protein (amino acid) contents are higher in wastewater treatment than in normal irrigation and suggested that wastewater have to be diluted before it is used for irrigation.

Biochemical analysis of selected plant leaves irrigated with wastewater (Bamniya et al., 2010)

Crop	Treatments	Total chlorophyll (mg/g)	Chlorophyll [a] (mg/g)	Chlorophyll [b] (mg/g)	Protein (mg/g)
Brassica oleracea	Wastewater	0.01632	0.00526	0.0069	3.26
	Control (0.0248)	0.0101	0.0271	0.088	2.22
Spinaccina oleracea	Wastewater	0.0174	0.0163	0.0118	3.58
	Control	0.0496	0.0294	0.0305	4.13

The richness of the soil and plant systems with heavy metals is considered as one of the major cons for wastewater use and their repetitive use affects biochemical processes (metabolism, stomatal opening or photosynthesis) and morphological characteristics (root or shoot length or foliage yield), at last reduction in the grain yield was observed (Ali et al., 2022; Singh et al., 2009; & Singh et al., 2010). Some metals have the ability to move throughout the plant structure even from roots to where they are required in the plant body (Ali et al., 2022b).

Thereafter, it could be concluded (in crop growth section) that wastewater affects the morphological and biochemical characteristics of plants such as reduction in the formation of chlorophyll (either type a or b) content amino acids or protein formation. So, it is suggested that wastewater use after dilution because effluents characteristics will become within prescribed limits and toxic pollutant load on soil and plant decreased. In this way better results will be yielded in crop production sense.

Wastewater irrigation and crop yield

Begum et al. (2011) conducted an experiment on normal and polluted soil to evaluate the effects of fresh, mixed and raw polluted industrial water on rice grain yield. Resulted that in normal soil irrigated with fresh water produce highest grain yield than mixed and the least grain yield observed in the raw wastewater irrigated soil. Similarly, in the case of polluted soil, fresh water produce the highest grain yield than mixed and least observed in raw wastewater irrigated soil. Many researchers showed that wastewater positively affects the grain yield of foxtail millet and corn (Amir et al., 2011; & Tavassoli et al., 2010).

Chakrabarti and Chakrabarti (1988) resulted that use of raw or diluted sewage water produces no significant results in increment or reduction of wheat grain yield.

Effect of sewage water irrigation on grain yield of the wheat plant (Chakrabarti & Chakrabarti, 1988)

Treatments	**Grain yield (t ha^{-1})**
Normal (Control)	2.06
50%	1.92
66%	1.89
100%	2.05

Debatable scenario of wastewater use

Many agronomic experiments have been conducted to evaluate the use of wastewater and their correlation with yield of different crops. Even a much debatable scenario is still existing among the cited literature whether wastewater produces significant positive or negative or insignificant effects on crop yield. Some experiments concluded that wastewater either from industrial or domestic origin produce significant positive effects on yield of corn, rice and wheat (Almeida et al., 2018; Jung et al., 2014; Tran et al., 2019; & Mojid et al., 2016) while in contrast, reduction in crop yield was observed by many researchers (Rinaldi et al., 2003; Huang et al., 2006; & Hu et al., 2009). Increment in crop yield was observed from 2-10 times and recorded reduction ranges from 1 to 50%. Additionally, many researchers proved that wastewater does not significantly impact the yield of different crops (Chakrabarti & Chakrabarti, 1998; Zhang et al., 2015; & Zhang, 2016). WANG Han-jie et al. (2022) in their meta-analysis paper described that wastewater type might affect due to difference in nutrient composition.

CONCLUSION

From the review of the literature, it could be concluded that wastewater is an excessively available substitute for fresh water in agricultural crop production. Wastewater use may significantly impact seed germination and crop growth and a significant or non-significant on crop yield. Wastewater use adds huge amounts of organic material and inorganic nutrients and is discouragable only due to the addition of toxic material (i.e. heavy metals) to soil and plant systems reaches the permissible limits. Freshwater resources are depleting so fastly that's why wastewater is used as a reliable source for irrigation. This debatable scenario of wastewater uses, and their impacts on crop production needs more research due to limited available resources of freshwater.

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