**Journal of Manuscript Studies**

www.journalofmanuscriptstudies.com

**ISSN: 2393-9443**

Volume-14 Issue-1 || January 2024 || PP.9 -14

# Amendment of soil with sugar industry effluent and its effect on tomato plant development characteristics (*Lycopersicon esculentum L.*)

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## ABSTRACT

**Sugar industry effluent is a waste water of pure plant origin that contains a high concentration of soluble organic matter and plant nutrients. The byproducts of the sugar industry are utilized as raw materials in a variety of industries. The concern with sugar industrial wastewater includes high BOD, COD, and electrical conductivity. The problem could be solved by applying sugar factory effluent after suitable dilution with irrigation water, or by applying it prior to planting to allow for natural oxidation of organic matter in the soil. The study was done at a college campus located 2 kilometers distant from the sugar industry to investigate the physiochemical parameters of sugar industrial effluent treated with soil and its impact on tomato plants. Effluent from the sugar industry contains a high concentration of organic matter and nutrients such as nitrogen, phosphorus, potassium, calcium, magnesium, bicarbonate, and sulfur. Furthermore, it has an adequate number of micronutrients. Based on the above notion, a pot culture experiment was carried out to investigate the physiochemical parameters of soil with varying percentages of dilution of sugar industrial effluent and their effect on tomato plant growth parameters. The results showed that the physiochemical parameters of soil at different percentages of dilution of sugar industry effluent were raised (BD, OC, CO3, HCO3-, Total PO4-3, Total NO3-2, Total K+, Mg2+, Ca2+SO4-2, and Cl-) and decreased (pH, Soil Moisture, and WHC) compared to control soil. The vegetative development of 25-day-old plants, measured by shoot length, root length, shoot weight, and root weight, was highest in the 25% effluent treatment compared to the control group, followed by 50%, 10%, 75%, and 5%. 100% effluent treated soil had a negative growth parameter value compared to control. The pot experimental experiments suggest that the judicious application of sugar industrial effluent in agriculture could decrease fertilizer expenditures while also reducing pollution load on the environment.**

***Keywords-*** Effluent, Growth parameters, Lycopersicon esculetum, Physiochemical, Soil health, treatment

## I. INTRODUCTION

India's sugar industry contributes significantly to the country's economic growth, but the effluents it releases into the environment cause a high level of organic and inorganic pollutants in both terrestrial and aquatic environments. Because there is a limited amount of land available for land-based treatment and disposal, managing the large volume of water-based industrial effluent generated by enterprises is a significant challenge. Recent study has noticed the emerging tendencies of agricultural automation and soil reclamation through irrigation of industrial wastewater. There is now a growing awareness that the trend toward diminishing global production and environmental protection cannot be reversed by adopting ecological and sustainable farming techniques (Wani et al., 1995).Effluents are rich sources of both beneficial and harmful elements which helps for soil amendment. Since effluents are rich source of plant nutrients therefore soil provides the logical sink for their disposal. There is an increasing interest in the agricultural use of industrial wastes because of possibility of recycling valuable components such as organic matter, nitrogen, phosphorous, potassium and other nutrients and their suitability for land application (Ramasamy et al.,2007).In recent past years various studies have been made on the characteristics of effluent of industries and their interaction with soil and different crops(Patterson et al.,2010, Mohammadi et al., 2010, Vinod Kumar et al., 2010, Madan and Saxena, 2012, Rath et al., 2013).The present investigation focused the effect of graded doses of sugar industry effluent on soil physiochemical characteristics and its influence on growth parameters of 25 days old Tomato plant.

## II. MATERIALS AND METHODS

Gathered wastewater from the sugar industry from Rajshree Sugars and Chemicals Ltd. in Mundiampakkam, Villupuram. Kept in a dim area. Various effluent concentrations (5%, 10%, 25%, 50%, 75%, and 100%) were created by combining distilled water (v/v) with stock effluent. To prepare each cement pot, ten kg of garden soil were filled in. Ten kilograms of soil were placed into each cement pot, and each pot was then filled with 1000 milliliters of the six graded sugar industry effluents (5%, 10%, 25%, 50%, 75%, and 100%). 10 Kg of garden soil in cement pot with water treatment act as control for comparing the results with different dose of effluent treatments. In agricultural fields, each treatment was placed in a randomized block pattern after being duplicated three times. Five tomato seeds were sown in the soil of each cement container after ten days. For a total of twenty-five days, the pots were watered on alternate days. Following a 25-day period, the soils, plants, and control samples were gathered, and the physiochemical properties and growth metrics were assessed. Many physiochemical characteristics were measured using standard methods, such as measuring shoot length and weight, root length and weight, and moisture content and EC (Buurman et al.,1996), WHC and bulk density (Carter,1993), and oc,co3-,po4-3,No3- 2,K+,Na+,Mg+,Ca2+,So4-2, and Cl- (APHA, 2005).

## III. RESULTS AND DISCUSSION

Following a 25-day treatment period, the soil's physiochemical properties were assessed and recorded in Table 1 using various concentrations of sugar factory effluent. Because of its range of acidity and alkalinity, pH is a crucial soil parameter that can be used to estimate the availability of nutrients in the soil. Throughout the trial, the soil's pH was raised above the control at a lower concentration; additional increases in the soil's effluent concentration led to a drop in pH. The dilution factor affected the alkalinity of soil pH; above 75% dilution, the soil shifted towards acidity. Many weak salts regulate the soil's ability to act as a buffer. These salts dissolve and release free cations, which may be the source of soil dynamics. Cationic dynamics is higher in lower effluent concentration in soil and it decrease towards higher concentration. The earlier studies reported that the nutrient availability enhanced at a particular pH range which increased plant growth and change in pH range from a particular limit the availability of nutrients in soil is inhibited that effected the growth and development of plant (Brady and Weil, 2005).EC of soil increased over control and exhibited a negative correlation between doses of effluent concentration in soil and its EC values. Increased EC values towards higher effluent concentration might be due to the increased different salt concentration in soil. Sandhu et al., (2007) reported that potassium salts increased EC of the soil. The moisture and overall water content in soil at a particular place is governed by the amount of water coming and going out from that soil. Soil particle size determines the moisture content and inversely proportional to each other. The present result showed a positive correlation with moisture content and effluent concentration .It may be suggested that the effluent load with higher doses in soil increase the soil particle size, it may negatively impact on soil moisture content. Water holding capacity is related to the number, size and distribution of soil pore and quality of organic matter in soil medium. The present result observed that WHC decrease when effluent dose concentrations were increased in soil. It might be suggested the effluent salt load and organic matter increased in soil with higher doses which decreased number, size and quality of soil pore and it leads to determine the WHC. Ramulu, (2001) reported that WHC is related to soil moisture content and organic matter. At lower concentration (5 %) increased bulk density over control, further increased dose system exhibited a positive correlation with bulk density. Bulk density decreased at 50 % and above doses, this may be attributed due to addition of organic matter which play an important role in soil physical environment. Organic carbon content of soil increased considerably with the application of different doses to soil starting from 5 % to100 % .Increased organic content with higher doses of effluent with soil resulted in soil sickness due to poor aeration and higher BOD. The results of Vinod Kumar and Chopra,(2010), Norwal et al., (1993) and Nathan, (1994) support these findings. The bicarbonates and carbonates content of the treated soil with different doses increased over control starting from 5 % to 100 % effluent concentration. Amount of bicarbonate was increased more towards higher percentage of effluent in compared with carbonate. Soil biochemical character is changed due to carbonate and bicarbonate which increased sodicity at higher concentration while salinity with lower concentration .This findings conformity with Thompson et al., (2001). Total phosphate, Nitrate and Potassium in treated soil were increased in different doses of effluent i.e. 5%, 10%, 25%, 50%, 75% and 100% over control soil. Sodium, Magnesium and Calcium in treated soil with different doses of effluent exhibited a positive correlation with increased effluent concentration. Similar findings were observed by Vinod et al., (2010) in paper mill effluent. Potassium is a soluble cation in soil solution which may displace slowly in soil. The potassium ions, on being absorbed by the colloids, it can displace some other ions such as Ca, Mg and Na (Miller and Turk, 2002).Sulphate and Chloride are two ions noticed a positive correlation with increased doses of effluent in soil and its values. All the values of sulphate and chloride increased over control. These two anions might have contributed towards the salinity hazards associated with higher effluent doses. These findings corroborated with earlier reports of Srivastava et al., (2012) in the distillery effluent and Vinod et al., (2010). The present experimental results revealed that different concentration of effluent in soil (5%, 10%, 25%, 50% and 75%) enhanced different growth parameters (shoot length and weight & root length and weight) over control in 25 days old Tomato plants. Shoot length of Tomato plant was highest in 25 % effluent treatment soil over control i.e. 48 % followed by 50 %, 10

ISSN: 2583-4053
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%, 75 % and 5 % treatment and their values were 33 %,26%,19 % and 10 % respectively. 100 % effluent treated plants were showed a decreased trend of shoot length i.e. 13 % over control. Similar trend were observed in shoot fresh and dry weight but percentage of dry weight were more in compared with its fresh weight (Table-2).Root length was increased 46 % over control in 25 % effluent treated soil but 50%, 10 %, 75 % and 5 % effluent treatment soil were showed an increased value 34 %, 26 %,22 % and 16 % respectively.100 % effluent treatment soil exhibited deceased percentage of root length over control i.e.11 %. The increased or decreased of growth parameters of 25 days old Tomato plant with different doses of effluent treatment to soil over control were noticed more or less similar trend .The fresh and dry weight of root were more compared with fresh and dry weight of shoot in 25 % effluent treated soil. Other treatment exhibited intermediate values (Table- 2).The above results were in agreement with the findings of Chandrashekhar et al.,(1998) in black gram, Kaushik et al.,(2004) in wheat plant, Saravanamurthy and Ranjita kumari,(2005) in peanut and green gram, Ale et al.,(2008) in wheat and rice plants, Vijayaragavan et al.,(2011) in radish plant, Siva Santhi and Suja Pandian (2012) in Peanut and green gram and Narain et al., (2012) in *Pisum sativum*, and Srivastava et al.,(2012) and Madan and Saxena,(2012) in *Solanum melongena* and Rath et al.,(2013) in Rice plant. At appropriate effluent concentration in soil ion exchange is one of the most significant functions that occupy in soils. Ion exchange is a consequence of mineral change that is derived from isomorphic substitution and pH dependant charge sites. These charged sites are the results of ionisation (H+ dissociation) or protonation of uncharged sites; ionization results in a negative charged site and protonation a positive charged site. Both of these reactions are dependent on pH. As the pH increases, the cation exchange capacity of soil is generally greater due to an increase in the number of pH dependant charged sites. Clays, organic matter, Ca, Mg and carbonates are the component responsible for pH buffering in soils. The soil pH can influence plant growth and its biochemical turnover through the activities of soil microorganism in shape of micronutrients mobility. Nitrate is the most essential and available form of nitrogen to plants. The overall increase in nitrogen is due to that a particular effluent concentration in soil provides maximum amount of nitrogen to soil health. Graded concentration of effluent adds a significant quantity of salts to the soil such as sulphate and chlorides that stimulate the growth at lower concentration but inhibits the growth at higher concentration (Patterson et al., 2008).Availability of K+ and Po-4 content in the soil might be due to increase in mineralization activity of organic matter as well as nutrients present in effluent that may be responsible for increased availability of plant nutrient. At higher effluent concentration the soil become acidified which results in a gradual leaching of basic cations i.e.(Mg+2,Ca2+,K+ and Na+) from the upper most horizons, leaving Al3+ as the dominant exchangeable cation.In the acidic medium microbial activity towards organic matter and soil internal stoechiometry may be changed which decreased the availability of micronutrients including soil nitrogen. Patterson,(2008) reported that higher concentration of Na causes the decreased of the bulk density as well as water holding capacity by reducing the porosity in clay soil due to de flocculating of clay particles in presence of higher sodium content as it effects the cation exchange capacity in the soil and adversely affects the plant growth and biochemical parameters. In present study, it has been revealed that the 25 % effluent treatment soil exhibited a better vegetative growth in 25 days old Tomato plant. The present investigation has clearly proved that the 25 % effluent treated soil may be optimum for the better growth of the plant and high bimolecular turnover rate. It could be suggested that the better growth and bimolecular content in 25 % effluent treatment may be due to the influence of combined effect of various ingredients of sugar industry effluent such as macro (N.P.K.) and micro (Ca, Mg, Mn, Fe, Zn, Cu and sulphur) nutrients, organic matter and many beneficial microbes. Lower concentration of effluent (5%, 10%, 25%, 50% and 75%) in soil exhibited a better growth in compared to control. Maximum growths of plant were noticed in 25 % followed by 50 %, 10 %, 75 % and 5 % respectively.100 % effluent treatment with soil showed retardation of growth in compared with control. Different concentration of effluent were highly effected the plant growth due to the excess amount of organic matter, micro and macro nutrients. Lower concentration of (5%, 10%, 25%, 50% and 75%) effluent the growth parameters were higher than that of control plants, which may be taken as an indication of beneficial range, while for higher concentration (100 %) of effluent, a decreasing trend was observed, which confirms the toxic effect of this effluent to Tomato plants. At lower concentration of effluent treatment soil may be lower bulk density and increased hydraulic conductivity. This can be attributed to improve in total porosity and aggregate stability in the soils due to addition of organic matter which play an important role in improving soil physical environment. Application of higher concentration (100 %) of effluent reduced the hydraulic conductivity of soils due to pore clogging by suspended solids. Higher concentration of effluent (100 %) with high organic matter resulted soil sickness due to poor aeration and high BOD. 100 % of effluent in soil may be containing above critical concentration of heavy metal of respective metal concentration which influence the plant growth retardation. Plant growth retardation changes the bimolecular content and its turnover rate. The present study concluded that the sugar industry effluent had a considerable effect on the properties of soil. It decreased the

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pH, moisture content, WHC and Bulk density whereas EC, Organic carbon, Co3-, HCo3-,Po4-3,No3-2,K+,Na+,Mg2+,Ca2+,So4-2 and Cl- values were increased over control.

**Table.1 Physiochemical characteristic of soil after treatment of different concentration of Rajshree sugars and chemicals Ltd effluent**

| Parameters | Effluent concentration (%) | | | | | | |
|---|---|---|---|---|---|---|---|
| | **Control** (Water treatment) | **5%** | **10%** | **25%** | **50%** | **75%** | **100%** |
| pH | 7.28 ± 0.14 | 7.49 ± 0.16 | 7.23 ± 0.11 | 7.19 ± 0.09 | 7.11 ± 0.08 | 6.55 ± 0.12 | 6.13 ± 0.14 |
| EC ($dsm^{-1}$) | 1.96 ± 0.11 | 2.16 ± 0.18 | 2.28 ± 0.15 | 2.41 ± 0.13 | 2.56 ± 0.12 | 2.74 ± 0.21 | 3.12 ± 0.16 |
| Soil moisture (%) | 38.62 ± 0.24 | 42.18±0.21 | 40.32±0.26 | 39.58±0.32 | 38.76 ± 0.23 | 34.35 ± 0.34 | 31.24 ± 0.28 |
| WHC (%) | 45.21 ± 0.27 | 45.86±0.18 | 43.3 ± 0.22 | 41.54±0.21 | 38.35 ± 0.25 | 34.23 ± 0.19 | 28.16 ± 0.23 |
| BD ($gm\ cm^{-3}$) | 1.38 ± 0.12 | 1.40 ± 0.15 | 1.39 ± 0.13 | 1.38 ± 0.18 | 1.37 ± 0.17 | 1.31 ± 0.11 | 1.28 ± 0.21 |
| OC ($mg\ kg^{-1}$) | 1.47 ± 0.09 | 5.61 ± 0.12 | 6.87 ± 0.26 | 9.32 ± 0.24 | 10.82 ± 0.28 | 13.64 ± 0.34 | 18.5 ± 0.26 |
| $CO_3^{-2}$ ($mg\ kg^{-1}$) | 130.06±0.32 | 143.23±0.29 | 149.11±0.24 | 158.38±0.25 | 163.31±0.26 | 186.64±0.32 | 204.11±0.21 |
| $HCO_3$ ($mg\ kg^{-1}$) | 273.14±0.21 | 311.23±0.26 | 389.45±0.23 | 461.74±0.18 | 510.83±0.15 | 696.24±0.26 | 830.34±0.22 |
| Total $PO_4^{-3}$ ($mg\ kg^{-1}$) | 41.41±0.27 | 51.82 ± 0.19 | 60.91±0.18 | 72.23±0.23 | 79.63 ± 0.25 | 90.34 ± 0.19 | 112.62±0.21 |
| Total $NO_3^{-2}$ ($mg\ kg^{-1}$) | 51.34±0.25 | 54.61 ± 0.23 | 58.92±0.27 | 62.36±0.21 | 71.56 ± 0.28 | 86.65 ± 0.29 | 90.45 ± 0.22 |
| Total $K^+$ ($mg\ kg^{-1}$) | 136.82±0.34 | 138.41±0.42 | 142.53±0.32 | 146.75±0.46 | 152.91±0.41 | 162.83±0.28 | 209.74±0.35 |
| $Na^+$ ($mg\ kg^{-1}$) | 28.23 ± 0.21 | 30.62 ± 0.31 | 36.24±0.26 | 41.55±0.22 | 52.82 ± 0.21 | 63.76 ± 0.27 | 82.54 ± 0.24 |
| $Mg^{2+}$ ($mg\ kg^{-1}$) | 2.68 ± 0.11 | 3.23 ± 0.09 | 3.94 ± 0.16 | 4.63 ± 0.14 | 5.76 ± 0.15 | 6.81 ± 0.18 | 8.32 ± 0.13 |
| $Ca^{2+}$ ($mg\ kg^{-1}$) | 18.13 ± 0.19 | 20.63 ± 0.12 | 26.34±0.13 | 32.54±0.14 | 41.64 ± 0.08 | 62.36 ± 0.23 | 90.06 ± 0.22 |
| $SO_4^{-2}$ ($mg\ kg^{-1}$) | 61.38 ± 0.23 | 64.94 ± 0.32 | 73.66±0.29 | 89.15±0.26 | 96.37 ± 0.23 | 112.45±0.34 | 136.34±0.38 |
| $Cl^-$ ($mg\ kg^{-1}$) | 89.82 ± 0.31 | 96.38 ± 0.36 | 119.46±0.34 | 142.1±0.29 | 168.36±0.28 | 206.8 ± 0.37 | 276.1 ± 0.35 |

**Table.2 Effect of different concentration of sugar industry effluent on 25 days old Tomato plant s (*Lycopersicum***

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***esculentum L*) Morphological growth parameters.(Each value is mean of 5 samples ± SEM)**

**SHOOT LENGTH**

| Treat | Shoot Length | Diff. from Control | % of IOC | F.wt. | Diff. from Control | % of IOC | D.wt. | Diff. from Cont rol | % of % of IOC |
|---|---|---|---|---|---|---|---|---|---|
| Control | 5.8 ± 0.16 | 0 | 0 | 7.2 ± 0.18 | 0 | 0 | 0.68 ± 0.08 | 0 | 0 |
| 05% | 6.4 ± 0.14 | 0.6 | 10 | 8.1± 0.16 | 0.9 | + 9 | 0.80 ± 0.05 | 0.12 | + 18 |
| 10% | 7.3 ±0.13 | 1.5 | 26 | 9.0± 0.13 | 1.7 | + 24 | 0.88 ± 0.06 | 0.20 | + 29 |
| 25% | 8.6 ±0.12 | 2.8 | 48 | 10.1±0.17 | 2.9 | + 40 | 1.06 ± 0.06 | 0.38 | + 56 |
| 50% | 7.7±0.19 | 1.9 | 33 | 9.3± 0.14 | 2.1 | + 29 | 0.96 ± 0.06 | 0.28 | + 42 |
| 70% | 6.9 ±0.18 | 1.1 | 19 | 8.4 ±0.11 | 1.2 | + 17 | 0.84 ± 0.02 | 0.16 | + 24 |
| 100% | 5.0 ±0.11 | - 0.8 | 13 | 6.5 ± 0.09 | -0.7 | - 10 | 0.56 ± 0.03 | 0 | + 18 |

**igure -1**

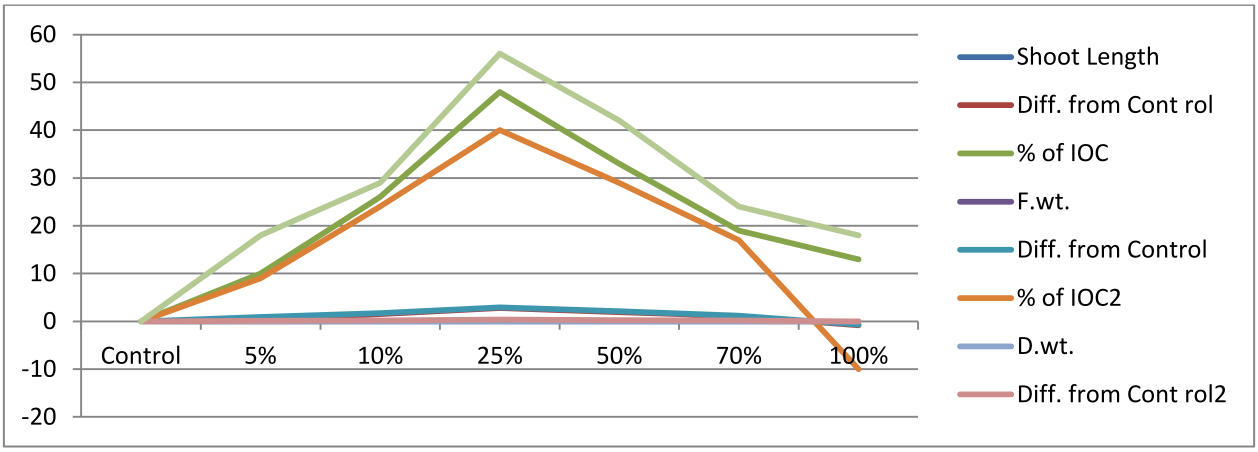
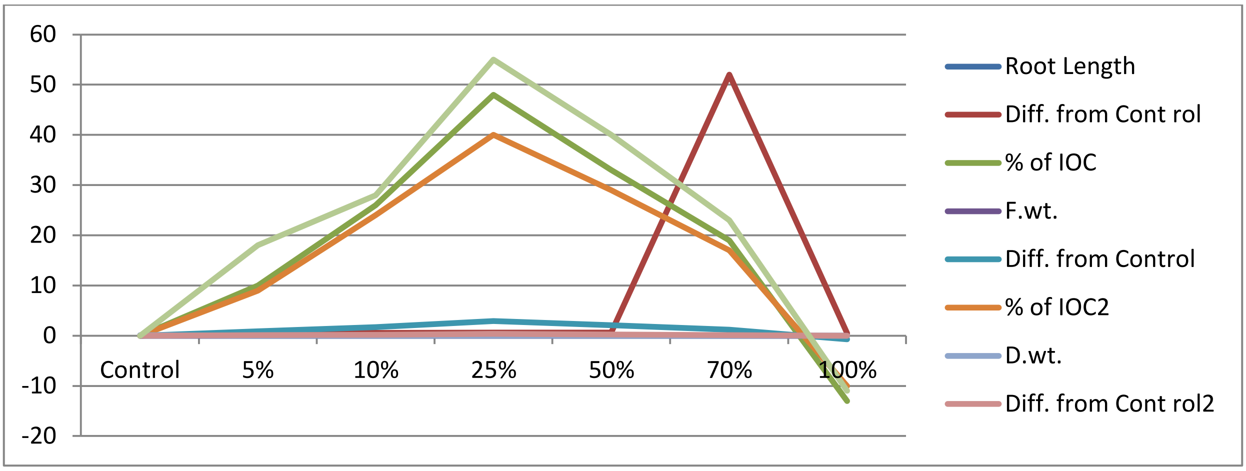



**Table.3 Effect of different concentration of sugar industry effluent on 25 days old Tomato plant s (*Lycopersicum esculentum L*) Morphological growth parameters.(Each value is mean of 5 samples ± SEM)**

**ROOT LENGTH**

| Treat | Root Length | Diff. from Cont rol | % of IOC | F.wt. | Diff. from Control | % of IOC | D.wt. | Diff. from Cont rol | % of % of IOC |
|---|---|---|---|---|---|---|---|---|---|
| Control | 3.6 ±0.19 | 0 | 0 | 0.45 ± | 0 | 0 | 0.09 | 0 | 0 |
| 05% | 4.17 ±0.18 | 0.57 | + 10 | 8.1± 0.16 | 0.9 | + 9 | 0.81 ± 0.05 | 0.10 | + 18 |
| 10% | 4.75±0.13 | 0.53 | + 26 | 9.0± 0.13 | 1.7 | + 24 | 0.84 ± 0.06 | 0.20 | + 28 |
| 25% | 5.25 ± 0.15 | 0.64 | +48 | 10.1±0.17 | 2.9 | + 40 | 1.04 ± 0.06 | 0.37 | + 55 |
| 50% | 4.82±0.18 | 0.65 | +33 | 9.3± 0.14 | 2.1 | + 29 | 0.96 ± 0.06 | 0.26 | + 40 |
| 70% | 4.39±0.25 | 052 | + 19 | 8.4 ±0.11 | 1.2 | + 17 | 0.81 ± 0.02 | 0.14 | + 23 |
| 100% | 3.21 ±0.23 | 0.52 | - 13 | 6.5 ± 0.09 | -0.7 | - 10 | 0.44 ± 0.03 | - | - 11 |

**Figure -2**




Micronutrients from the wastewater of the sugar industry significantly changed the quality and altered the soil's natural makeup. By treating sugar industrial wastewater in varying amounts, soil quality and composition can be altered, potentially improving the fertility and nutritional status of amended soil. All effluent concentrations that were diluted showed superior nutrient accumulation than the control. According to the experimental results, tomato plants grown best after 25 days when a 25% effluent dilution was used, followed by 50%, 10%, 75%, and 5%. Therefore, adding sugar industrial wastewater to agricultural land as an amendment may be a practical way to safely dispose of wastewater while also improving the soil's physical characteristics and micronutrient status. Based on these findings, farmers in the area should receive appropriate education on the advantages of using sugar industry effluent in agriculture. Doing so would save money on fertilizer and help reduce the amount of pollution that enters the environment.

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