

Original Research Article

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## Effect of Industrial and Distillery Effluents on *Spodoptera litura*

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### ABSTRACT

#### Keywords

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“Effect of industrial and distillery effluents on *Spodoptera litura*” 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 experiment comprised of 4 treatments viz., T<sub>1</sub> (75%), T<sub>2</sub> (50%), T<sub>3</sub> (25%) and T<sub>4</sub> (control, pond water). The As, Cd, Cr, Cu, Fe, Ni, Pb and Hg content in the 6<sup>th</sup> instar of *Spodoptera litura* varied, respectively. Larvae of *S. litura* were unable to complete their life cycle when fed on leaves of *S. lycopersicum* irrigated with treatments T<sub>1</sub>. Pupal and adult deformities were observed in treatments T<sub>2</sub>.

### Introduction

Water has become of serious economic, social and political concerns since last two decades due to its reduced availability and requirement in various sectors. Due to water scarcity, agricultural activities (using more than 50% of the total water resource extracted) are penalized. 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). Effluent is defined as wastewater treated or untreated that flows out of a treatment plant, sewer or industrial outflow (USEPA, 2006). There are beneficial and damaging effects of wastewater irrigation on crops including vegetables (Ramana *et al.*,

2002; Saravanamoorthy and Ranjitha-Kumari, 2007). Tomato (*Lycopersicon esculentum* Mill.) is one of the most widely grown crops in the world, with global tomato production exceeding 141 million tonnes yr<sup>-1</sup> (FAOSTAT, 2009). Heavy metals may move on to other organisms and through biomagnification enter in to food chain. Because insect behaviours are key contributors to the ecology of insect interactions with other plant and animal species, as well as with their abiotic environments, these behaviours are critical to the stability and diversity of ecosystems (Fishers, 1998). Among various insect pests attacking vegetable crops, *Spodoptera litura* Fabricius (Tobacco caterpillar) is cosmopolitan and polyphagous pest affecting

several crops like cotton, pulses, oilseed, vegetables, etc. all over the world and causing loss of agricultural production.

### **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. Industrial and distillery effluents were collected from industrial area Paonta Sahib (Jaimurti chemical Pvt Ltd), Sirmour and Mohan mekin distillery, Chamba Ghat, Solan and quality parameters studied. It was diluted with water for preparing working concentrations. The quantity of effluent treatments required 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 seedlings.

### **Analysis of effluent for quantity parameters**

pH was estimated in 1:2 soil water suspension (Jackson, 1973) by using microprocessor based pH meter (Model 510 of EIA make), turbidity was measured by using nephelometric turbidity meter and expressed as (NTU) nephelometric turbidity unit; electrical conductivity and total dissolved solids (TDS) were measured by microprocessor based conductivity meter (Model-1601 EIA make), alkalinity of the effluents was recorded by using titration method, BOD was estimated by 5 day BOD

test as per 5210 B method (APHA, 2011); COD was estimated by oxidizing the effluent sample with hot H<sub>2</sub>SO<sub>4</sub> solution of potassium chromate with silver sulphate as the catalyst by using closed reflux colorimetric method as per 5220 D method (APHA, 2011). 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) and estimated by using Inductively Coupled Plasma Emission Spectrometer-6300 DUO (ICAP-6300 Duo) and concentration expressed as mg kg<sup>-1</sup>. Except COD, TDS and Ni content all other parameters were above permissible level in industrial effluents, whereas in pond water which was used as control all the quality parameters except turbidity and mercury (Hg) content were below permissible level (Table 1). Therefore, the industrial effluent was further diluted to 75%, 50% and 25% and these concentrations used in the study.

### **Effect of effluent irrigation of tomato crop on *Spodoptera litura* (Tobacco caterpillar)**

The studies were conducted with the same set of experiment. Adults of *S. litura* collected manually from the field reared under laboratory conditions on castor leaves. For the study, freshly hatched larvae (10 larvae) were reared on tomato leaves collected from the plants treated with different effluent concentrations. The larval, pupal, adult and total developmental period, and any deformation during the life cycle of *S. litura* were recorded for each treatment.

### **Statistical 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).

## Results and Discussion

### Effect of industrial and distillery effluent treatments on total developmental period and heavy metals in *S. litura* infesting tomato crop

The incubation period and different developmental stages of *S. litura* which was reared under laboratory conditions on leaves of tomato plants, which were given different effluent treatments are presented in Table 2 and 3.

The incubation period in the treatments varied from  $2.66 \pm 0.33$  ( $T_1$  and  $T_3$ ) to  $3.33 \pm 0.33$  ( $T_2$ ) days. The incubation period in treatment  $T_2$  (50%) was greater than that in  $T_4$  (control). The larvae in treatments  $T_1$  (75% of industrial effluent) were not able to complete their normal larval period. Highest total larval period was recorded at treatment  $T_2$  (50% of industrial effluent,  $20.63 \pm 2.33$  days) whereas, lowest total larval period ( $18.29 \pm 2.33$  days) was recorded in treatment  $T_3$  (25% of industrial effluent).

In control ( $T_4$ ) the total larval period was of  $19.99 \pm 2.33$  days there was increase in total larval period at 50 per cent concentration of industrial and 75 per cent of industrial effluent as compared to control. Treatments  $T_3$  had higher pupal period than the control. No developmental period was recorded at treatments  $T_1$  (75% of industrial effluent), respectively. In control the total developmental period was of  $24.99 \pm 3.47$  days.

In Table 3, the incubation period in the treatments varied from  $2.66 \pm 0.33$  to  $3.00 \pm 0.00$  days. Lowest incubation period of  $2.66 \pm 0.33$  days was recorded at treatments  $T_1$  (75% of distillery effluent),  $T_2$  (50% of distillery effluent) and  $T_3$  (25% of distillery effluent). Whereas, highest incubation period of  $3.00 \pm 0.00$  days was recorded at treatment  $T_4$

(control, pond water). Thus there was decrease in incubation period as compared to control ( $T_4$ ) except for the treatments viz.,  $T_2$  (50% of industrial effluent) having  $3.33 \pm 0.33$  days as compared to  $3.00 \pm 0.00$  days in control. Highest total larval period was recorded at treatment  $T_4$  (control, pond water) whereas, lowest total larval period ( $18.29 \pm 2.33$  days) was recorded in treatment  $T_2$  (50% of distillery effluent). Highest pupal period was recorded in treatment  $T_1$  (75% of distillery effluent) whereas, lowest ( $7.33 \pm 0.33$  days) was recorded in treatment  $T_3$  (25% of distillery effluent), respectively. Treatments  $T_1$  had higher pupal period than the control. In control the total developmental period was of  $24.99 \pm 3.47$  days

The data presented in Table 3 shows the effect of distillery effluent on status of heavy metals in sixth instar of *Spodoptera litura*. The arsenic content in the body of *S. litura* ranged from 0.02 to 0.10 ppm, highest (0.10 ppm) was recorded at treatment  $T_1$  (75% of distillery effluent). Whereas, lowest As content (0.02 ppm) was recorded in  $T_3$  (25% of distillery effluent) which was statistically at par with all other treatments except  $T_1$  (75% of distillery effluent), respectively. The Cd values ranged from 0.02 to 0.10 ppm.

Highest Cd content (0.10 ppm) was recorded in treatment  $T_1$  (75% of distillery effluent) whereas, lowest Cd content (0.02 ppm) was recorded at treatments  $T_4$  (control, pond water). The chromium (Cr) content varied from 0.05 to 0.82 ppm. Highest Cr content (0.82 ppm) was recorded at  $T_1$  (75% of distillery effluent) whereas, statistically lowest Cr content (0.05 ppm) recorded at  $T_4$  (control), respectively. Statistically, Cu content was recorded highest (8.40 ppm) at treatment  $T_1$  (75% of distillery effluent) whereas, lowest Cu content of 2.52 ppm was recorded at  $T_4$  (control), respectively. The iron (Fe) content varied from 2.20-15.70 ppm.

**Table.1** Physico-chemical characteristics of industrial and distillery effluents

Parameters	Industrial (100%)	Distillery (100%)	Control (pond water)	Permissible levels
pH	6.72	6.84	6.50	6.5
Turbidity (NTU)	34.99	11.67	10.62	1.0
EC (dSm <sup>-1</sup> )	2.19	1.19	0.36	2.0
TDS (mg/l)	175.20	75.20	88.32	1300
Alkalinity (mg/l)	355.00	387.00	198.00	200
BOD	33.00	30.00	20.00	20
COD	248.00	74.00	141.00	250
As (ppm)	0.25	0.10	0.02	0.2
Cd (ppm)	0.25	0.22	0.07	0.03
Cr (ppm)	1.17	1.87	0.07	0.3
Cu (ppm)	7.35	6.35	0.05	1.0
Fe (ppm)	26.69	29.45	0.22	0.3
Ni (ppm)	-1.20	-1.02	0.07	0.2
Pb (ppm)	0.60	0.57	0.05	0.1
Hg (ppm)	8.87	8.57	0.30	0.005

**Table.2** Effect of effluent treatments on total developmental period of *S. litura* infesting tomato crop

Treatments	Incubation period (days)	Total larval period (days)	Pupal period (days)	Total developmental period (days)	Heavy metals (mg/l)							
					As	Cd	Cr	Cu	Fe	Ni	Pb	Hg
T <sub>1</sub> (Industrial effluent 75%)	2.66±0.33	-	-	-	0.07	0.07	0.55	3.60	19.60	0.02	0.77	1.00
T <sub>2</sub> (Industrial effluent 50%)	3.33±0.33	20.63±2.33	7.66±0.57	24.97±3.47	0.05	0.05	0.45	3.33	16.70	0.01	0.57	0.82
T <sub>3</sub> (Industrial effluent 25%)	2.66±0.33	18.29±2.33	10.00±0.33	26.29±3.47	0.04	0.05	0.42	3.30	16.42	0.01	0.52	0.55
T <sub>4</sub> (Control, pond water)	3.00±0.00	19.99±2.33	8.00±0.57	24.99±3.47	0.02	0.02	0.05	2.52	2.20	0.02	0.02	0.10
CD (0.05)	<b>0.01</b>					<b>0.03</b>	<b>0.09</b>	<b>1.69</b>	<b>2.03</b>	<b>0.01</b>	<b>1.10</b>	<b>0.41</b>

\* Pupal and Adult deformities observed

**Table.3** Effect of effluent treatments on total developmental period and status of heavy metals in sixth instar of *Spodoptera litura* infesting tomato crop

Treatments	Incubation period (days)	Total larval period (days)	Pupal period (days)	Total developmental period (days)	HEAVY METALS (mg/l)							
					As	Cd	Cr	Cu	Fe	Ni	Pb	Hg
T <sub>1</sub> (Distillery effluent 75%)	2.66±0.33	19.30±2.33	8.33±0.33	24.97±3.47	0.10	0.10	0.82	8.40	15.70	0.03	1.65	0.90
T <sub>2</sub> (Distillery effluent 50%)	2.66±0.33	18.29±2.33	7.66±0.33	23.29±3.47	0.04	0.10	0.60	3.60	13.60	0.02	0.69	0.32
T <sub>3</sub> (Distillery effluent 25%)	2.66±0.33	18.63±2.33	7.33±0.33	23.30±3.47	0.02	0.05	0.57	3.37	10.05	0.01	0.57	0.15
T <sub>13</sub> (Control, pond water)	3.00±0.00	19.99±2.33	8.00±0.57	24.99±3.47	0.02	0.02	0.05	2.52	2.20	0.02	0.02	0.10
CD (0.05)			<b>0.02</b>			<b>0.04</b>	<b>0.24</b>	<b>1.72</b>	<b>2.08</b>	<b>0.01</b>	<b>1.12</b>	<b>0.39</b>

\* Pupal and Adult deformities observed

Highest Fe content (15.70 ppm) was recorded at treatment T<sub>1</sub> (75% of distillery effluents) whereas, statistically lowest Fe content (2.20 ppm) was recorded at treatment T<sub>4</sub> (control, pond water), respectively. The nickel (Ni) content in the sixth instar of *S. litura* ranged from 0.00 to 0.02 ppm. Highest Ni content (0.03 ppm) was recorded at treatment T<sub>1</sub> (75% of distillery effluent) which was statistically at par with treatment T<sub>4</sub> (control, pond water, 0.03 ppm) whereas, lowest Ni content (0.00 ppm) which was statistically at par with treatment T<sub>2</sub> (50% of distillery effluent, 0.02 ppm) and T<sub>4</sub> (25% of distillery effluent, 0.02 ppm), respectively. The lead (Pb) content ranged from 0.02 to 1.65 ppm.

Highest Pb content (1.65 ppm) was recorded at treatments T<sub>1</sub> (75% of distillery effluent) whereas, lowest Pb content (0.02 ppm) was observed at T<sub>4</sub> (control, pond water), respectively. The mercury (Hg) contents ranged from 0.10 to 0.90 ppm. Highest Hg (0.90 ppm) was recorded at treatment T<sub>1</sub> (75% of distillery effluent) whereas, lowest Hg (0.10 ppm) was recorded at T<sub>4</sub> (control, pond water),

respectively. The present findings are in confirmation with the findings of Sildanchandra and Crane, (2000) who reported that high Cd concentration increases the larval duration of holometabolous insects. Significant prolongation of gypsy moth larval development was obtained after acute or chronic exposure to Cd at a concentration of 100µg/g (Ortel *et al.*, 1993; Gintenreiter *et al.*, 1993; Ilijin *et al.*, 2010). According to Barbosa *et al.*, (1983) chronic exposure of gypsy moth larvae to Cd or unstable host plant led to decrease in pupal duration.

These findings are in confirmation with the findings of Smith *et al.*, (2004) who observed that Zn@ 5mg Zn/dry food led to increase of developmental period of *Falsomia candida*. Zheng- Tian *et al.*, (2011) reported that Cd in food significantly led to increase in developmental period of *Pirata sub piraticus*. Heliovaara *et al.*, (1987) who reported that heavy metal concentrations in *Araduscin namomeus* were highest (Cd 17 µg g<sup>-1</sup>, Cu 1900 µg g<sup>-1</sup>, Ni 202 µg g<sup>-1</sup>, Pb 32 µg g<sup>-1</sup>) in the vicinity of the factor complex, and lowest in the



outermost zones. Variation in contents of various heavy metals in the body of 6<sup>th</sup> instar larvae of *S. litura* was observed in the present study. The insect was fed on tomato leaves irrigated with effluents containing varied heavy metal content with Pb and Hg above the permissible levels in some treatments of higher concentration. Studies on movement of heavy metals from the host plant to the herbivore level are reported (Vogel, 1986; Zvereva *et al.*, 2003). Insects living in polluted areas have shown accumulation of heavy metals particularly Ni and Cu (Zvereva *et al.*, 2003). Absorption of Cd and Hg by crops and accumulation in insects through food chain is reported (Devkota and Schmidt, 2000; Pedersen *et al.*, 2008) which supports the present findings of higher Cd and Hg levels as compared to control. Some levels of mineral elements are already present in the insect body e.g. Na, K, Ca, Mg, Fe, Zn, Cu and Mn in the level of 10.6, 30.2, 5.2, 15.9, 0.40, 0.68, 0.20 and 0.86 mg/100g, respectively are found in the body of white grubs normally. No nickel content was detected in effluents, soil and leaves of tomato fruit but in the larval body nickel content of 0.01-0.03 ppm was found, which could be normally present in its body. Accumulation of nickel in the body of *Spodoptera* 6<sup>th</sup> instar larvae when fed on artificially amended Ni diet has been reported Xia *et al.*, (2007). Biomagnifications of mercury (Hg), cadmium (Cd) and lead (Pb) through soil-plant, herbivorous insect and carnivorous insect food chain i.e. 0.18, 6.57, 7.88, for mercury: 6.82, 2.01, 0.48 and for cadmium: 1.47, 2.24 and 0.57, respectively has been investigated (Sheng Zhang *et al.*, 2009).

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