Journal of Pharmacognosy and Phytochemistry
Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
JPP 2019; 8(1): 01-07
Received: 01-11-2018
Accepted: 03-12-2018

Shreya Handa
Department of Environmental Science, Dr. Y S Parmar University of Horticulture and Forestry, Nauni, Solan, Himachal Pradesh, India

Meena Thakur
Department of Entomology, Dr. Y S Parmar University of Horticulture and Forestry, Nauni, Solan, Himachal Pradesh, India

Kuldeep Singh Thakur
Department of Vegetables Sciences, Dr Y S Parmar University of Horticulture and Forestry, Nauni, Solan, Himachal Pradesh, India

Correspondence
Shreya Handa
Department of Environmental Science, Dr. Y S Parmar University of Horticulture and Forestry, Nauni, Solan, Himachal Pradesh, India

Effect of domestic effluents on tomato crop *Solanum lycopersicum* (L.) production

Shreya Handa, Meena Thakur and Kuldeep Singh Thakur

Abstract
Effect of domestic effluents on tomato crop *Solanum lycopersicum* (L.) production" was carried out during 2015-2016 in pot experiment in the experimental farm of Department of Environmental Science, Dr. Y. S. Parmar University of Horticulture and Forestry, Nauni, Solan which is located at an altitude of 1273 m amsl and at latitude of 35.5°N, longitude of 77.8°E. The studies were conducted in pot experiment, comprising of 4 treatments viz., T_1 (75% of domestic effluent), T_2 (50% of domestic effluent), T_3 (25% of domestic effluent) and T_4 (control, pond water). The whole set of experiment was carried out in 3 replications in CRD. The analysis of effluent (100%) indicated pH in the range of 5.92 - 6.84, As content below permissible level, Cd, Cr, Cu, Fe and Pb content above permissible level except for pond water, high, Hg content (much above the permissible level) and negligible amount of Ni. Statistically, lowest number of flowers and lowest number of fruits were recorded at treatment T_4 (control, pond water) as compared to domestic effluent. Lowest leaf area was recorded at treatment T_4, respectively. Lowest plant height was recorded in treatment T_4, respectively. The number of branches varied from 2-3. The highest tomato fruit weight and yield was recorded in treatment T_1, respectively. The As, Cd, Cr, Cu and Pb content was below permissible level, whereas, Fe content was above the permissible level for soil and Ni was negligible. Heavy metal contents for tomato leaves and fruits was below the permissible level. The N, P, K values for soil, leaves and fruits of tomato varied, respectively.

Keywords: Heavy metal, effluent, heavy metal accumulation

Introduction
Water is a vital and precious Natural Resource which forms the basis of life. It is the median for development of civilizations all over the world and plays vital role in socio-economic development of a country. Water has become of serious economic, social and political concerns since last two decades due to its reduced availability and requirement in various sectors. Irrigation of crops with effluents is a very common practice in India due to scarcity of water for irrigation (Sharma *et al.*, 2007, Arora *et al.*, 2008) [37, 3]. Effluent is defined as wastewater treated or untreated that flows out of a treatment plant, sewer or industrial outflow (USEPA, 2006) [47]. Apart from domestic wastewater, application of wastewater/ effluents from agro industrial units, distillers and domestic or municipal effluents in agriculture is a common practice in many parts of the world. There are beneficial and damaging effects of wastewater irrigation on crops including vegetables (Ramana *et al*., 2002; Saravanamoorthy and Ranjitha-Kumari, 2007) [31]. Vegetables constitute an important part of the human diet since they contain carbohydrates, proteins, vitamins, minerals and fibers required for human health. Tomato (*Lycopersicum esculentum* L.) is one of the most widely grown crops in the world, with global tomato production exceeding 141 million tonnes yr^{-1} (Faostat, 2009) [9]. Himachal Pradesh is well known for off-season commercial vegetable crop production viz., tomato, cauliflower, cabbage, peas, potato etc.

Materials and methods
Four to five week old seedlings of tomato (*Solanum lycopersicum*) variety-Solan Lalima were procured from the Department of Vegetable Science, Dr Y.S. Parmar university of Horticulture and Forestry, Nauni-Solan, H.P. and planted in pots of 16 kg capacity in the month of April. The pots were filled with planting materials i.e. sand, soil and FYM in the ratio 1:1:1. The seedlings were irrigated daily with pond water until their establishment. The seedling took approximately one month for the establishment. Domestic effluent was collected from domestic treatment plant Nauni, Solan. The effluents were further diluted with water for preparing working concentrations. The quantity of effluents required for irrigating per pot was standardized according to the capacity of the soil per pot. The whole set of experiment was laid in three replications.

The effluent treatments were given twice in every week for 3 months, after the establishment of the seedling. The effluents were analysed for various biochemical and morphological parameters.

Biochemical parameters

pH was estimated in 1:2 soil water suspension (Jackson, 1973) [13] by using microprocessor based pH meter (Model 510 of EIA make), turbidity was measured by using nephlometeric turbidity meter and expressed as (NTU) nephlometric turbidity unit, electrical conductivity and total dissolved solids (TDS) was measured using microprocessor based conductivity meter (Model-1601 EIA make), alkalinity of the effluents was recorded by using titration method, BOD was estimated by using 5 day BOD test as per 5210 B method (APHA, 2011) [2], The COD was estimated by oxidizing the effluent sample with hot H_2SO_4 solution of potassium chromate with silver sulphate as the catalyst by using closed reflux colorimetric method as per 5220 D method (APHA, 2011) [2], the effluent samples were filtered with Whatman filter paper (No. 1). The samples for detection of heavy metal were prepared as per the digestion method of US-EPA 3050 B method (APHA, 2011) [2]. Heavy metals were estimated by using Inductively Coupled Plasma Emission Spectrometer-6300 DUO (ICAP-6300 Duo), concentration expressed as mg kg^{-1}.

Studies on morphological parameter of tomato irrigated with domestic effluent

Various morphological parameters and quality parameters of the tomato plant viz., leaf area, plant height, number of branches, average fruit weight, yield/plant, heavy metals and mineral elements were studied. Randomly five leaves were collected from each plant and leaf area was measured with leaf area meter (Model-LI-COR-3100), the values were expressed as average leaf area (cm^2). Plant height was measured at the end of the experiment from soil level to the highest tip of the plant and mean height was expressed in meters (cm), number of branches in each seedlings were counted at the end of the experiment, at every harvest total fruit/plant was weighed by using weighing balance and mean fruit weight was expressed in (g), total yield was calculated by adding the total weight of the fruit at each harvest/plant.

Studies on quality parameters of tomato irrigated with domestic effluents

Preparation of samples and detection of heavy metals in leaf/fruit

The samples for detection of heavy metals were prepared as per method of Singh *et al*. (2005) [39].

Detection of mineral elements in leaf and fruit of tomato

Total nitrogen was determined by microkjeldhal method (Jackson, 1973) [13] and expressed as (%), total phosphorus was determined by Vando-molybdo-phosphoric yellow colour method (Jackson, 1973) [13] and expressed as (%), total potassium was determined by flame photometer method (Jackson, 1973) [13] and expressed as (%).

Soil Analysis

Heavy metal estimation in soil

The samples were digested in nitric acid and hydrogen peroxide mixture by using US-EPA 3050 B method (APHA, 2011) [2] and heavy metals estimated by Inductively Coupled plasma Emission Spectrometer-6300 DUO (Model ICAP-6300 DUO), and concentration expressed as mg/kg.

Detection of mineral elements in soil

Available nitrogen was determined by alkaline potassium permanganate method (Subbiah and Asija, 1956) [44] and expressed as kg/ha, available phosphorus was determined by extraction with ammonium molybdate solution (Olsen *et al*., 1954) [25] and expressed as kg/ha, available potassium was determined by ammonium acetate method (Merwin and Peech, 1951) [22], estimated with a flame photometer and expressed as kg/ha.

Statiscal Analysis

The data generated in the study was analysed by using standard statistical procedure through CRD (Completely Randomised Design) as per method described by Cochran and Cox (1963) [8].

Results

Physico-chemical characteristics of domestic effluents

The physico-chemical analysis of the domestic effluents which were selected for the study is presented in Table 1. The pH was higher in domestic 6.57 than the pond water 6.5. The turbidity, EC, TDS, alkalinity and BOD values were more in the effluents as compared to the control i.e. pond water. Whereas, COD was less for domestic as compared to pond water (141.00). The arsenic (As), cadmium (Cd) and chromium (Cr) content was 0.12; 0.22 and 1.07 ppm in analyzed domestic, respectively. The As content was below the permissible level in domestic effluent (0.12 ppm). Whereas, the Cd content was above the permissible level except in control (pond water, 0.07 ppm). Similarly, Cr content was also above the permissible level except for pond water (0.07 ppm).

The copper (Cu), iron (Fe) and lead (Pb) content was 6.67; 21.20 and 0.77 ppm in domestic effluents, respectively. The Cu content was above the permissible level except for control (pond water, 0.07 ppm), also the Fe content was above the permissible level except for control, pond water (0.22 ppm). Similarly, Pb content was above the permissible level except for control, pond water (0.05 ppm). Among all the heavy metals, mercury (Hg) content was much above the permissible level (0.005 ppm) i.e 4.00 in domestic effluents, respectively as compared to 0.30 ppm in control (pond water).

Table 1: Physico-chemical characteristics of domestic effluents

Parameters	Domestic effluent (100%)	Control (pond water)	Permissible limits
pH	6.57	6.50	6.5
Turbidity (NTU)	21.24	10.62	1
EC (dSm^{-1})	1.99	0.36	2
TDS (mg/l)	161.00	88.32	1300
Alkalinity (mg/l)	360.00	198.00	200
BOD	36.00	20.00	20
COD	51.00	141.00	250

As (ppm)	0.12	0.02	0.2
Cd (ppm)	0.22	0.07	0.03
Cr (ppm)	1.07	0.07	0.3
Cu (ppm)	6.67	0.05	1.0
Fe (ppm)	21.20	0.22	0.3
Ni (ppm)	-1.04	0.07	0.2
Pb (ppm)	0.77	0.05	0.1
Hg (ppm)	4.00	0.30	0.005

Morphological parameters of tomato crop

Periodic variation in number of flowers and fruits under domestic effluent treatments in tomato crop and effect of domestic effluent treatments on various growth parameters of tomato

The data recorded on number of flowers per plant is presented in Table 2. Highest total number of flowers (48.29) were recorded at treatment T_3 (25% of domestic effluent). Whereas, lowest number of flowers (42.31) was recorded for treatment T_4 (control, pond water) which was statistically different from all other treatments. The data pertaining to number of fruits per tomato plant is presented in Table 2. Highest (67.30) total number of fruits were recorded in T_3(25% of domestic effluent). Whereas, the lowest (47.90) total number of fruits were recorded at T_4 (control, pond water) followed by T_1 (75% of domestic effluent) and T_2 (50% of domestic effluent). The data pertaining to leaf area, number of branches, plant height, average fruit weight and yield per plant for tomato crop is presented in Table 2. Highest leaf area (34.20 cm^2) was recorded in treatment T_1 (domestic effluent) followed by T_2 (50% of domestic effluent). Whereas, lowest leaf area of 16.50 cm^2 was recorded in T_3 (25% of domestic effluent).

Table 2: Periodic variation in number of flowers and fruits under domestic effluent treatments in tomato crop and effect of effluent treatments on various growth parameters of tomato

Treatments Parameters							
	Total No. of Flowers	**Total No. of fruits**	**Leaf area (cm^2)**	**Plant height (cm)**	**Number of branches**	**Average fruit weight (g)**	**Yield/ plant (g)**
T_1(Domestic effluent75%)	44.98	50.30	34.20	108.70	3.00	47.96	293.60
T_2(Domestic effluent 50%)	47.30	55.60	30.80	131.70	3.00	52.33	379.50
T_3(Domestic effluent 25%)	48.29	67.30	16.50	138.70	3.00	86.04	699.00
T_4 (Control, pond water)	42.31	47.90	22.90	92.00	2.66	71.98	558.80
$CD_{0.05}$	1.08	1.11	2.38	28.51	1.10	32.04	151.50

Whereas, lowest plant height of 92.00 cm was recorded in T_4 (control, pond water) which was statistically at par with treatments T_1 (75% of domestic effluent), respectively. The mean number of branches in tomato crop irrigated with different effluent treatments varied from 2-3 (Table 2). Lowest number of branches (2.66) was recorded in treatments T_4 (control, pond water). Thus, from the data it is evident that there was no significant impact of effluent treatment when compared with control on number of branches beared by tomato.

The observations recorded on average weight of fruits of tomato crop irrigated with different effluents (Table 2) indicated that the fruit weight varied from 47.96 g to 86.04 g. Highest fruit weight 86.04 g was recorded in treatment T_3 (25% of domestic effluent). Whereas, the lowest fruit weight (47.96 g) was recorded at T_1 (75% of domestic effluent). The total yield (g) per individual tomato plant when irrigated with domestic effluent treatments was calculated after harvest (Table 2). The average yield/tomato plant varied from 293.60 to 699.00 g. The highest yield of 699.00 g was recorded in treatment T_3 (25% of domestic effluent). Lowest yield of 293.60 g was recorded for treatment T_1 (75% of domestic effluent).

Effect of domestic effluents on status of heavy metals and mineral nutrients in soil, leaves and fruits

The data presented in Table 3, shows status of heavy metals in soil of tomato pot plants when irrigated with different dilution of domestic effluents. The arsenic content in soil ranged from 0.02 to 0.07, highest (0.07 ppm) being at treatment T_1 (75% of domestic effluent) whereas, lowest As content (0.02 ppm) was recorded in T_3 (25% of domestic effluent) and T_4 (control, pond water). The Cd values in soil ranged from 0.02 to 0.05 ppm. Highest Cd content (0.05 ppm) was recorded in treatment T_1 (75% of domestic effluent) which was followed by T_2 (50% of domestic effluent, 0.05 ppm) whereas, lowest (0.02 ppm) was recorded at treatments T_4 (control, pond water). The chromium (Cr) content in the soil varied from 0.02 to 0.50 ppm. Statistically highest Cr content (0.50 ppm) was recorded at T_1 (75% of domestic effluent) followed by T_2 (50% of domestic effluent), T_3 (25% of domestic effluent) whereas, statistically the lowest Cr content (0.02 ppm) recorded at T_4(control, pond water). Similarly Cu content of 0.95 ppm was recorded highest at treatment T_1 (75% of domestic effluent) followed by T_2 (50% of domestic effluent) and lowest Cu content of 0.37 ppm was recorded at T_4 (control, pond water). Highest Fe content (29.15 ppm) was recorded at treatment T_1 (75% of domestic effluents) whereas, statistically lowest Fe content (2.77 ppm) was recorded at treatment T_4 (control, pond water). The soils samples for all the treatments were also analyzed for heavy metals but negligible content of Nickel (Ni) was recorded in all the analysed effluents (100% concentration). The lead (Pb) content in the soils ranged from 0.10 to 0.60 ppm. Statistically, highest Pb content (0.60 ppm) was recorded at treatments T_1 (75% of domestic effluent) followed by T_2 (50% of domestic effluent, 0.50 ppm) whereas, lowest Pb content (0.10 ppm) was observed at T_4 (control, pond water), respectively. The mercury (Hg) contents in the soils of tomato crop when irrigated with effluents ranged from 1.17 to 2.05 ppm. Highest Hg (2.05 ppm) was recorded at treatment T_1 (75% of domestic effluent) which was statistically at par with T_2 (50% of domestic effluent, 1.70 ppm), whereas, lowest Hg (1.17 ppm) was recorded at T_4 (control).

Table 3: Effect of domestic effluents on status of heavy metals and mineral nutrients in soil, leaves and fruits

Treatments	Heavy metals in soil (ppm)								Mineral nutrients (Kg/ha)		
	As	Cd	Cr	Cu	Fe	Ni	Pb	Hg	N	P	K
T_1 (Domestic effluent 75%)	0.07	0.05	0.50	0.95	29.15	-0.90	0.60	2.05	227.00	9.14	128.10
T_2 (Domestic effluent 50%)	0.05	0.05	0.45	0.70	26.45	-0.10	0.50	1.70	288.00	11.33	128.90
T_3 (Domestic effluent 25%)	0.02	0.02	0.30	0.67	27.3	-0.07	0.47	1.22	309.40	22.85	129.00
T_4 (Control, pond water)	0.02	0.02	0.02	0.37	2.77	0.05	0.10	1.17	222.90	5.79	120.00
$CD_{0.05}$	0.02	0.02	0.15	1.32	4.23	0.17	0.71	0.54	4.18	1.46	1.43
Treatments	Heavy metals in leaves (ppm)								Mineral nutrients (%)		
	As	Cd	Cr	Cu	Fe	Ni	Pb	Hg	N	P	K
T_1 (Domestic effluent 75%)	0.07	0.05	0.40	0.55	30.52	-0.22	0.55	1.57	2.62	0.72	2.46
T_2 (Domestic effluent 50%)	0.02	0.02	0.37	0.47	20.87	-0.07	0.55	1.37	2.76	0.78	2.51
T_3 (Domestic effluent 25%)	0.02	0.02	0.12	0.20	15.17	-0.77	0.35	0.95	2.81	0.86	2.58
T_4 (Control, pond water)	0.05	0.22	0.02	0.05	0.22	-0.22	0.17	0.15	2.61	0.76	2.50
$CD_{0.05}$	0.05	0.24	0.21	0.22	6.55	2.68	0.40	0.60	0.15	0.03	0.09
Treatments	Heavy metals in fruits (ppm)								Mineral nutrients (%)		
	As	Cd	Cr	Cu	Fe	Ni	Pb	Hg	N	P	K
T_1 (Domestic effluent 75%)	0.02	0.02	0.30	0.25	2.82	-0.12	0.37	1.05	2.49	0.60	2.22
T_2 (Domestic effluent 50%)	0.02	0.02	0.07	0.12	2.27	-0.30	0.25	0.25	2.70	0.68	2.37
T_3 (Domestic effluent 25%)	0.02	0.02	0.02	0.02	1.55	-0.02	0.05	0.12	2.78	0.79	2.46
T_4 (Control, pond water)	0.02	0.02	0.02	0.02	0.05	-0.02	0.02	0.02	2.62	0.62	2.21
$CD_{0.05}$	0.02	0.02	0.11	0.15	1.25	0.02	0.13	0.41	0.15	0.07	0.05

The data presented in Table 3 shows the effect of domestic effluent on status of heavy metals in leaves of tomato crop. The arsenic content in leaves ranged from 0.02 to 0.07 ppm, highest (0.07 ppm) being at treatment T_1 (75% of domestic effluent) whereas, lowest As content (0.02 ppm) was recorded in T_2 (50% of domestic effluent) which was statistically at par with T_3 (25% of domestic effluent, 0.02 ppm) andT_{13} (control, 0.05 ppm), respectively. The Cd values in leaves ranged from 0.02 to 0.22 ppm. Highest Cd content (0.22 ppm) was recorded in treatment T_4 (control, pond water) whereas, lowest Cd content (0.02 ppm) was recorded at treatments T_2 (50% of domestic effluent) which was statistically at par with T_3 (25% of domestic effluent, 0.02 ppm and T_1 (75% of domestic effluent, 0.05 ppm), respectively. The chromium (Cr) content in the leaves varied from 0.02 to 0.40 ppm. Highest Cr content (0.40 ppm) was recorded at T_1 (75% of domestic effluent) followed by T_2 (50% of domestic effluent, 0.37 ppm) whereas, the lowest Cr content (0.02 ppm) recorded at T_4 (control) was statistically at par with T_3 (25% of domestic effluent, 0.12 ppm), respectively.

Statistically, Cu content was recorded highest (0.55 ppm) at treatment T_1 (75% of domestic effluent) whereas, lowest Cu content of 0.05 ppm was recorded at T_4 (control) which was statistically at par with T_3(25% of domestic effluent), respectively. The iron (Fe) content in leaves varied from 0.22-30.52 ppm. Statistically highest Fe content (30.50 ppm) was recorded at treatment T_1 (75% of domestic effluents) followed by T_2 (50% of domestic effluent) whereas, lowest Fe content (0.22 ppm) was recorded at treatment T_4 (control, pond water), respectively. The leaves samples for all the treatments were also analyzed for heavy metals but contents of Nickel (Ni) was recorded negligible. The lead (Pb) content in the leaves ranged from 0.17 to 0.55 ppm. Highest Pb content (0.55 ppm) was recorded at treatments T_1 (75% of domestic effluent) which was statistically at par with T_2 (50% of domestic effluent) and T_3 (25% of domestic effluent) whereas, lowest Pb content (0.17 ppm) was observed at T_4 (control, pond water). The mercury (Hg) contents in the leaves of tomato ranged from 0.15 to 1.57 ppm. Highest Hg (1.57 ppm) was recorded at treatment T_1 (75% of domestic effluent) which was statistically at par with T_2 (50% of domestic effluent) whereas, lowest Hg (0.15 ppm) was recorded at T_4 (control, pond water), respectively.

The arsenic content in fruits was 0.02 ppm in all the concentration and control. The Cd values in fruits was also 0.02 ppm. The chromium (Cr) content in the fruits varied from 0.02 to 0.30 ppm. Highest Cr content (0.30 ppm) was recorded at T_1 (75% of domestic effluent) which was statistically at par with T_2 (50% of domestic effluent) whereas, the lowest Cr content (0.02 ppm) recorded at T_4 (control), respectively. Statistically, Cu content was recorded highest (0.25 ppm) at treatment T_1 (75% of domestic effluent) followed by T_2 (50% of domestic effluent) whereas, lowest Cu content of 0.02ppm was recorded at T_4 (control) which was statistically at par with all the effluent treatments except T_1 (75% of domestic effluent), respectively. The iron (Fe) content in fruits varied from 0.05-2.82 ppm. Statistically, highest Fe content (2.82 ppm) was recorded at treatment T_1 (75% of domestic effluents) followed by T_2 (50% of domestic effluent) and T_3 (25% of domestic effluent) whereas, lowest Fe content (0.05 ppm) was recorded at treatment T_4 (control, pond water), respectively. The fruit samples for all the treatments were also analyzed for heavy metals but contents of Nickel (Ni) was recorded negligible. The lead (Pb) content in the fruits ranged from 0.02 to 0.37 ppm. Highest Pb content (0.37 ppm) was recorded at treatments T_1 (75% of domestic effluent) followed by T_2 (50% of domestic effluent) and T_3 (25% of domestic effluent) whereas, lowest Pb content (0.02 ppm) was observed at T_4 (control, pond water), respectively. The mercury (Hg) contents in the fruits of tomato ranged from 0.02 to 1.05 ppm. Statistically, highest Hg (1.05 ppm) was recorded at treatment T_1 (75% of domestic effluent) followed by T_2 (50% of domestic effluent) and T_3 (25% of domestic effluent) whereas, lowest Hg (0.02 ppm) was recorded at T_4 (control, pond water) which was statistically at par with all the treatments except T_1 (75% of domestic effluent), respectively.

The data presented in Table 3 represented the effect of domestic effluent treatments on N, P, K content in soil, leaves and fruits of tomato crop. Statistically highest nitrogen content of 309.40 kg/ha was recorded at treatment T_3 (25% of domestic effluent) followed by T_2 (50% of domestic effluent) whereas, lowest nitrogen content of 222.90 kg/ha was recorded at treatment T_4 (control, pond water), respectively. Statistically, highest phosphorous content of 22.85 kg/ha was recorded at T_3 (25% of domestic effluent) whereas, lowest phosphorous content of 5.79 kg/ha was recorded at treatment T_4 (control, pond water), respectively. Statistically, highest potassium content of 129.00 kg/ha was recorded at T_3 (25% of domestic effluent) whereas, lowest potassium content of 120.00 kg/ha was recorded at T_4 (control, pond water), respectively.

Highest nitrogen content (2.81%) in leaves were recorded in treatment T_3 (25% of domestic effluent) which was statistically at par with treatments T_2 (50% of domestic effluent). Whereas, lowest nitrogen content were recorded in treatment T_4 (control, 2.61%) which was statistically at par with treatment T_1 (75% of domestic effluent). Similarly, highest phosphorus content (0.86%) was recorded in treatment T_3 (25% of domestic effluent) whereas, statistically lowest phosphorus content (0.72%) was recorded in treatment T_1 (75% of domestic effluent), respectively. Statistically, highest potassium content (2.58%) was recorded in treatment T_3 (25% of domestic effluent) whereas, lowest potassium content (2.46%) was recorded in treatment T_1 (75% of domestic effluent).

In fruits of tomato crop, highest nitrogen content (2.78%) was recorded in treatment T_3 (25% of domestic effluent) which was statistically at par with treatment T_2 (50% of domestic effluent) and T_4 (control, 2.62%). Whereas, lowest nitrogen content were recorded in treatment T_1 (75% of domestic effluent). Similarly, highest phosphorus content (0.79%) was recorded in treatment T_3 (25% of domestic effluent) whereas lowest phosphorus content was recorded at treatment T_1 (75% of domestic effluent). The highest potassium content (2.46%) was recorded in treatment T_3 (25% of domestic effluent) whereas, lowest potassium content was recorded in treatment T_4 (control), respectively.

Discussion

Physico-chemical characteristics of domestic effluents

These findings are in confirmation with the findings of Somashekar *et al*. (1984) [43] who reported high levels of BOD, COD, dissolved solids, suspended solids and residual chlorine as compared to ISI standard. Further, the pH of all the effluents was on alkaline side in the automobile industry situated close to Mysore (Karnataka). Turbidity in water is caused by the presence of suspended matter such as clay, silt, finely divided organic/inorganic matter plankton and other microscopic organisms (Mishra, 2010) [23]. High turbidity values are in agreement with the results of Gupta *et al*. (2013). Similarly, Vaidhyanathan *et al.* (1995) [48] reported pH in the range of 4-4.2 and Vasanthy *et al*. (2004) [49] recorded 5 pH for untreated and 6.8 pH for treated wastewater as compared 6.84 reported in the present study.

Periodic variation in number of flowers and fruits under domestic effluent treatments in tomato crop and effect various growth parameters of tomato

Detrimental effect of industrial effluents on the flowering of okra (*Abelomoschus esculentus*) with mean values for fruit numbers 3 has been reported by (Uaboi-Egbennai *et al*., 2009) [46]. The present study find support from the study of Rajan and Periyasamy (2013) [29] who reported declined trend in number of fruits with increase in the quantity of the electroplating industry effluent residue (500–2500 mg, 12.33±1.15–7.67±0.58), as compared to control (13.67±1.53). Detrimental effect of industrial effluent on the fruiting of okra (*A. esculentus*) with mean number of fruits viz., 4, 4, 3, 4, 3, 9 for main drain, detergent bar, toiletries, paint, plastic and control, respectively has been reported by (Uaboi- Egbenni *et al*., 2009) [46]. These findings are in confirmation with the findings of Magre and Khillare (2016) [19] reported decrease in the number of fruits of tomato crop when irrigated with 20, 40, 60 and 80 per cent concentrations of tannery effluents i.e 5±0.258, 3±0.167, 2±0.14 as compared to control 6±0.258. Similarly in an study on effect of different quantities viz., 0, 200, 400, 600, 800, 1000 and 1200 mg of dyeing industrial effluent residue on number of fruits on brinjal (*Solanum melongena*) on 90th day, the number of fruits decreased with increasing concentration of residues i.e 1.0, 1.0, 1.0, 0.0, 0.0 and 0.0 respectively (Rajan *et al*., 2013) [29]. Similar to present findings, the reduction in leaf area index of brinjal at higher concentration 1200 mg was 12 cm^2 as compared to 50 cm^2 in control of dyeing industrial effluent residues (Rajan *et al*. 2013) [30]. Whereas, at 25 per cent of tannery effluent treated plant showed an increase leaf area of tomato (Karunyal *et al*., 2000) [15]. In general with application of increasing concentrations of effluents there was increase in plant height of the crop. Similar to present findings, the decrease in plant height for industrial effluent as compared to control observed in the present study can be support from the findings of Magre and Khillare (2016) [19] who reported decrease in the plant height of tomato crop when irrigated with 20, 40, 60 and 80 per cent concentrations of tannery effluents i.e. 54.8±0.514, 50.1±0.305, 46.3±0.217 and 25.9±0.94, respectively as compared to control 60.7±0.728. Whereas, Medhi *et al*. (2011) [21] reported that plant height of mustard and pea crop showed an increased trend up to 30 per cent concentration of paper mill effluent applied on soil and thereafter, gradually decreased, which supports the present results of increase in plant height with decrease in concentration of the effluents in all the treatments. These findings are in confirmation with the findings of Aliello *et al*. (2007) [1] who reported highest yield obtained for tomato crop (variety 'Missouri') irrigated with fresh water than irrigated with wastewater. Rajan and Periyasamy (2013) [29] also reported reduction in the yield of tomato with the increase in the quantity of electroplating industry effluent residue. Similarly, Yakasai *et al.* (2015) [52] also reported that the wheat plants which were grown near the source of industrial pollution had decreased growth and yield, as well disorder of biochemical parameters.

Effect of effluent on status of heavy metals and available n, p and k in soils, leaves and fruits

These findings are in confirmation with the findings of Kashyap. (2015) [16] who revealed that there was significant increase in the content of Cu (81.62%) at (P>1%), Fe (79.62%), Zn (90.73%), Cd (98.99%), Pb(95.91%), Ni (98.40%), Cr (97.54%) at (p>0.1%) in the soil irrigated with paper mill effluent as compared to soil irrigated with pond water (control). Singh and Kansal (1983) [41] reported that the use of sewage water for irrigation substantially increased the accumulation of DTPA extractable Zn, Cu, Pb and Cd in soils of different cities of Punjab. The accumulation was higher in soils receiving sewage water of industrial cities. Kumar and Chopra (2013) [27] also reported that the content of heavy metals were increased significantly from their initial (control) level to 100 per cent of sewage sludge i.e (2.55-12.75, 0.88-9.36, 0.09-8.59, 2.42-14.28, 0.12-6.75 and 0.18-5.88). In leaves**,** the findings are in confirmation with the findings of Kumar and Chopra (2013) [18] who reported that highest concentrations of Fe and Zn was found in the leaves (12.88 mg g^{-1} and 9.66 mg g^{-1}) while the least (8.36 mg g^{-1} and 5.44 mg g^{-1}) in the fruits of *P. vulgaris* at 100 per cent of sewage sludge. Similarly, Pathak *et al*. (2013) [27] reported that their was increased in the ratio of heavy metals as the dilution increased in the leaves of B. juncea grown in paper mill effluent and bore well water irrigated soil i.e. 10 per cent, 25 per cent, 50 per cent, 75 per cent and 100 per cent (Pb, 9.21-42.66; Cr, 13.55-39.80; Cd, 1.34-5.84; Ni, 30.06-88.64). Farooq *et al*. (2008) also reported that the concentration of Pb in the leaves of spinach, coriander, lettuce, radish, cabbage and cauliflower from the vicinity of industrial areas were 2.251, 2.652, 2.411, 2.035, 1.921 and 1.331 mg kg^{-1}, respectively. In fruits, the findings are in confirmation with the findings of Singh and Kansal (1983) [41] and Schirado *et al*. (1986) [36] who reported the effect of wastewater on maize, berseem, cauliflower and spinach. And found considerably higher concentrations of Fe, Mn, Zn, Cu, Pb and Cd than those soils irrigated with tube well water. Similarly, under acidic conditions, elements such as Fe, Al, Mn and the heavy metals (Zn, Cu, Pb and Cr) become highly soluble and may create problems for vegetation (Charman and Murphy, 1991) [7]. This is also agreement with what was reported by other workers that organic wastes contain high amounts of micronutrients and heavy metals (Roy *et al*., 2007) [33]. Singh *et al*. (1991) [42] also reported that heavy metals (Pb, Zn, Cd) are known to inhibit wheat growth and cause the decrease of crop. However, the observed differences in the metal accumulation in the different parts of the plant suggest cellular mechanisms of metal bioaccumulation, which may control their translocation and partitioning in the plant (Bradford *et al*., 1975) [5]. Fe, Zn and Cu are associated with the photosynthesis (Porra, 2002) [28].

Kaistha *et al.* (1990) [14] also reported low to medium available N in some soils of Kangra district of Himachal Pradesh. Similar results were recorded by Verma and Tripathi (1982) [51], Sharma and Kumar (2003) [38] and Pal *et al*. (2013) [26]. Verma *et al.* (1985) [50] also reported that potassium content in the soils of Himachal Pradesh varies from 40.26 to 1507.00 kg/ha. Similar results were worked out by Khan *et al*. (1997) [17]. The available P was less which might be due to the higher organic matter content in surface soils of region (Ghosh *et al*., 1981) [11]. In the light of suggested critical limits soils of the studied area were rated low in their available P status. Similar results were also reported by Singh and Singh (2005) [40].

Whereas, in leaves, the observations are in agreement with those made by Thakur (1979) [45] and Campbell (2000) [6]. Maheswarapa *et al*. (2001) [20] reported that N content was higher in plants treated with FYM + NPK compared with NPK alone. Similarly, the increase in fruit nutrient element content of N, P and K with increasing levels of fertilization has also been reported by Rao and Seth (1959) [32] and Mortley *et al.* (1991) [24].

In fruits of tomato crop, this may be attributed to the fact that the amount of nutrients taken up by the plants primarily depends upon the concentration of these nutrients in the close proximity of the root surface (Black, 1968; Russell, 1973) [4, 34].

References

1. Aliello R, Cirelli GL, Consoli S. Effects of reclaimed wastewater irrigation on soil and tomato fruits: A case study in Sicily (Italy). Agricultural Water Management. 2007; 93:65-72.
2. APHA. Standard methods for examination of water and wastewater. 20th ed. American Public Health Association, American water works association and water environment federation, Washington, DC New York, 2011.
3. Arora M, Kiran B, Rani A, Rani S, Kaur B, Mittal M. Heavy metal accumulation in vegetables irrigated with water from different sources. Food Chemistry. 2008; 111:811-815.
4. Black CA. Soil Plant Relationship. Second Ed. John Wiley and Sons Inc. New York, 1968.
5. Bradford GR, Page AL, Lund LJ, Olmstead W. Trace element concentrations of sewage treatment plant effluents and sludges; their interactions with soils and uptake by plants. Journal of Environmental Quality. 1975; 4:123-127.
6. Campbell CR. Reference sufficiency ranges for plant analysis in the southern region of the United States. Southern Cooperative Series Bulletin, 2000, 79-80.
7. Charman PEV, Murphy BW. In: Soils: Their Properties and Management. In a soil Conservation Handbook for New South Wales. Sydney University Press. Sydney, 1991.
8. Cochran GC, Cox GM. Experimental designs. Asia publishing house, Bombay, 1963, 611p.
9. Faostat. 2009. http://www.Faostat.fao.org/site/567/Desktopdefeult.aspx?PageID=567#ancor.
10. Farooq M, Anwar F, Rashid U. Appraisal of heavy metals in different vegetables grown in the vicinity of an industrial area. Pakistan Journal of Botany. 2008; 60:633.
11. Ghosh SC, Amanwar PK, Sachan RS, Sharma RB. Reserves of organic and total P in cultivated and forested mollisoils. Journal of the Indian Society of Soil Science. 1981; 29:332-336.
12. Gupta S, Satpati S, Nayek S, Garai D. Effect of wastewater irrigation on vegetables in relation to bioaccumulation of heavy metals and biochemical changes. Environmental Monitoring and Assessment. 2010; 165:169-177.
13. Jackson ML. Soil chemical analysis. New Delhi, Prentce Hall of India. Pvt. Ltd, 1973, 189p.
14. Kaistha BP, Sood RD, Kanwar BS. Distribution of nitrogen in some forest soil profiles of north western Himalayan region. Journal of the Indian Society of Soil Science. 1990; 38(1):15-20.
15. Karunyal S, Renuga G, Kailash P. Effects of tannery effluent of seed germination, leaf area, biomass and mineral content of some plants. Bioresource Technology. 2000; 47:215-218.
16. Kashyap R. Phytoextraction and bioconcentration of heavy metals by *Spinacia oleracea* grown in paper mill effluent irrigated soil. Thesis Dr Y.S Parmar University of Horticulture and Forestry, Nauni, Solan (H P), 2015.
17. Khan ZH, Mazumdar AR, Hussain MS, Mohiuddin ASM. Total and DTPA-extractable Fe, Mn, Cu and Zn content in some soils of Bangladesh. Journal of the Indian Society of Soil Science. 1997; 45(3):485-489.
18. Kumar V, Chopra AK. Accumulation and translocation of metals in soil and different parts of French bean (*Phaseolus vulgaris* L.) amended with sewage sludge. Bulletin of Environmental Contamination and Toxicology. 2013; 10:1142.
19. Magre MR, Khillare YK. Effect of tannery industry effluent on germination and growth of tomato plant. World Journal of Pharmacy and Pharmaceutical Sciences. 2016; 5(2):1064-1074.
20. Maheswarapa HP, Nanjappa HV, Hegde MR, Biddappa CC. Nutrient content and uptake by arrowroot (*Maranta arundinacea*) as influenced by agronomic practices when

grown as intercrop in coconut (*Cocos nucifera*) garden. Indian Journal of Agronomy. 2001; 45(1):86-91.
21. Medhi UJ, Talukdar AK, Deka S. Impact of paper mill effluent on growth and development of certain agricultural crops. Journal of Environmental Biology. 2011; 32:185-188.
22. Merwin HD, Peech PM. Exchangeability of soil potassium in the sand by nature of complimentary exchangeable cation. Journal of Soil Science Society of America. 1951; 15:125-128.
23. Mishra RK, Patel JH, Baxi VR. Reuse potential of laundry greywater for irrigation based on growth, water and nutrient use of tomato. Journal of Hydrology. 2010; 386(1):1-13.
24. Mortley DG, Smith CB, Demchak K. Fertilizer placement affects growth, fruit yield and elemental concentrations and contents of tomato plants. Journal of American Society of Horticulture Science. 1991; 116:659-662.
25. Olsen SR, Cole CV, Watanabe FS, Dean LA. Estimation of available phosphorus by extraction with sodium bicarbonate, U S Dept. Journal of Agriculture and Food Chemistry. 1954, 939p.
26. Pal S, Panwar P, Bhardwaj DR. Soil quality under forest compared to other land-uses in acid soil of north western Himalaya, India. Annals of Forest Research. 2013; 56(1):187-198.
27. Pathak C, Chopra AK, Srivastava S. Accumulation of heavy metals in Spinacia oleracea irrigated with paper mill effluent and sewage. Environmental Monitoring Assessment, 2013, 8-14.
28. Porra RJ. The chequered history of the development & use of simultaneous equations for the accurate determination of chlorophyllys a and b. Photosynthesis Research. 2002; 73:149-156.
29. Rajan MR, Periyasamy M. Impact of zinc electroplating industry effluent residue on growth, biochemical charecteristics and yield of tomato *Lycopersicom esculentum.* Indian Journal of Applied Research. 2013; 3(12):2249-2555.
30. Rajan MR, Nisath FU, David NS. Impact of dyeing industry effluent residue on growth, biochemical characteristics and yield of brinjal *Solanum melongena*. Indian Journal of Applied Research. 2013; 3(4):2249-2555.
31. Ramana S, Biswas AK, Kundu S, Saha JK, Yadav RBR. Effect of distillery effluent on seed germination in some vegetable crops. Bioresourse Technology. 2002; 82:273-275.
32. Rao Sundara WVP, Seth SP. The effect of fertilizer treatment on the yield. Composition and total uptake of the nutirients by tomato. Indian Journal of Agronomy. 1959; 3:3.
33. Roy PR, Prasad J, Joshi AP. Effect of sugar factory effluent on some physic-chemical properties of soils- A case study. Journal of Environmental Science & Engineering. 2007; 49(4):277-282.
34. Russell EW. Soil Conditions and Plant Growth, 10th ed. London: Longman, 1973.
35. Saravanamoorthy MD, Kumari R. Effect cotton yarn dye effluent on physiological and biochemical content of peanuts and green gram. Biochemical cell Archs. 2005; 5(1):113-117.
36. Schirado T, Vergara I, Schalscha EB, Pratt PF. Evidence for movement of heavy metals in a soil irrigated with untreated wastewater. Journal of Environmental Quality. 1986; 15:9-12.
37. Sharma RK, Agrawal M, Marshall FM. Heavy metals contamination of soil and vegetables in suburban areas of Varanasi, India. Ecotoxicology and Environmental Safety. 2007; 66:258-266.
38. Sharma VK, Kumar A. Characterization and classification of the soils of upper Moul khad catchment in wet temperate zone of Himachal Pradesh. *Agropedology*. 2003; 13(2):39-41.
39. Singh AP, Singh R. Effect of paper mill effluent on soil properties and performance of maize in mollisols of Uttaranchal. Journal of the Indian Society of Soil Science. 2005; 55: 267-269.
40. Singh D, Choonkar PK, Dwivedi BS. Manual on soil, plant and water analysis. New Delhi, 2005, 78-79.
41. Singh J, Kansal BD. Accumulation of heavy metals in soils receiving municipal waste water and effect of soil properties on their availability. In heavy metals in Environment CPC consultanls, Edinburg, U.K, 1983, 409-412.
42. Singh OV, Labana S, Pandey G, Budhiraja R, Jain RK. Phytoremediation: an overview of metallicion decontamination from soil. Applied Microbiology and Biotechnology. 1991; 61:405-412.
43. Somashekar RK, Gowda MTG, Shettigar SL, Nand Srinath KP. Effect of industrial effluent on crop plants. Indian Journal of Environmental Health. 1984; 26(2):136-146.
44. Subbiah BW, Asija GL. A rapid procedure for estimation of available nitrogen in soil. Current Science. 1956; 25:259-260.
45. Thakur NR. Nutritional status of cauliflower seed producing area of Himachal Pradesh. M.sc. Thesis. Department of Soil Science, CSK Himachal Pradesh Krishi Vishvadiyalaya, Palampur, India, 1979, 63.
46. Uaboi-Egbenni PO, Okolie PN, Adejuyitan OE, Sobande AO, Akinyemi O. Effect of industrial effluents on the growth and anatomical structures of *Abelmoschus esculentus* (okra). African Journal of Biotechnology. 2009; 8(14):3251-3260.
47. USEPA. Air Quality Criteria for Lead Final Report. U.S. Environmental Protection Agency, Washington, DC, EPA/600/R-05/144aF-bF, 2006.
48. Vaidhyanathan R, Meenambal T, Gokulda K. Biokinetics coefficients for the design of two stage anaerobic digester to treat distillery waste. Indian Journal of Environmental Health. 1995; 37(4):237-242.
49. Vasanthy AK, Rao R, Krishnan S. Comparitive effects of secondary treated wastewater irrigation on soil quality parameters under different crop types. The Affrican Journal of Plant Science and Biotechnology. 2004; 32(4):22-27.
50. Verma SD, Tripathi BR, Kanwar BS. Soils of Himachal Pradesh and their Management. Fertilizer Association of India, New Delhi, 1985, 149-163.
51. Verma TS, Tripathi BR. Relationship of micronutrient elements in soils growing rice. Journal of the Indian Society of Soil Science. 1982; 30(1):89-91.
52. Yakasai SM, Abubakar MM, Abba H. Effects of textile effluents on the growth of tomato and pepper plants in Kano Metropolis, Nigeria. International Journal of Scientific Engineering and Applied Science. 2015; 1(4):87-92.