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Original Research

Effects of Marble Industry Effluents on Soil Quality, Growth and Productivity of Tomato (*Lycopersicon esculentum*) in District Swat, Khyber Pakhtunkhwa, Pakistan

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Abstract

Soil and water pollution adversely affect growth and productivity of agri-business oriented crops in Pakistan. There are many crops consumed in Pakistan such as *Lycopesicon Esculentum* which is a major staple used in District Swat, Khyber Pakhtunkhwa, Pakistan. A greenhouse study was conducted to evaluate the effect of marble effluents on soil pH, water holding capacity (WHC) of soil, seed germination, number of leaves, number of inflorescences, stem girth, root, and shoot length along with their dry biomasses. Interestingly, there was a linear rise in pH of soil with increase in effluents concentration. Likewise, seed germination and root length were also improved with higher concentration of industrial effluents. The study found out no inflorescence at 100% effluent concentration. In contrast, highest inflorescence (6) was recorded at 10% effluent concentration. The earlier ripening of tomatoes occured with the highest concentration of effluents. There were no drastic changes in terms of number of seeds and its germination, while the shoot length was reduced as compared to control group. Significant differences of WHC in soil was found, moreover the maximum WHC was found in 20% treatment. These empirical results indicate that marble industry effluents may degrade the growth and productivity of *Lesculentum*. The study contributes to a better understanding

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of marble effluents on growth and productivity of Lycopesicion Esculentum in target area of study to improve agribusiness productivity for tomato while improving envoironmental sustainability.

Keywords: marble effluents, *Lycopersicon esculentum,* WHC, seed germination, post germination

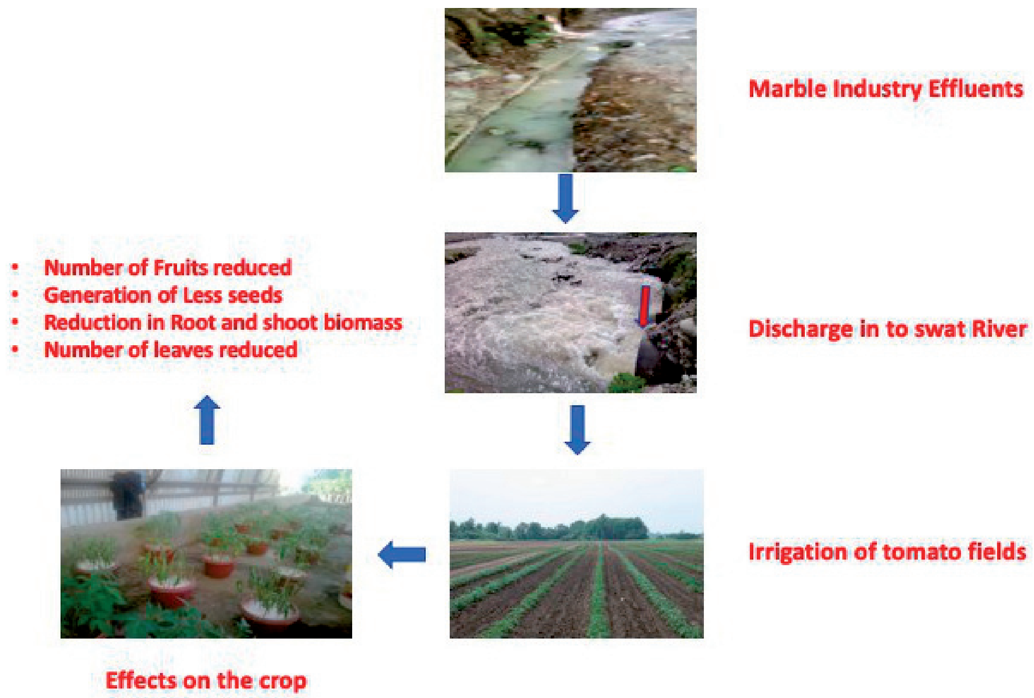
Introduction

On the one hand, world economy contributes with industries which pays a pivotal role in economic prosperity. On the other hand, industries contributed largely to global environmental pollution due to transboundary movements of industrial waste [1]. From the production process perspective, industries generate huge amounts of solid, semi-solid and liquid wastes containing substantial amounts of organic and inorganic pollutants [2, 3]. In most of developing countries, industries discharge large volume of wastewater contaminants to surface water [4], which is increasingly utilized as a valuable resource for irrigation in urban and peri-urban agri-business related activities in developing countries [5]. Hence, significant amount of contaminants are discharged directly into rivers without any prior treatment [6, 7]. These contaminants get accumulated in a biomagnified manner in water, sediments and aquatic life [8, 9].

In Pakistan, main contributors of the contaminant to the surface and ground water pollution are the by-products of various businesses or industries such as textile, marble, dying chemicals, fertilizers, mining and other industries [10-12]. Different types of industrial effluents have been reported to affect the growth and productivity of various crops [13]. Marble industries effluents contain different kind of toxics including but not limited to heavy metals such as Chromium (Cr), Molybdenum (Mn), Nickel (Ni), Iron (Fe), Cadmium (Cd), Copper (Cu), Lead (Pb) and Zink (Zn) which are ultimately drained into irrigation water [14]. In Pakistan, especially in the province of Khyber Pakhtunkhwa (KPK) advanced level wastewater treatment facilities are neither available nor economicall viable for for industries [15]. Thus, these effluents are drained off into various water bodies resulting in surface/ground water pollution, which endangers biodiversity and lowers agriculture production [14].

In the preceding discussion, having discussed the negative aspects of wastewater, now we divert our attention towards relatively positive aspects of such phenomena. The useful impact of wastewater on irrigation cannot be overstated because it provides some basic nutrients to the soil nourishment [16], in contrast, it adds many toxicants into the soil, which changes the different properties of soil. For instance, stone crusher dust is extremely hazardous for crops due to lower porosity [17]. Since different crop species may have different tolerance to various pollutants [18] thus, results in lower productivity of crop yield varie from one species to another [19].

Tomato (*Lycopersicon esculentum*) is an important vegetable crop in Pakistan, grown in home gardens and



Schematic representation of Marble industry effluents effect on tomato plants.

also in the farm fields. It is consumed as fresh fruit or processed into different edible products. The cultivation of the tomato is one of the most popular and widely consumed vegetable crops due to the fact that it is part of daily routine as well as a source of economic prosperity for farmers due to its higher demand throughout the year [20]. The main source of irrigation of tomato fields in the target area of study is a stream also known as "Swat river"which unfortunately is home to a number of marble industries in its proximityMost of the effluents of marble industry are drained in the river. So, it's very relevant to document the effect of marble industry effluents on this important cash crop. The major purpose of this study is to determine the effect of marble industry effluents on quality of soil, growth and productivity of *Lycopersicon esculentum*. Against the backdrop of preceding scholarly literature the experimental work was conducted in Agriculture Research Centre, Mingora, District Swat, KPK, Pakistan to figure out the effects of marble industry effluents on soil quality, growth and productivity of *L. esculentum*. Seeds of *L. esculentum* were taken from Agriculture Research Centre, Mingora Swat.

Material and Methods

Study Areas

District Swat lies in the northern part of Khyber Pakhtunkhwa (KPK), Pakistan. It covers an area of 5037 km^2. It lies from 34°30′00″ to 35°50′00″ north latitudes and 72°05′00″ to 72°50′00″ east longitudes. The district has elevation range from 600 to above 6000 meters. The experimental work was conducted in Agriculture Research Centre, Mingora, District Swat, KPK, Pakistan to figure out the effects of marble industry effluents on soil quality, growth and productivity of *L. esculentum*. Seeds of *L. esculentum* were taken from Agriculture Research Centre, Mingora Swat.

Experimental Design

Plastic pots were filled with 2 kg mixture of soil, dung and sand with a ratio of 2:1:1, respectively. Seeds of *L. esculentum* (Sultan F1hybrid tomato) were sown. Ten seeds were sown in each pot and after their germination; three uniform seedlings were selected in each pot. The pots were used in triplicate for each treatment and were placed in glass house throughout the vitro work to prevent the interference of harsh environment with the samples. *L. esculentum* was watered after every 3rd day.

Industrial Effluents Treatment

The marble industry effluents were collected from Al Madina Marble industry in Swat district and were diluted with tap water at concentration of N1 = 10%, N2 = 20%, N3 = 40%, N4 = 80% and N5 = 100%, while the tap water (N0) was used as a control. Before sowing the seeds, all 180 seeds were treated with 70% ethyl alcohol for two minutes and then 0.1% mercuric chloride for 5 minutes as previously described in detail by [21]. Frequent visits were made to the site for measurement of the seed's germination after the first week of sowing. Plant height was measured from base of stem till the top of apical leaf on weekly basis. After harvesting, root length was measured with the help of ruler in centimeter (cm). Roots and shoots of plants were washed with tap water and then dried in oven at 60 °C for 72 hours andsubsequently their dry biomass was determined with the help of balance according to the process described [22]. The numbers of fruits (*lycopersicon esculentum*) per plant were counted in the end of experiment and their wet and dry weight were calculated. To characterize the soil physical properties, dry soil samples were collected from the pot after treatment with marble industrial effluents. pH was measured in soil-water suspension (1:5) using a corning glass electrode pH-meter upon harvestionof plants [20]. Soil sample of 100 grams has been taken from each pot, then weighted along with moisture pot after that kept in oven for 36 hours at 105ºC. Later the soil samples were removed and allowed to cool down, then the dry weight of samples along with moisture pot was calculated and subtracted from wet weight of soil along with moisture pot [24].

The following formula was used to calculate the moisture content.

$$\text{Moisture content in soil} = Y - Z$$
$$\text{Weight of oven dry soil} = Z - X$$
$$\text{Percentage of moisture in soil} = (Y-Z / Z-X) \times 100$$

Where:

X = Weight of empty moisture pot
Y = Weight of moisture pot + moist soil
Z = Weight of moisture pot + oven dry soil

Statistical Analysis

Statistical Package for Social Sciences (SPSS) version 17 was used for analysis of the experimental data. The resulted measurements were subjected to ANOVA (analysis of variance) [25].

Results

Effects of Effluents on Leaves, Stem Girth, and Soil pH

Significance of treatment effects on number of leaves, stem girth and pH of soil was tested by ANOVA. The significant effects were found in soil pH such as

Table 1. Mean effects of marble effluents on soil pH, number of Leaves, and stem girth.

		Effects on Soil pH				Effects on number of Leaves				Effects on stem girth			
Treatments	Denoted as	Mean pH	±SEM	Std. Dev	Co. of Varia	Mean (%)	±SEM	Std. Dev	Co. of varia	Mean	±SEM	Std. Dev	Co.of Varia
Control	N0	6.9	0.03	0.06	0.87	46.7	2.33	4.04	8.66	1.54	0.06	0.10	6.49
10%	N1	7.43	0.09	0.15	2.02	53.6	2.32	4.01	7.53	1.56	0.04	0.08	5.56
20%	N2	7.5	0.06	0.1	1.33	56	4.04	7	12.51	1.46	0.08	0.13	8.50
40%	N3	7.6	0.15	0.26	3.42	46.5	2.35	4.04	8.67	1.27	0.04	0.07	3.51
80%	N4	7.7	0.12	0.20	2.60	37.3	2.31	4.02	10.82	1.39	0.09	0.16	11.51
100%	N5	7.7	0.12	0.20	2.60	35	0	0	0	1.15	0.02	0.04	3.48
F-value		8.262				11.20				6.521			
P-value		0.001				0.000				0.004			

corresponding rises were recorded with the increase in marble effluents concentration. The maximum pH (7.7) was found for 80% and 100% concentration as compared to control. The maximum number of leaves value was found at in 20% concentration. While, the minimum was at 100% concentration. Stem girth shows the minimum value at 10% concentration. The significant variations are shown in Table 1.

Effects of Marble Effluents on Plant Height and Root Length

Maximum plant height was observed in control group in the comparison of other treatment groups. It was found that the maximum root length value was at 80% concentration. While, the minimum root value length was determined at control group (Fig. 1). Mean value and ANOVA for the effects of effluents on plant height and root length.

Effects of Marble Effluents on Biomass of Shoots and Roots

The maximum fresh and dry biomasses of shoot value was found at 20% concentration. While, the minimum was found at control group. The significant differences were determined through ANOVA in root dry biomass. The maximum mean value found in root dry biomass (gm) at 20% concentration, while the minimum value found at control. The ANOVA and mean values show that marble effluents have no significant effects on shoots fresh and dry biomass (Fig. 2).

Effects of Marble Effluents on Number of Inflorescence and Yield of *L. esculentum*

Inflorescence at anthesis presents the flowers in a way that allows for the transfer of pollen and optimization of the plant's reproductive success.

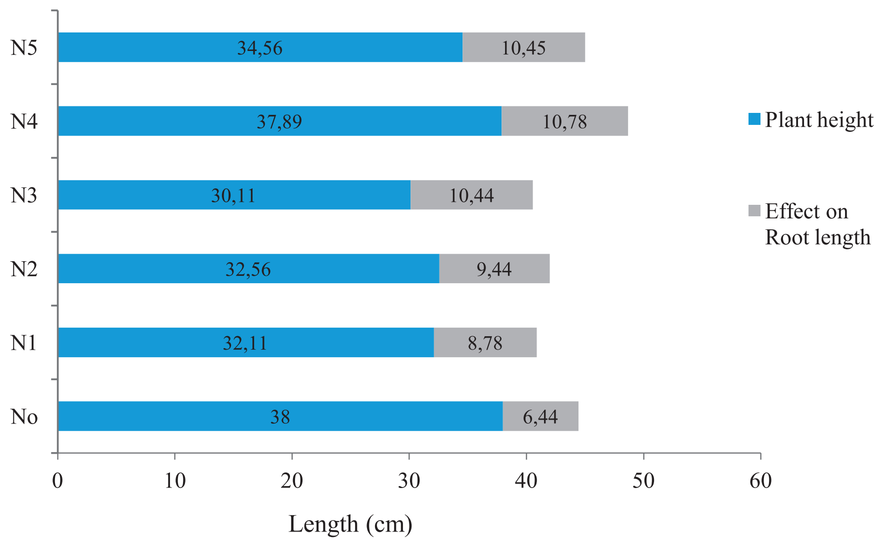


Fig. 1. Mean effect of Marble industry effluents on plant height and on root length.

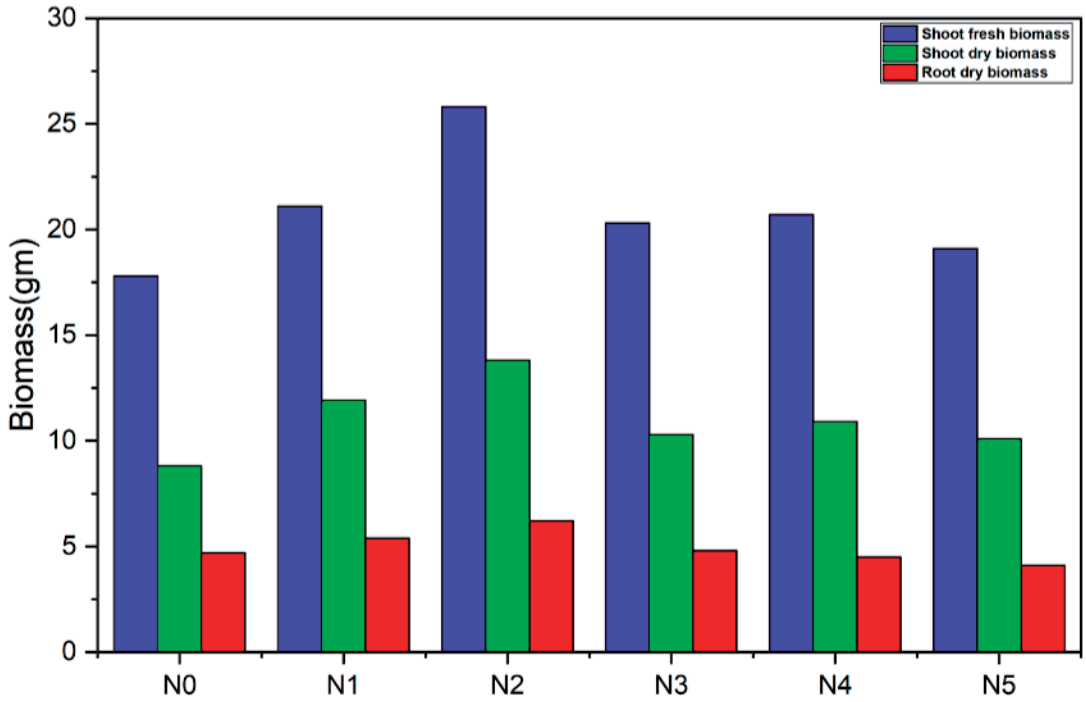


Fig. 2. Mean effects of marble effluents on shoot fresh biomass and dry biomass of shoot and root.

As can be seen in Fig. 3. the maximum inflorescence was observed in 10% concentration of marble effluents, while the minimum was gauged at 80% and 100% concentrations respectively. The maximum fruit yield were observed in 10% concentration while the minimum at 100% concentrations. First fruit was observed on 29th July 2020 in 20% concentration, while first ripening appears with the 80% concentration of effluents. Mean value and ANOVA for the effects of marble industrial effluents on inflorescence and yield of *L. esculentum*.

Effects of Effluents on Seed Germination and Soil Moisture Content

Interestingly, maximum number of seeds were germinated at 40% marble effluent concentration, while minimum germination was observed at 10 and 100% respectively. On the one hand, maximum moisture in soil was found at 20% effluent concentration. On the other hand, minimum value was found in control group. Mean value of seed germination and water holding capacity of soil has been shown in Fig. 4.

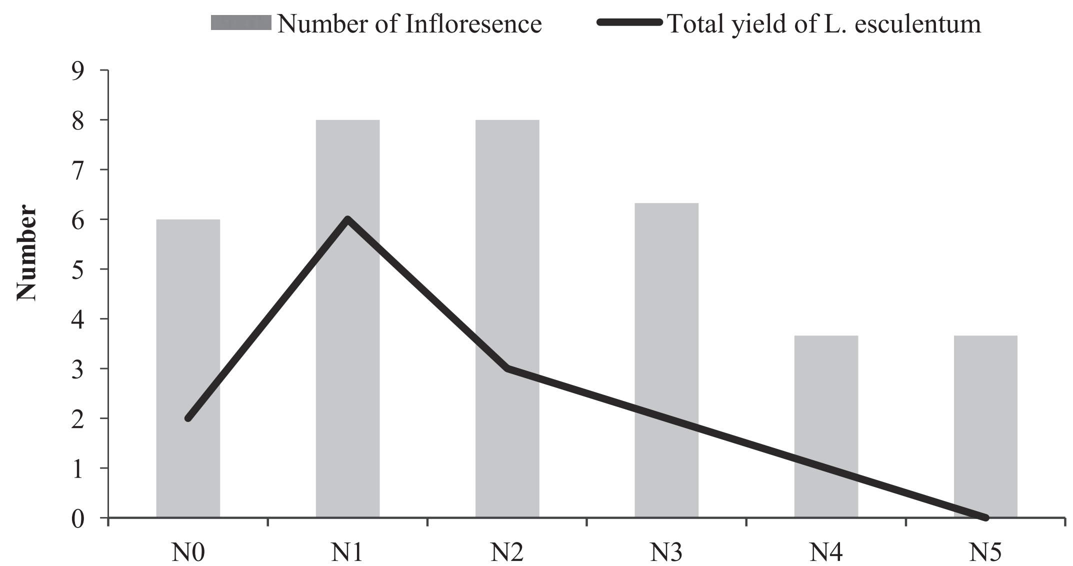


Fig. 3. The effects of marble effluents on number of inflorescence and yield of *L. esculentum.*

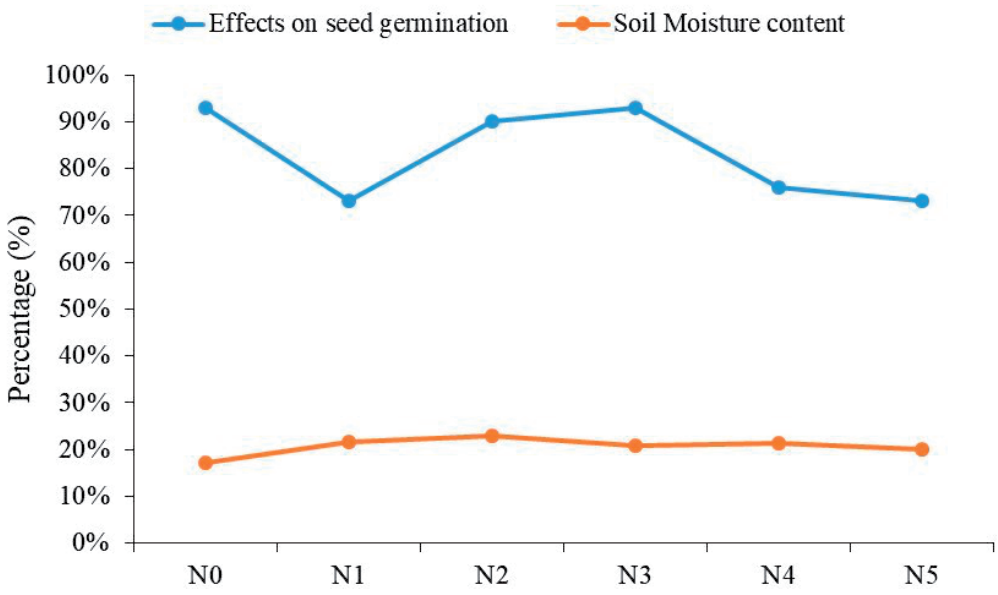


Fig. 4. Mean effect of marble industry effluent on seed germination and soil moisture content of soil.

Discussion

Lycopersicon escolentum is an important greenhouse crop plant of district Swat, KPK, Pakistan. The income of the local farmer depends on the yield and quality of the crop. The growth in population of study area has resulted into substantial increase in industrial pollutant load. Most of these industries are located on the bank of river Swat, which discharge their effluents directly to the river without any proper treatment. Therefore, this research work was carried out to document the effects of marble industrial effluents on the yield of tomato plants. The best yields were found in lowest diluted concentration of marble effluents, while the minimum yield was found in undiluted marble effluents. First fruit was observed in 20% concentration of effluents, While, the first redness appears with the 80% concentration which shows the fruits ripening happened earlier as the marble effluents concentration increases. The study found out that the maximum germination was at 40% while the minimum at 10% and 100% treatment respectively. Germination of seed reduced due to excessive quantities of inorganic salts along with higher electric conductivity values. The results from Zaouri et al. (2021) and David Noel and Rajan (2015) strongly correlate or goes in agreement with our research findings. They documented that when the field was irrigated with increased percentage of industrial waste effluents the germination of plants declined drastically [26, 27]. The presence of basic pH, salts and other contaminants are not compatible with the seedling germination and plant growth [28]. Enaime et al. (2020) also observed that olive mill wastewater even at low concentration showed inhibitory effect on germination of tomato seed [29]. Similarly, Rusan et al. (2015) observed no germination of seed with untreated and olive mill wastewater diluted with water (75 and 50% olive mill wastewater) [30].

The current study shows the maximum plant height of tomato was at control while minimum at 10% concentration of marble effluents. It has been observed in a number of studies that the application of wastewater enhanced chlorophyll content, plant height, and reduced number of leaves and stem girth [31, 32]. From the present study, we found that maximum root length value was at 80% and maximum shoot dry biomass value was found at 20% concentration of marble effluents. Our experimentation shows a linear increase in pH from low concentration to high concentration, the maximum pH at 90% and 100% concentartion. while, lowest was recorded at control group. The rise in pH is due to the presence of high concentration of Calcium salts from the effluents of marble industry. Maximum number of leaves were counted at 20% while minimum at 100% concentration., the toxic nature of the effluents and the leaves of the plants were affected by decreased photosynthetic rate. Our results goes in agreement with Osaigbovo and Orhue (2006), they documented the maize plant height, chlorophyll content and no. of leaves were maximum at 25% treatment of pharmaceutical effluents. The maximum absorption of Potassium from nutrients and turgor pressure in plant cells play an important role for improving vegetation growth [33]. Channakeshava and Sarangamath (2007) concluded that as marble industry effluents contain Calcium and Phosphorous which can be beneficial for growth of *Brassica juncea* but its excessive amount could retard the growth of plants. In the present study, we found the decrease in growth and production of plants at 100% concentration of marble effluents [34]. Rusan et al. (2015) also found reduce root length, shoot length, shot dry weight, root dry weight as compared to control group.

Conclusion

The study concludes that different concentrations of marble industry effluents has drastic effect on the seed germination, growth of plant and productivity of *L. esculentum*, dependent on the nature of wastewater and time of exposure. This inwardly impacts the economic wellbeing of farmers and their associated businesses. Marble industry effluents in low concentration have insignificant negative effects in the target area of study. The response of plant biomass (fresh and dry weight) root shoot and fruit production rate also responded differently to various marble industry effluents concentrations. But there is still need to carry out series of greenhouse and field trials to determine the positive and negative effects of these effluents for tomato crop with a higher sample size and logitudnal research design. It is recommended that the wastewater should be properly treated before discharges so to prevent the adverse effects of marble industry effluents on agricultural crops and vegetation for environmental sustainability and economic growth.

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Conflict of Interest

The authors declare no conflict of interest.

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