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Impact Assessment of Abattoir Wastewater on Growth and Yield of *Solanum lycopersicum* L (Tomato)

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Abstract

The aim of this research was to determine the effect of abattoir wastewater on the growth and yield of tomato plants. The Physicochemical properties of the wastewater such as colour, odour, PH, Total Dissolved Solid (TDS), temperature, Dissolved Oxygen (DO), Biological Oxygen Demand (BOD) and heavy metals were determined using standard analytical procedure. It was found that most of the physicochemical parameters were within the permissible limit stipulated by the World Health Organization (WHO, 1996). A pot experiment was conducted in the botanical garden of the Federal University Dutse. Tomato seeds obtained from JASCO were sown and transplanted into experimental pots with each of the pots watered with different concentrations of Dutse abattoir wastewater. The abattoir wastewater was prepared in the following concentrations (0ml of DAWW +23kg of soil =0%), (200ml of DAWW +23kg of soil =25%), (400ml of DAWW +23kg of soil =50%), (600ml of DAWW +23kg of soil =75%) and (800ml of DAWW +23kg of soil =100%) while distilled water was used as control, the experiment were carried out in complete randomized design with three replications. Statistical analysis using ANOVA revealed that the plant height, number of leaves, flowers and fruits differed significantly ($p<0.05$) compared to control. It was found that the growth and yield were

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concentrations dependent in all the weeks after transplanting. Highest growth and yield were observed in tomato plants treated with 800ml (100%) of abattoir wastewater. Abattoir wastewater from Dutse can be utilized for irrigation at best concentration of 100%.

Keywords: Abattoir wastewater, Growth, Physicochemical parameters, Solanum lycopersicum, Yield,

INTRODUCTION

Tomato (*Lycopersicum esculentum* L.) is a vegetable crop that is produced all over the world and comes third in terms of output (Alhrout *et al*., 2018). According to the Global Tomato Industry Report from 2018, it had a global production of 27.3 metric tonnes, down from over 159 million tonnes in 2011 (MINFAL, 2011), and 37.5 million tonnes in 2019 (Colvine *et al*., 2019). Over 80% of tomatoes grown worldwide are converted into a range of consumer goods (Viskelis *et al*., 2015). Nigeria is one of the top producers in the world, accounting for roughly 50% of African production (Idowu-agida *et al*., 2014). The majority of the spice used in Nigerian cuisine is employed in the meat-processing business, which consumes between 35% and 40% of global production (Kekere *et al*., 2020). Vegetable output has recently fallen short of the rising human population's need (Tripathi *et al*. 2019). For instance, the Horticultural Institute of Nigeria reported in 2017 that there were 2.3 million metric tonnes of tomatoes produced nationally, compared to a demand of 3 million metric tonnes. Many small-scale African farmers have considerable worries as a result of the production drop caused by soil infertility (Tripathi *et al*., 2019). Chemical fertilizers can increase crop output, but they are frequently difficult to get and expensive (Mishra *et al*., 2013). As a result, there is now more support for alternate nutrient sources in infertile soils, such as recycling organic wastewater for crop cultivation (Okereke *et al*., 2020).

Currently, tomatoes form a vital part of the world's diet. Tomatoes are the second-largest vegetable in terms of both production and consumption (Xue *et al*., 2021). According to reports from the United States, tomato was the second-most popular fresh vegetable with 6 kg/person in 2017 (USDA, 2016). Vitamin C, pro-vitamin A, beta-carotene, folate, minerals including potassium, and secondary metabolites like lycopene, flavonoids, phytosterols, and polyphenols are all known to be present in tomatoes (Aliyu *et al*., 2020). So, according to Hofney *et al*. (2002), 100 g of fresh tomato supplies more than 46%, 8%, and 3.4% of the daily requirements for vitamins A (900 UE), vitamin C (82 mg), and potassium (3.5 g), respectively. The presence of the aforementioned components in processed tomato products including ketchup, paste, concentrate, juice, and soup (Ugonna *et al*., 2015) also benefits human health. The crop's economic and social relevance around the world, temperate, subtropical, and tropical regions all produce tomatoes.

According to Siddiki *et al*. (2021), each animal that is slaughtered generates waste that accounts for roughly 35% of its weight. This is typically released in huge quantities without a sufficient treatment process directly into the ecosystems (Artiola *et al*., 2019). Additionally, it is not unusual for abattoirs to be situated next to aquatic settings in order to ensure water availability; as a result, the waste produced is dumped into the water bodies (Al-Gheethi *et al*., 2021). Marella *et al*. (2020) claimed that AWW may raise the concentrations of nitrogen, phosphorus, and total solids in receiving water bodies, which may induce eutrophication, causing rapid growth of algae. It is still a great source of nutrients even after primary treatment (McCarty *et al*., 2011). Compared to other wastewater sources, abattoir wastewater has the largest concentration of organic load, with high levels of proteins (70%) and suspended particles of 15–30 mg/L, as well as Chemical Oxygen Demand (8000 img/L) in comparison to other wastewater sources (Thomas, 2007). According to Suwaileh *et al*. (2020), AWW can serve as a source of micronutrients including calcium, sodium, magnesium, sulphur, and iron as well as important nutrients like nitrogen and phosphorus. Wastewater irrigation can be a low-cost method of managing wastewater and a valuable supply of nutrients for barren soils. According to Kekere *et al*. (2020), irrigation with AWW had a favourable effect on plant development and growth. The yield of annual and total herbage was greatly boosted by AWW irrigation, according to Kekere *et al*. (2020). According to Bhunia *et al*. (2021), plants cultivated in soil that had been supplemented with abattoir wastes showed a noticeably greater rise in height, number of leaves, leaf area, fruits, blooms, and total fruit weight.

Surface water contamination, general environmental pollution, and public health issues have all been linked to the discharge of untreated AWW (Assegide *et al*., 2022). Regarding how plants react to various AWW concentrations or levels, there is insufficient information currently available. A high likelihood of direct interaction with wastewater from abattoirs located close to residential areas or from runoff of those disposed of in gullies exists for vegetables like tomato and sweet pepper that are widely grown in home gardens in South-Western Nigeria (Okereke *et al*., 2020). The purpose of this study was to evaluate tomato growth and yield quality utilizing Dutse abattoir wastewater. Tomatoes are a significant food that are highly demanded for daily diets in Nigeria. In order to improve the sustainable management of the waste water and increase food security, we hypothesized that utilizing it for crop cultivation might have a good impact.

MATERIALS AND METHODS

Study Area

The experiment was conducted at the Botanical Garden of the Department of the Biological Sciences, Federal University Dutse Jigawa State, Nigeria. Dutse is in Sudan savanna of North Western Nigeria. It is situated between latitude 11.0^0N to 13.0^0N and longitude 8.0^0E to 10.15^0E with the total land area of approximately 22,410 square kilometer (Abdulmumini, 2019)

Materials used for the Study

The seed of tomato variety (UC/82B) was obtained from Jigawa State Agricultural Supply Company (JASCO) located in Dutse town, while Abattoir wastewater used was obtained from Dutse Abattoir. The top soils were collected from Agricultural farm, Federal University Dutse, Jigawa State, Nigeria.

Determination of Physicochemical Parameters

The physicochemical properties of the abattoir wastewater such as colour, odour Total Dissolved Solids (TDS), temperature, pH, Dissolved Oxygen (DO), and Biological Oxygen Demand (BOD), heavy metal (Cu, Zn, Fe, Cr) were analyzed at the central laboratory of Bayero University Kano. The analyses of heavy metal were carried out using AAS, PH and DO analysis were carried out using multipurpose pH meter, and temperature was measured using Hanna instrument.

Determination of Heavy Metals

Each sample was measured to a volume of 100 ml in a measuring cylinder, transferred to a beaker, and 10 ml of HNO_3 added before being heated to 1000 °C, the sample was allowed to evaporate to a final volume of between 70 and 600 ml, and then 5 ml HNO_3 was added while the mixture continued to be heated to a final volume of 20 ml. The digested sample was then filtered and diluted with distilled water to a final volume of 50 ml. To have the heavy metals analysed, 10–12 ml of the digestion was transferred to Atomic Absorption Spectrometer (Rashid *et al*., 2016).

Experimental Design and Treatment Combination

The abattoir wastewater was prepared in the following concentrations
0ml of abattoir waste water +23kg of soil is =0%
200ml of abattoir waste water +23kg of soil is =25%
400ml of abattoir waste water +23kg of soil is =50%
600ml of abattoir waste water +23kg of soil is =75%
800ml of abattoir waste water +23kg of soil is =100%
The experiment were carried out in Complete Randomized Design (CRD) with three replications.

Soil Preparation

In the Federal University Dutse's Agricultural field, soil was collected, broken up into smaller pieces, and sieved through wire mesh to remove big particles. Before planting, each of the polythene pots was filled with soil to a depth of 3/4 and uniformly hydrated.

Planting, Transplanting and Arrangement of the Polythene Pots

A bed was set up in the Botanical Garden of the Department of Biological Sciences, Federal University Dutse. The tomato seeds were sown in beds with water for at least two weeks before being transplanted onto the soil in polythene pots with healthy seedlings of roughly the same size.
The rows and spacing between the polythene pots were both set at 80 cm × 80 cm. The experiment employed a total of 60 polythene pots

Data Collection

At intervals of 2, 3, 4, 5, 6 and 7 weeks after transplanting, growth parameters including plant height and leaf counts were observed and recorded. Plant leaves were physically counted while the plant height was measured using a calibrated ruler. Physical counting methods were also used to count yield factors including the number of flowers and fruits.

Statistical Data Analysis

The results were presented as a mean of triplicate per sample ± standard error (S.E) at level 5%, differences between exposure treatments and equivalent controls were deemed statistically significant. ANOVA were used to analyse the data, LSD were used to separate the means where there is significance using a Paleontological Statistics and Software (PAST).

RESULTS AND DISCUSSION

Physicochemical Properties of Dutse Abattoir Wastewater

Table 1 lists the physicochemical characteristics of abattoir wastewater. BOD and DO levels were extremely low, and TDS and pH were within the allowable range established by the World Health Organisation (WHO, 1996). Chromium was above the allowable limit, but other heavy elements, such as Cu, Fe, and Pb, were below the WHO recommended values. Due to the majority of the parameters studied not exceeding the allowed standard set by the environmental regulatory body, the results of the physicochemical properties below had shown that Dutse abattoir wastewater was not poisonous. Low levels of heavy metals are advantageous for plant growth and yields, but over a certain level, their effects start to have negative effects on plant physiology.

Table 1: Physico–chemical properties of Abattoir wastewater obtained from Dutse Abattoir, Jigawa State.

Parameters	DAWW	WHO
Colour	Brown	NS
Odour	Offensive	NS
Temperature	28.6±0.07	NS
Dissolved Oxygen	0.5±0.05	NS
PH	7.4±0.57	6.5-9.5
Total Dissolved Solid	1095±1.15	<1200
Biological Oxygen Demand	0.2±0.05	NS
Cr	0.219±0.0083	0.01
Cu	0.015±0.0075	1.0
Fe	1.506±0.0703	3.0
Pb	-0.050±0.0115	0.01
Zn	0.092±0.0079	NS

Key: NS: Not stated, DAWW: Dutse abattoir wastewater

Effect of Abattoir wastewater on growth parameters of *Solanum lycopersicum*

Tables 2 and 3 illustrate the effects of abattoir wastewater on tomato plant growth and development metrics. The concentration of 800ml of abattoir wastewater (100%) produced the highest mean value of the height and number of leaves, whereas the 200ml (25%) produced the lowest value. In all the weeks after transplanting (WAT), an increase in the concentration of abattoir wastewater resulted in an increase in plant height and leaf count. The height of the plant and the number of leaves were substantially different ($p < 0.05$) from control, according to statistical analysis using ANOVA. This outcome is consistent with research done by Kekere *et al*. (2020) on *Solanum lycopersicum*, *Solanum melongena*, and *Capsicum annuum*. It also accords with studies on *Pennisetum purpureum*, *Sinapis alba*, *Helianthus annus*, and *Medicago sativa*, where plant growth and development were aided by abattoir wastewater (Pakwan *et al*., 2020). Similar to this, Castrol *et al*. (2011) revealed that AWW irrigation influenced plant growth and development in a favourable manner. Growth improvement can be ascribed to an increase in soil fertility after AWW treatment, as demonstrated by Matheyarasu and Bolan (2016), who applied AWW to low-fertility soils and discovered an improvement in soil fertility status.

Table 2: Effect of different concentrations of abattoir effluent on the height of tomato plant

Treatments	2WAT	3WAT	4WAT	5WAT	6WAT	7WAT
Control	11.23±0.721^{a}	15.03±0.73^{a}	17.86±0.46^{a}	17.73±0.93^{a}	19.06±0.58^{a}	20.36±0.58^{a}
200ml	18.13±0.75^{b}	20.70±0.72^{b}	20.33±0.99^{c}	21.33±0.88^{b}	24.76±0.90^{b}	23.06±0.82^{b}
400ml	23.5±0.86^{c}	24.80±1.04^{c}	25.53±0.86^{c}	24.50±0.86^{c}	28.23±0.78^{c}	26.00±0.57^{c}
600ml	27.9±0.95^{d}	29.10±0.66^{d}	29.10±0.49^{d}	27.00±1.15^{d}	31.53±0.74^{d}	28.60±0.86^{d}
800ml	31.6±1.45^{e}	30.86±1.07^{e}	32.56±0.75^{e}	30.96±1.59^{e}	34.56±0.74^{e}	35.66±1.45^{e}

Key: Means with the different superscript letter along the column are significantly different ($P<0.05$), WAT: weeks after transplanting.

Table 3: Effect of different concentrations of Dutse abattoir wastewater on the number of leaves of tomato plant

Treatments	2WAT	3WAT	4WAT	5WAT	6WAT	7WAT
Control	29.66±1.76^a	34.33±1.20^a	37.00±0.57^a	39.66±1.20^a	43.33±1.45^a	46.66±0.88^a
200ml	53.33±1.76^b	63.66±2.02^b	65.33±1.45^b	69.00±1.15^b	70.66±0.88^b	72.33±0.33^b
400ml	62.66±1.45^c	70.66±1.45^c	72.66±2.96^c	75.66±1.76^c	83.00±2.30^c	77.66±1.20^c
600ml	69.66±0.88^d	78.00±1.52^d	80.33±0.88^d	83.00±173^d	89.66±1.20^d	85.33±2.02^d
800ml	75.33±1.45^e	86.00±1.15^e	84.66±2.02^e	91.66±2.02^e	96.00±1.15^e	91.33±3.38^e

Key: Means with the different superscript letter along the column are significantly different ($P<0.05$), WAT: weeks after transplanting.

Effect of Dutse Abattoir Wastewater on Yield Parameters of Tomato plant

The effect of different concentrations of abattoir wastewater on the number of flowers and fruits were shown in Table 4 below. The concentration of 800ml of abattoir wastewater (100%) gave the highest mean value of the number of flowers and fruits while the least value was recorded in control. All the concentrations of Dutse abattoir wastewater increased plant number of flowers and fruits at all weeks after transplanting (WAT) when compared to control. More flowers and fruits are produced by plants when wastewater concentration rises. This study found that AWW, especially at 100% concentration in comparison to other treatments, increased the tomato plant's fruit yield. This supports the earlier work by Bedbabis *et al*. (2015) showing irrigation of olive trees with municipal wastewater increased yields significantly when compared to yields from the plot irrigated with well water. According to De los Sontos *et al*. (2019), irrigation using food sector raw wastewater considerably boosted tomato growth and yield metrics as well as cucumber plant height and fruit production. The impact of irrigation with pump water and municipal wastewater on wheat was also contrasted by Uttara *et al*. (2018). They found that wastewater irrigation increased grain yields, taller plants, and heavier seeds compared to pump water irrigation. On *Arachis hypogaea*, similar findings were also noted by Okereke *et al*. (2020). Additionally, the increase in yields in plants grown in wastewater-treated soil is consistent with findings made by Matheyarasu and Bolan (2016), who discovered that plants like *Pennisetum purpureum, Medicago sativa, Sinapis alba, and Helianthus annuus* yielded about 70% less under tap water irrigation than they did under irrigation of abattoir wastewater. Similar to this, in a pot experiment, it was discovered that fertilizer made from abattoir waste products greatly increased the biomass yield of wheat (Triticum aestivum) and AberMagic grass (*Lolium perenne*) compared to the nil treatment pots (Darch *et al*., 2019). They discovered that AWW is a sustainable substitute for traditional fertilizers after observing increased grain production in wheat and AberMagic grass when it was applied. Increased leaf area allowed for more photosynthetic activities, which in turn produced more photosynthates for fruit production, which could be connected to yield enhancement (El-Desouky *et al*., 2021). When absorbed by plants, Mg in wastewater, which is a crucial component of chlorophyll, may increase chlorophyll synthesis, which is a factor in yield generation.

Table 4: Effect of different concentrations of abattoir wastewater on the number of Flowers (8WAT) and Fruits (9WAT) of tomato plant

Treatments	Flower (8WAT)	Fruits (9WAT)
Control	14.66±1.45[a]	5.33±0.88[a]
200ml	18.00±1.15[b]	9.00±1.00[b]
400ml	22.33±1.20[c]	13.00±0.57[c]
600ml	27.33±0.88[d]	16.33±0.88[d]
800ml	32.66±1.45[e]	20.00±1.15[e]

Means with the different superscript letter along the columns are significantly different (P<0.05), WAT: weeks after transplanting.

CONCLUSION

The results demonstrated that the majority of the physicochemical parameters of the wastewater from Dutse abattoir were within the permitted limit established by WHO, 1996, showing that the wastewater was not harmful. Due to the availability of nutrients, irrigation with abattoir wastewater boosted tomato plant growth and productivity. Tomato plants treated with 100% (800ml) of the concentration of the abattoir wastewater produced the highest growth rate and yield. Growth and yield were significantly higher at all concentrations of the abattoir effluent (25, 50, 75, and 100%) than at control. Regular monitoring and testing of both the abattoir wastewater and the irrigated crops are crucial. This helps to assess the quality of the wastewater, the effectiveness of the treatment processes, and the potential accumulation of contaminants in the crops. Testing for pathogens, heavy metals, and other contaminants will ensure that the crops meet safety standards.

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