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# Effect of purified industrial wastewater on the growth of tomato plant (*Lycopersicon esculentum*)

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## ABSTRACT

*Because of the lack of water supply in the last years and the increase of the industrial sector in the world, purification of the wastewater became an obligatory process to improve and purify the water, remove some or all of the contaminants and making it fit for reuse or discharge back to the environment. In this study, we tested the effect of purified industrial wastewater discharged from CMCP of Kenitra city on the growth of tomato plant (Lycopersicon esculentum).*

*After testing the agronomical parameters we found that the highest fresh weight is observed in plants irrigated with drinking water and those irrigated with unpurified wastewater have shown the lowest fresh weight. Also the growth of tomato plants irrigated with drinking water were higher than plants treated with purified wastewater, followed by plants treated with percentages of 25, 75 and finally with unpurified wastewater.*

***Key words:*** *Industrial wastewater, Treatment plant, Irrigation, Growth, Tomato.*

## INTRODUCTION

Because of the decrease of our natural water resources, it is expected that this insufficiency will determine the state of food production in the coming decades. That's why today it is required more than ever to pay attention to the balances in the use and distribution of water and to utilize the sources in a more prudent way[14].

Morocco's economy depends heavily on the weather, with a semi-arid climate and an ill-developed irrigation system; it is difficult to assure enough irrigation, at the same time, with population expanding at a high rate, the need for increased food production is apparent[27]. For that reason planners are forced to consider any sources of water which might be used economically and effectively to promote further development[20]. Irrigation does not usually require high-grade water quality compared to drinking water[25]. Because of that wastewater has been reused extensively as a source of irrigation water for centuries[6].

CMCP (Moroccan Company of cardboard and paper) has initiated a wastewater treatment plant in KENITRA called the "WWTP". This project was implemented in partnership with the Industrial Pollution Control Fund (FODEP), the Agency of Sebou river basin and the Secretary of State to the Minister of Energy, Mines, Water and Environment. The WWTP started in September 2013 and it has an investment of about 50 million DH[4].

It is anticipated that recycling of effluent for agriculture, landscape and refill of ground water will become an important practice in the near future[11]. However, effluents could contain heavy metals and persistent organic contaminants, which are originated from both domestic and industrial discharges[2,7,9,29,35].

There were plenty of research work that focused on persistent organic contaminants, which could be accumulated in soils and transferred through food chains and consequently cause adverse health effects on human or biological effects on soil fauna and flora after long-term application[8,30,33,34,26,13].

Also, Increases in population and industrialization have resulted in increased heavy metals content of many municipal effluents[19]. The effluent has been found to contain high concentrations of Cu, Pb and Zn; all three heavy metals are listed as priority pollutants by the US Environmental Protection Agency.

Tomato is the second-most important vegetable in the world after potato[12], with a worldwide production of 129 million tons in 2008[16]. In Morocco, the tomato cultivation plays an important socio-economic role in the Moroccan economy as it generates by currency and provides many job opportunities. It occupies a total area of 18 642 ha, providing a total production of 1 312 305 tones[10], which more than half of it is exported mainly to the countries of the European Union[21].

The objective of this work is to assess the effect of purified industrial wastewater discharged from the CMCP of Kenitra city on the growth of tomato plant (*Lycopersicon esculentum*).

## MATERIALS AND METHODS

- **Study station**

Kenitra region located in the northwest of Morocco, between the meridians 30 ° 6 'and 6 ° 45' West and parallel 34 ° 15' and 34 ° 20', the climate is semi-arid to sub-humid, caused by the influence of the ocean, and presents fairly temperate and hot summers winters. The wastewater discharged by urban areas of this city, are discharged in the raw state in Wadi Sebou and Lake Fouarat through several urban collectors[13].

The experimental site is located at the wastewater treatment plant (WWTP), longitude of 6°56' west and latitude of 34°27' north, in 2013 CMCP-International Paper inaugurated the treatment plant anaerobic wastewater, which has a 6.000m3 daily processing capacity, Through this project, management of the factory has two main purposes. First, reduce water consumption and thus the flow of industrial waste. And secondly provide treatment of these discharges prior to discharge into the river Sebou.

This is an EGSB type digester. It involves a biological type "granular". This biologically treats the carbon pollution and produces biogas recoverable (power generation, boiler used to heat the effluent ...) [3].

- **Plant material**

Tomato seeds (*Lycopersicon esculentum* Mill.) of ‘Campbell 33’ variety were superficially disinfected with sodium hypochlorite 5% and rinsed thoroughly with the tap water and dried on the filter paper during 15 minutes. These seeds were then germinated in a plastic pots (diameter 15cm; 25cm length) containing sterile substrate by heating it at 180°C for 2H for four consecutive days. Pots were arranged in a completely randomized design with six replicated per treatment and the experiment was repeated twice.

After 3 weeks of germination, tomato seedlings were distributed into 6 groups (the first four groups contain tomato plants irrigated with treated wastewater of different concentrations, the fifth group irrigated with fresh water (witness group), and the last group is irrigated with unpurified industrial wastewater) each group has 5 pots and every pot include 5 seeds each. The plants were irrigated for 5 weeks. All precautions were taken to secure that all conditions were controlled and that the pots were watered (20-100mL per pot) during this period on a daily basis.

- **Measured parameters**

After a period of five weeks, tomato plants were selected from each treatment then tested by measuring their fresh weight (g), dry weight (g), Root length (cm), Shoot length (cm) and leaves numbers were counted.

Leaves area and dwarfing indexes were measured to estimate the effect of different treatment on the growth of tomato seedling:

Vegetative growth percentage (VGP): it evaluates the growth plants treated with different treatments relative to the control treated with tap water, was calculated using the following formula:

$$\mathrm{VGP} = \frac{\mathrm{C} - \mathrm{T}}{\mathrm{C}} \times 100$$

VGP: Vegetative growth percentage.

C: Average length of control plants.

T: Length of the plants irrigated with different purified waters.

## RESULTS

The Physico-chemical characteristics of the water types and soil were represented in table 1 and 2.

The main physicochemical characteristics (heavy metals) of the three primary types of water we used (Table 1).

**Table 1: Physico-chemical characteristics of the types of water**

| **Parameters** | **drinking water** | **Un-purified industrial wastewater** | **Purified industrial wastewater** |
|---|---|---|---|
| **pH** | 7.41 | 6.61 | 7.2 |
| **COD** $mgO_2/L$ | < 250 | 2758 | 550 |
| **Zinc** mg/L | 3 | 0.59 | 8.05 |
| **Lead** mg/L | 0.01 | Un-identified | 4.2 |
| **Copper** mg/L | 2 | Un-identified | 7 |
| **Iron** mg/L | 0.3 | 2.30 | 47.3 |

The main physicochemical characteristics of the soil we used (pH, electrical conductivity, organic matter, carbon, nitrates...) were determined by conventional analyzes performed by the soil analysis laboratory of (ORMVAG) “Regional Office of Agricultural Development of Gharb” in Kenitra (Table 2).

**Table 2: Chemical characteristics of tomato plants substrate**

| **physicochemical parameters** | **pH** | **Organic matter (%)** | **Humidity (%)** | **C/N** | **Nitrogen (%)** | **Phosphorus $P_2O_5$ (%)** | **Potassium $K_2O$ (meq/100)** | **Magnesium (Mg) (meq/100g)** | **Calcium (Ca) (mg/kg)** |
|---|---|---|---|---|---|---|---|---|---|
| **Mamora’s soil** | 7.53 | 0.7 | - | - | 0.05 | 0.239 | 0.15 | 0.20 | 7351.5 |

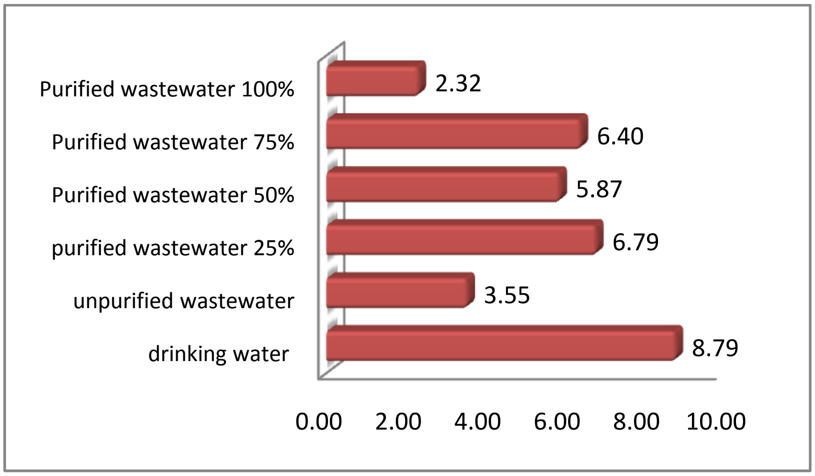
Tomato plants irrigated with drinking water have shown the highest fresh weight (6.11g). Thus, the irrigation with treated wastewater has decreased their fresh weights which were 2.97; 2.86 and 3.86g respectively for the treatment percentages of 25%; 50% and 75 %. On the other hand, tomato plants irrigated with unpurified wastewater have shown the lowest fresh weight (0.94g) (Table 3).

**Table 3: Agronomical parameters of tomato plants five weeks after treatments**

| | Fresh weight (g) | Dry weight (g) |
|---|---|---|
| **Drinking water** | 6.11 | 1.73 |
| **Unpurified wastewater** | 0.94 | 0.18 |
| **Treated wastewater 25%** | 2.97 | 0.64 |
| **Treated wastewater 50%** | 2.86 | 0.67 |
| **Treated wastewater 75%** | 3.86 | 0.58 |
| **Treated wastewater 100%** | 1.08 | 0.20 |

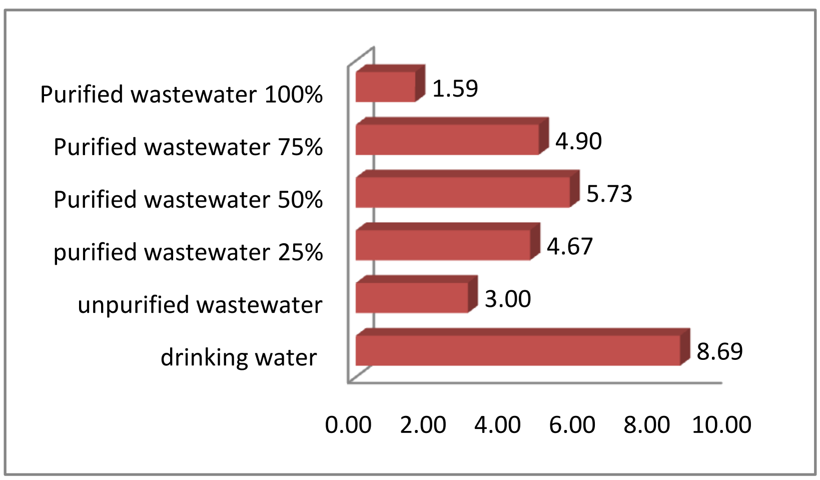
The highest stem length was observed in the tomato plants irrigated with tap water (8.79cm). Plants irrigated with treated water with percentages of 25%, 50% and 75 % were respectively 6.79; 5.87 and 6.4cm were higher than plants irrigated water before its treatment with WWTP (3.55cm) and also higher than those irrigated with totally treated wastewater (2.32cm) (Figure 1).

**Fig. 1: Stem length of tomato plants irrigated with various percentage of treated wastewaters**



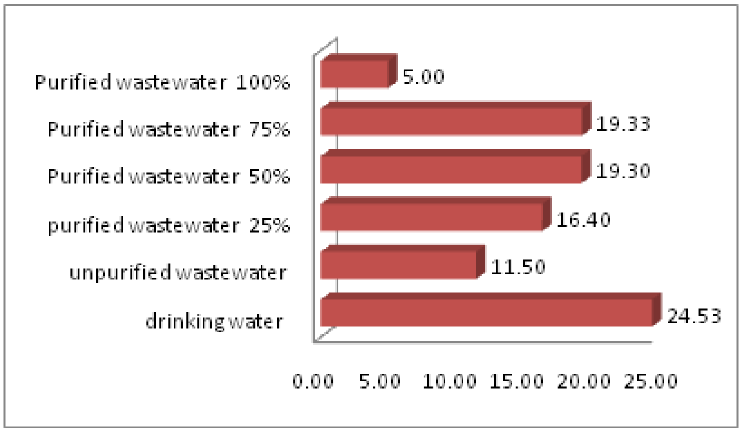

Plants irrigated with 100% purified wastewater have shown the lowest roots length (1.59cm), relative to those irrigated with the tap water (8.69 cm). Furthermore plants irrigated with treated water with percentages of 25%, 50% and 75 % were respectively 4.67; 5.7 and 4.9cm (Figure 2).

**Fig. 2: Root length of tomato plants irrigated with various percentage of treated wastewaters**



The highest leave number was observed in tomato plants irrigated with tap water (24.53). irrigation with treated wastewater has decreased the number of leaves relative to plants irrigated with untreated wastewater which has shown the lowest leaves number (5 leaves) (Figure 3).

**Fig. 3: leaves number of tomato plants irrigated with various percentage of treated wastewaters**



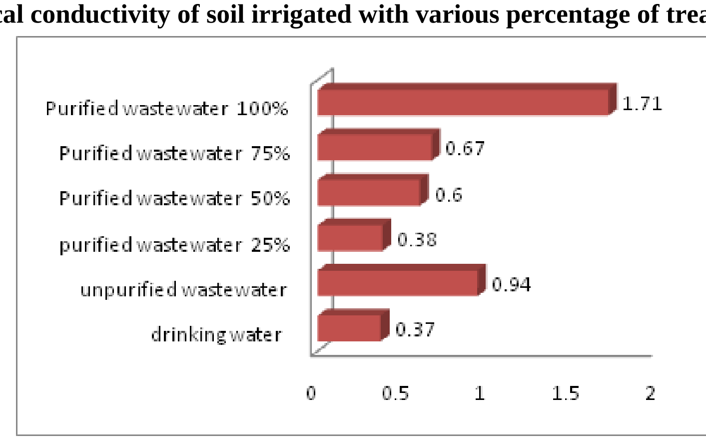

The big difference of the growth between tomato plants irrigated with different types of water was mentioned in table 4. Thus, the vegetative growth percentage of plants irrigated with untreated wastewater was 73.6 %, followed by totally treated water 59.61%. Plants irrigated with water treated with 25%, 50% and 75 % were low relative to plants irrigated with tap water, their Vegetative growth percentage were respectively 29.45%; 33.21% and 27.1 %.

**Table 4: Vegetative growth percentage of tomato plants treated with different types of water**

| | **Vegetative growth percentage (%)** |
|---|---|
| **unpurified wastewater** | 73.6 |
| **purified wastewater 25%** | 29.45 |
| **Purified wastewater 50%** | 33.21 |
| **Purified wastewater 75%** | 27.1 |
| **Purified wastewater 100%** | 59.61 |

After five weeks of irrigating the tomato plants with different types of water, different electrical conductivities of soil were observed. The lowest value was measured in soil of tomato plants irrigated with drinking water (0.37 S/m). Soil electrical conductivity of plants irrigated with untreated water was 0.94 S/m followed by the highest value that was measured on soil of plants irrigated with water which was totally treated (1.71 S/m) (Figure 4).

**Fig. 4: Electrical conductivity of soil irrigated with various percentage of treated wastewaters**



## DISCUSSION AND CONCLUSION

In arid and semi-arid regions, water resources of good quality are becoming scarcer and are being allocated with priority for urban water supply. Therefore, there is an increasing necessity to irrigate with water that already contains salts, such as saline groundwater, drainage water and treated wastewater[15,22]. One of the sources of water which might be used economically and effectively is treated municipal and industrial wastewater[17].

Irrigation does not usually require high-grade water quality compared to drinking water. In addition, reusing wastewater for agriculture has several advantages,[31] such as reducing the amount of effluent discharged into receiving environment, nutrient recovery as fertilizers, and increase crop production[25].

The reuse of treated wastewater for irrigation is a practical solution to overcome water scarcity, especially in arid and semiarid regions[1]. However, there are several potential environmental and health risks associated with this practices[18]. According to Kiziloglu *et al.*[24], wastewater has a high nutritive value that might improve plant growth. Indeed, the obtained results showed that tomato plants irrigated with drinking water had the most important development relative to other plants irrigated with other type of wastewaters.

The plants irrigated with wastewater treated with the percentage of 100% showed lowest agronomical parameters compared to the other wastewater treatments. This might be explained by that the more the wastewater is treated; the more is the essential minerals for plants growths are eliminated.

The irrigation of tomato plants with different types of wastewater was responsible to change the electrical conductivity of soil of these plants. In the same way, plants irrigated with purified wastewater with percentage of 25% and 50% were equal to those irrigated with drinking water. On the other hand, the highest electrical conductivity was respectively found in soil of plants irrigated with untreated wastewater and plants irrigated with treated wastewater with the percentage of 100%. The greater the conductivity, the greater is its salt content. So, this salt accumulation the rhizosphere might be the responsible factor of the loss of tomato plants. Wahid *et al*.[32] reported that the growth and yield of soybean cultivars were greatly reduced as a result of wastewater effluents from a chemical industry in Lahore that were highly saline and had extremely high electrical conductivity.

According to the FAO[15] guideline, toxicity and miscellaneous problems, can be expected from use of treated wastewater effluents. Wastewater contains substantial amounts of toxic heavy metals, which create problems. Excessive accumulation of heavy metals in agricultural soils through wastewater irrigation may not only result in soil contamination, but also affect food quality and safety. Food and water are the main sources of our essential metals; these are also the media through which we are exposed to various toxic metals. Heavy metals are easily accumulated in the edible parts of plants[5]. The effluent for reuse must comply with reuse standards to minimize environmental and health risks[36]. The required quality of effluent will depend on water uses, crops to be irrigated, soil conditions and the irrigation system[28]. Heavy metal uptake by the plants grown in polluted soils (mostly from anthropogenic activities such as wastewater and sewage sludge application) has been extensively studied[23].

The average of heavy metals was very much lower than the recommended maximum concentration base on threshold levels of trace elements for crop production.

Wastewater irrigation reuses water that would have been lost and therefore a constant supply of irrigation water could be provided for farming. However, there are risks that are associated with waste water reuse. Heavy metals may accumulate in soils and plants grown using waste water. So, further studies should be affected to determine the suitable percentage of water treatment for each culture that it would be able to tolerate the accumulation of salts and heavy metals around its roots.

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