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# Influence of Water Quality on the Efficacy of Certain Insecticides on *Spodoptera litura* Fab. (Noctuidae: Lepidoptera)

**S V D Divya, P V Krishnayya, T Madhumathi, V Manoj Kumar and P Prasuna Rani**
Department of Entomology, Agricultural College, Bapatla 522 101, Andhra Pradesh

**ABSTRACT**

A laboratory experiment was conducted during 2014–2015 in the Department of Entomology, Agricultural College, Bapatla, Andhra Pradesh to study influence of water quality on the efficacy of selected insecticides on larvae of *Spodoptera litura*. The results revealed that highest per cent mean larval mortality (54.7-58.0%) was observed when water with neutral pH (7.03) was used compared to that of pH 5.04 (52.7-56%) and pH 9.01 (50-52%) indicating greater efficacy of the insecticides at optimum pH. The per cent mortality decreased gradually from 58.7 to 52.7% and 56 to 50% with increasing solvent water EC 1.01-3.04 dS $m^{-1}$ and hardness 150-450 ppm, respectively indicating decrease in insecticidal efficacy on increasing the solvent water EC and hardness. Among the collected water samples when used as solvent in the preparation of the insecticidal spray solutions rain water was proved to be highly efficacious followed by canal, bore-well and sea water.

**Key words :** Pesticide efficacy, *Spodoptera litura*, Water quality.

Water is the most commonly used carrier for diluting pesticides applied as sprays, which constitutes of about 95 per cent of the spray solution to meet a wide array of pest control needs, application methods, environmental safety, handling and storage conditions. The quality of water used to mix with agricultural chemicals may come from various sources. Water chemistry may potentially react and change the efficacy of pesticides (Park and Chong, 2015).

## MATERIAL AND METHODS

Water samples with varied quality *viz.,* pH (5, 7 & 9), electrical conductivity (EC) (1, 2 & 3 dS $m^{-1}$) and hard water (150, 300 & 450 ppm) were prepared using distilled water. The pH of the samples was adjusted with 0.01 M acetic acid or 0.01 M sodium hydroxide using combined glass electrode DIGISUN electronics pH meter model: DI-707 (Jackson, 1973). The EC of the samples was adjusted with 0.01 M sodium chloride solution using an electrical conductivity bridge CM-180 (Jackson, 1973). The hardness of the samples was adjusted by Ethylene Diamine Tetra Aceticacid (EDTA) titration method (Kanwar and Chopra, 1976) by the addition of one per cent calcium chloride solution. Water samples were collected from different sources *viz.,* sea water from Bay of Bengal, Suryalanka Beach (Bapatla), rain water in well washed glass containers, canal and bore-well water from Agricultural College Farm, Bapatla.

The test insect *Spodoptera litura* Fab. was reared on the leaves of castor, *Ricinus communis* Linn. in the laboratory at a room temperature of 27 $^0$C ± 4 and 70% relative humidity. Procedure described by Tabashnik and Cushing (1987) was adopted for the leaf dip bioassay. Third instar larvae of *S. litura* were exposed to the test insecticides at six different concentrations using water with varied quality as diluent including control in which only distilled water was taken. Fresh castor leaves were taken, and washed. Nine centimeter leaf discs were cut and dipped in test solutions for ten seconds with gentle agitation and were placed on filter paper for drying. The leaf discs were placed in nine centimeter glass petri dishes in three replicates. Ten larvae were placed in each petridish with a fine camel hair brush and were covered with lids. Per cent mortality at different concentration levels of the insecticides was recorded after 24 hours of the exposure to the insecticides.

Per cent larval mortality was calculated using the formula

$$\% \text{ mortality} = \frac{\text{No. of insects dead}}{\text{Total number of insects released}} \times 100$$

Table. 1. Influence of solvent water quality on efficacy of acephate spray solutions against third instar larvae of *Spodoptera litura* by leaf dip method at 24 hours after treatment

| S.No. | Water samples | | Per cent larval mortality of *S. litura* against acephate spray solutions at different concentrations. | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | 20ppm | 40ppm | 60ppm | 80ppm | 100ppm | Mean |
| I | Prepared samples | | | | | | | |
| | A) pH | 5.04 | 26.7(31.1)$^{cd}$ | 36.7(37.3)$^{c}$ | 53.3(46.9)$^{ab}$ | 66.7(48.9)$^{cdefg}$ | 83.3(66.3)$^{abc}$ | 52.7(45.6)$^{cdefg}$ |
| | | 7.03 | 33.3(35.3)$^{a}$ | 40.0(39.3)$^{b}$ | 56.7(48.9)$^{a}$ | 70.0(50.4)$^{ab}$ | 83.3(66.4)$^{ab}$ | 56.0(47.4)$^{ab}$ |
| | B) EC | 9.01 | 23.3(28.9)$^{e}$ | 33.3(35.3)$^{d}$ | 50.0(45.0)$^{bc}$ | 63.3(48.5)$^{defghi}$ | 73.3(59.1)$^{j}$ | 52.0(45.4)$^{cdefgh}$ |
| | | 1.01 dS m$^{-1}$ | 30.0(33.2)$^{b}$ | 36.7(37.3)$^{c}$ | 56.7(48.9)$^{a}$ | 70.0(50.0)$^{abc}$ | 83.3(66.3)$^{abc}$ | 56.0(46.4)$^{abcd}$ |
| | C) Hardness | 2.03 dS m$^{-1}$ | 26.7(31.1)$^{cd}$ | 33.3(35.3)$^{d}$ | 53.3(46.9)$^{ab}$ | 70.0(49.2)$^{bcdef}$ | 80.0(63.6)$^{bcdefg}$ | 54.0(46.1)$^{cde}$ |
| | | 3.04 dS m$^{-1}$ | 26.7(31.1)$^{cd}$ | 33.3(35.3)$^{d}$ | 53.3(46.9)$^{ab}$ | 66.7(48.9)$^{cdefg}$ | 80.0(63.7)$^{bcdef}$ | 52.7(45.7)$^{cdef}$ |
| | | 150 ppm | 30.0(33.2)$^{b}$ | 36.7(37.3)$^{c}$ | 56.7(48.9)$^{a}$ | 70.0(48.9)$^{cdefg}$ | 83.3(66.2)$^{abcd}$ | 54.0(46.1)$^{cde}$ |
| | | 300 ppm | 28.0(31.9)$^{bc}$ | 33.3(35.3)$^{d}$ | 53.3(46.9)$^{ab}$ | 66.7(48.7)$^{cdefgh}$ | 80.0(63.5)$^{bcdefgh}$ | 52.3(45.1)$^{efghi}$ |
| | | 450 ppm | 23.3 (28.9)$^{e}$ | 33.3 (35.2)$^{de}$ | 46.7 (43.1)$^{cd}$ | 66.7(49.2)$^{bcdef}$ | 76.7(61.2)$^{efghi}$ | 50.0(44.1)$^{ij}$ |
| II | Collected samples | | | | | | | |
| | A) Rain water | | 33.3 (35.3)$^{a}$ | 43.3 (41.2)$^{a}$ | 56.7 (48.9)$^{a}$ | 70.0 (51.2)$^{a}$ | 86.7(68.9)$^{a}$ | 58.0 (48.1)$^{a}$ |
| | B) Canal water | | 30.0 (33.2)$^{b}$ | 40.0 (39.3)$^{b}$ | 53.3 (46.9)$^{ab}$ | 70.0 (49.6)$^{bcd}$ | 83.3(66.0)$^{abcde}$ | 54.7(46.5)$^{abc}$ |
| | C) Bore-well water | | 26.7 (31.1)$^{cd}$ | 33.3 (35.3)$^{d}$ | 46.7 (43.1)$^{cd}$ | 63.3 (49.3)$^{bcde}$ | 76.7 (61.2)$^{efghi}$ | 49.3(43.9)$^{jk}$ |
| | D) Sea water | | 26.7(31.1)$^{cd}$ | 33.3(35.3)$^{d}$ | 46.7(43.1)$^{cd}$ | 60.0 (45.8)$^{j}$ | 73.3(59.1)$^{j}$ | 48.7 (43.5)$^{jkl}$ |
| III | Control | | 6.7(14.9)$^{f}$ | 6.3 (14.6)$^{f}$ | 8.3 (16.7)$^{e}$ | 7.7 (16.1)$^{k}$ | 7.0(15.2)$^{jk}$ | 7.2 (15.5)$^{m}$ |
| | SEm± | | 0.4 | 0.6 | 0.7 | 0.5 | 1.5 | 0.4 |
| | CD (P=0.05) | | 1.3 | 1.6 | 2.1 | 1.4 | 4.3 | 1.1 |
| | CV (%) | | 4.3 | 4.8 | 4.8 | 3.2 | 7.4 | 2.6 |

Values in parentheses are arcsine transformed values

In each column values with same alphabets are not significantly different at P=0.05

## RESULTS AND DISCUSSION

In the present study, the efficacy of different test insecticide spray solutions increased with increase in the concentrations of the insecticides. With reference to pH in general with all insecticides the mortality has increased with increase in water pH from 5.04 to 7.03 but significantly decreased at pH 9.01. Whereas, with increase in water EC (1.01-3.04 dS m$^{-1}$) and hardness (150-450 ppm) the efficacy of the test insecticides in terms of per cent mortality was decreased. Among the collected water samples, the insecticidal efficacy was higher when rain water was used as solvent followed by canal, bore-well and sea water samples.

### Acephate

Regarding the mean percent larval mortality of *S. litura* resulting from acephate spray solution prepared using water with pH 7.04 (56.0%) was significantly higher than that of pH 5.03 (52.7%) and 9.01 (52.0%) were & similarly EC 1.01 dS m$^{-1}$ (56.0%) was significantly higher than that of EC 2.03 dS m$^{-1}$ (54.0 %) and 3.04 dS m$^{-1}$ (52.7%). Whereas on increasing solvent water hardness from 150 to 450 ppm decrease in mortality 54.0 to 50.0% was observed and for the collected water *viz.,* rain (58.0%) and canal (54.7%) were significantly higher than that of bore-well (49.3%) and sea water (48.7%) which were at par. Lower insecticidal efficacy with higher pH (9.01) as solvent (Table.1.). This can be attributed to the reason that alkaline conditions might have induced the transformation of acephate to O,S-dimethylphosphorothioate (DMPT) by cleaving P-N bond (Chevron, 1972).

### Thiodicarb

The mean per cent larval mortality of *S. litura* resulting from thiodicarb spray solution prepared using water with pH 9.01 (50.0%) was significantly lower than that of pH 5.04 (55.3%)

Table. 2. Influence of solvent water quality on efficacy of thiodicarb spray solutions against third instar larvae of *S. litura* by leaf dip method at 24 hours after treatment.

| S.No. | Water samples | | Per cent larval mortality of *S. litura* against thiodicarb spray solutions at different concentrations | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | 20ppm | 40ppm | 60ppm | 80ppm | 100ppm | Mean |
| I | Prepared samples | | | | | | | |
| | A) pH | 5.04 | 26.7(31.1)$^{b}$ | 43.3(41.2)$^{b}$ | 53.3(46.9)$^{ab}$ | 70.0(56.8)$^{abcd}$ | 83.3 (66.1)$^{abcd}$ | 55.3 (48.5)$^{abcd}$ |
| | | 7.03 | 30.0 (33.2)$^{a}$ | 43.3 (41.2)$^{b}$ | 56.7 (48.9)$^{a}$ | 73.3 (59.0)$^{ab}$ | 86.7(68.7)$^{ab}$ | 57.3(49.7)$^{ab}$ |
| | B) EC | 9.01 | 23.3(28.9)$^{c}$ | 33.3(35.3)$^{d}$ | 46.7 (43.1)$^{d}$ | 63.3(52.8)$^{efg}$ | 76.7(61.5)$^{efg}$ | 50.0(45.1)$^{j}$ |
| | | 1.01 dS m$^{-1}$ | 30.0(33.2)$^{a}$ | 43.3 (41.2)$^{b}$ | 56.7(48.9)$^{a}$ | 70.0(56.9)$^{abc}$ | 83.3(66.1)$^{abcd}$ | 56.7(49.3)$^{abc}$ |
| | C) Hardness | 2.03 dS m$^{-1}$ | 30.0 (33.2)$^{a}$ | 43.3 (41.2)$^{b}$ | 53.3(46.9)$^{ab}$ | 66.7 (55.0)$^{cde}$ | 80.0(63.6)$^{cde}$ | 53.3(47.2)$^{cdefg}$ |
| | | 3.04 dS m$^{-1}$ | 23.3 (28.9)$^{c}$ | 40.0(39.3)$^{c}$ | 53.3(46.9)$^{ab}$ | 66.6 (54.8)$^{cdef}$ | 76.7(61.4)$^{efgh}$ | 53.3(47.1)$^{defgh}$ |
| | | 150 ppm | 30.0(33.2)$^{a}$ | 43.3 (41.2)$^{b}$ | 56.7(48.9)$^{a}$ | 70.0 (56.9)$^{abc}$ | 83.3 (66.1)$^{abcd}$ | 55.3 (48.4)$^{abcde}$ |
| | | 300 ppm | 30.0 (33.2)$^{a}$ | 43.3 (41.2)$^{b}$ | 53.3(46.9)$^{ab}$ | 70.0(56.8)$^{abcd}$ | 80.0(63.6)$^{cde}$ | 54.7 (48.0)$^{abcdef}$ |
| | | 450 ppm | 23.3(28.9)$^{c}$ | 40.0 (39.3)$^{c}$ | 50.0(45.0)$^{bc}$ | 66.7 (54.8)$^{cdef}$ | 76.7(61.2)$^{efghi}$ | 52.7 (46.8)$^{fghi}$ |
| II | Collected samples | | | | | | | |
| | A) Rain water | | 30.0 (33.2)$^{a}$ | 46.7 (43.1)$^{a}$ | 56.7 (48.9)$^{a}$ | 73.3(59.1)$^{a}$ | 86.7 (68.9)$^{a}$ | 57.3(49.8)$^{a}$ |
| | B) Canal water | | 30.0 (33.2)$^{a}$ | 43.3 (41.2)$^{b}$ | 56.7 (48.9)$^{a}$ | 73.3(59.0)$^{ab}$ | 83.3(66.2)$^{abc}$ | 57.3(49.7)$^{ab}$ |
| | C) Bore-well water | | 26.7 (31.1)$^{b}$ | 40.0(39.3)$^{c}$ | 53.3 (46.9)$^{ab}$ | 70.0 (56.8)$^{abcd}$ | 76.7(61.6)$^{def}$ | 53.3 (47.2)$^{cdefg}$ |
| | D) Sea water | | 22.7(28.4)$^{cd}$ | 33.3(35.3)$^{d}$ | 46.7(43.1)$^{d}$ | 63.3 (52.8)$^{efg}$ | 73.(59.1)$^{efghij}$ | 49.2(44.6)$^{jk}$ |
| III | Control | | 7.7 (16.1)$^{e}$ | 7.0(15.3)$^{e}$ | 7.7 (16.1)$^{e}$ | 9.3 (17.8)$^{h}$ | 7.7 (16.1)$^{k}$ | 7.9(16.2)$^{l}$ |
| | SEm± | | 0.5 | 0.6 | 0.7 | 1.1 | 1.6 | 0.5 |
| | CD (P=0.05) | | 1.3 | 1.8 | 2.0 | 3.3 | 4.5 | 1.4 |
| | CV (%) | | 4.5 | 4.8 | 4.6 | 6.4 | 7.7 | 3.2 |

Values in parentheses are arcsine transformed values
In each column values with same alphabets are not significantly different at P=0.05

and 7.03 (57.3%). Similarly, EC 1.01 dS m$^{-1}$ (56.7%) was significantly higher than that of EC 2.03 & 3.04 dS m$^{-1}$ (53.3%) and on increasing water hardness from 150 to 450 ppm), reduction in mortality from 55.3 to 52.7% was observed. For the collected water samples *viz.,* rain and canal (57.3%) were at par and significantly higher than that of bore-well (53.3%) and sea water (49.2%) (Table.2.).

**Lambda-cyhalothrin**

The mean per cent larval mortality of *S. litura* resulting from lambda-cyhalothrin spray solution prepared using water with pH 9.01 (50.0%) was significantly lower than that of pH 5.04 (53.3%) and 7.03 (54.7%). Whereas, with EC 1.01-3.04 dS m$^{-1}$ (54.7-53.3%) were at par but on increasing hardness from 150 to 450 ppm significant reduction in mortality from 52.7 to 50.7% was observed and for the collected water samples *viz.,* rain (56.7%) and canal (54.0%) were at par and significantly higher than that of bore-well (50.7%) and sea water (50.0%) were at par (Table.3.). Efficacy of lambda-cyhalothrin spray solution prepared using water with higher pH (9.01) was low because it might have been hydrolysed through nucleophilic attack of the hydroxyl ion leading to the formation of cyanohydrin derivative (Gupta *et al*, 1998)

**Indoxacarb**

The per cent mean mortality of *S. litura* resulting from indoxacarb spray solution prepared using water with increasing pH 5.04 to 7.03 significantly increased the mortality 56.0 to 58.0% and further on increasing pH 9.01 significant decrease in mortality to 51.3% was observed Whereas, the mortality in spray solution prepared using water with EC 3.04 dS m$^{-1}$ (53.3%) was significantly lower when compared to that of EC 1.01 dS m$^{-1}$ (58.7%) and 2.03 dS m$^{-1}$ (56.7%), respectively. The mortality recorded in the spray solutions using water with hardness 300 (52.7%)

Table. 3. Influence of solvent water quality on efficacy of lambda-cyhalothrin spray solutions against third instar larvae of *S. litura* by leaf dip method at 24 hours after treatment

| S.No. | Water samples | | Per cent larval mortality of *S. litura* against lambda-cyhalothrin spray solutions at different concentrations | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | 50 ppm | 100 ppm | 150 ppm | 200 ppm | 250 ppm | Mean |
| I | Prepared samples | | | | | | | |
| | A) pH | 5.04 | 26.7(31.1)$^{b}$ | 36.7 (37.3)$^{c}$ | 50.0(45.0)$^{ab}$ | 70.0(56.8)$^{cdef}$ | 80.0 (63.8)$^{bc}$ | 53.3 (47.3)$^{abcd}$ |
| | | 7.03 | 30.0 (33.2)$^{a}$ | 43.3 (41.2)$^{a}$ | 53.3(46.9)$^{a}$ | 76.7(61.2)$^{ab}$ | 83.3(66.0)$^{a}$ | 54.7 (48.1)$^{ab}$ |
| | B) EC | 9.01 | 23.3 (28.9)$^{c}$ | 33.3(35.3)$^{d}$ | 46.7 (43.1)$^{bc}$ | 70.0(56.8)$^{cdef}$ | 76.7(61.2)$^{bcdefgh}$ | 50.0(45.0)$^{ghij}$ |
| | | 1.01 dS m$^{-1}$ | 26.7(31.1)$^{b}$ | 40.0 (39.3)$^{b}$ | 50.0 (45.0)$^{ab}$ | 76.7(61.2)$^{ab}$ | 80.0(63.9)$^{ab}$ | 54.7 (48.0)$^{ab}$ |
| | C) Hardness | 2.03 dS m$^{-1}$ | 26.7 (31.1)$^{b}$ | 40.0(39.3)$^{b}$ | 50.0 (45.0)$^{ab}$ | 73.3(59.0)$^{abc}$ | 80.0 (63.7)$^{abcd}$ | 53.3 (48.1)$^{abcd}$ |
| | | 3.04 dS m$^{-1}$ | 23.3 (28.9)$^{c}$ | 33.3(35.3)$^{d}$ | 46.7(43.1)$^{bc}$ | 70.0(56.8)$^{cdef}$ | 80.0(63.5)$^{abcdef}$ | 53.3(47.1)$^{abcde}$ |
| | | 150 ppm | 26.7 (31.1)$^{b}$ | 40.0 (39.3)$^{b}$ | 50.0 (45.0)$^{ab}$ | 73.3(59.0)$^{abc}$ | 80.0 (63.6)$^{abcde}$ | 52.7(47.0)$^{bcdef}$ |
| | | 300 ppm | 26.7(31.1)$^{b}$ | 33.3(35.3)$^{d}$ | 50.0 (45.0)$^{ab}$ | 70.0 (56.9)$^{cde}$ | 80.0 (63.5)$^{abcdef}$ | 51.3 (46.0)$^{fg}$ |
| | | 450 ppm | 23.3(28.9)$^{c}$ | 33.3 (35.3)$^{d}$ | 46.7(43.1)$^{bc}$ | 70.0(56.8)$^{cdef}$ | 76.7(61.3)$^{bcdefg}$ | 50.7 (45.5)$^{gh}$ |
| II | Collected samples | | | | | | | |
| | A) Rain water | | 30.0 (33.2)$^{a}$ | 43.3 (41.2)$^{a}$ | 53.3 (46.9)$^{a}$ | 76.7 (61.3)$^{a}$ | 83.3(66.0)$^{a}$ | 56.7(49.1)$^{a}$ |
| | B) Canal water | | 26.7(31.1)$^{b}$ | 40.0 (39.3)$^{b}$ | 50.0(45.0)$^{ab}$ | 70.0(57.0)$^{cd}$ | 80.0(63.8)$^{abc}$ | 54.0(47.6)$^{abc}$ |
| | C) Bore-well water | | 26.7(31.1)$^{b}$ | 33.3 (35.3)$^{d}$ | 50.0 (45.0)$^{ab}$ | 70.0 (56.9)$^{cde}$ | 76.7(61.3)$^{bcdefg}$ | 50.7(45.5)$^{gh}$ |
| | D) Sea water | | 20.0(26.6)$^{d}$ | 30.0(33.2)$^{e}$ | 43.3(41.2)$^{cd}$ | 66.7 (54.8)$^{g}$ | 76.7(61.2)$^{bcdefgh}$ | 50.0(45.1)$^{ghi}$ |
| III | Control | | 7.7 (16.1)$^{e}$ | 8.3(16.8)$^{f}$ | 7.7 (16.0)$^{e}$ | 7.7 (16.1)$^{h}$ | 6.7(14.9)$^{i}$ | 7.6 (15.9)$^{k}$ |
| | SEm± | | 0.4 | 0.5 | 0.7 | 1.0 | 1.3 | 0.4 |
| | CD (P=0.05) | | 1.2 | 1.4 | 2.0 | 3.0 | 3.8 | 1.0 |
| | CV (%) | | 4.2 | 4.1 | 4.8 | 5.6 | 6.6 | 2.4 |

Values in parentheses are arcsine transformed values

In each column values with same alphabets are not significantly different at P=0.05

and 450 ppm (51.3%) were at par but significantly lower than that of hardness 150 ppm (56.0%). The mortality recorded using the collected water samples *viz.,* rain (59.3%) and canal (58.0%) were at par and significantly different and higher than that of bore-well (53.3%) and sea water (51.3%) which were at par. (Table.4.). Lower efficacy of indoxacarb in alkaline conditions because it may have degraded to IN-KT413 and IN-MF014 (Singles, 2004).

Regarding EC, with increase in the EC of the water as spray solvent, decline in the insecticidal efficacy was observed. This can be ascribed to the fact that with increase in electrical conductance there is an increase in the positively charged ions which may react with the negatively charged pesticide molecules and render the pesticide ineffective. Whereas, with increase in the hardness of the water as spray solvent decline in the efficacy was observed. This can be supported with the basis that with increase in water hardness there is an increase in the Calcium, Magnesium, Sodium, Iron ions *etc.,* which may assemble with pesticide molecules and render the active ingredient inefficacious (Ebeling, 1963).

Higher per cent mortality (76%) of *S. litura* with endosulfan (0.07%) when spray fluids are prepared with rain and river water compared to the mortality (52%) resulted with the spray fluid prepared with sea water. Similar results were obtained in the present study as-well the rain water used as spray solvent was found effective followed by canal water and bore-well water. This can be attributed to the reason that rain water was pure in physical and chemical composition and devoid of ions, salts, colloids *etc.,* and thus has less effect on the pesticide efficacy. Whereas chemical substituents in sea water like bicarbonates, carbonates, sulphates, chlorides, nitrates of calcium and magnesium may in general interfere with the pesticides and result inactivation of the spray fluids due to breakdown or precipitation. Hence, sea water with high salinity and hardness should be the least choice as solvent for the preparation of spray solutions.

Table 4. Influence of solvent water quality on efficacy of indoxacarb spray solutions against of third instar larvae of *S. litura* by leaf dip method at 24 hours after treatment.

| S.No. | Water samples | | Per cent larval mortality of *S. litura* against indoxacarb spray solutions at different concentrations | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | 4 ppm | 8 ppm | 12 ppm | 16 ppm | 20 ppm | Mean |
| I | Prepared samples | | | | | | | |
| | A) pH | 5.04 | 26.7 (31.1)$^{c}$ | 36.7(37.3)$^{d}$ | 53.3 (46.9)$^{c}$ | 70.0(56.9)$^{bcde}$ | 83.3 (66.1)$^{ab}$ | 56.0 (48.9)$^{cdef}$ |
| | | 7.03 | 33.3 (35.3)$^{a}$ | 43.3(41.2)$^{b}$ | 60.0(50.8)$^{ab}$ | 73.3(59.0)$^{abc}$ | 83.3 (66.1)$^{ab}$ | 58.0(50.0)$^{abc}$ |
| | B) EC | 9.01 | 23.3 (28.9)$^{d}$ | 33.3 (35.3)$^{e}$ | 50.0(45.0)$^{cd}$ | 70.0(56.9)$^{bcde}$ | 80.0(63.9)$^{abcd}$ | 51.3(46.0)$^{ghi}$ |
| | | 1.01 $dS\ m^{-1}$ | 33.3 (35.3)$^{a}$ | 43.3 (41.2)$^{b}$ | 60.0(50.8)$^{ab}$ | 73.3(59.0)$^{abc}$ | 83.3 (66.1)$^{ab}$ | 58.7(50.5)$^{ab}$ |
| | C) Hardness | 2.03 $dS\ m^{-1}$ | 30.0 (33.2)$^{b}$ | 40.0(39.3)$^{c}$ | 53.3(46.9)$^{c}$ | 70.0(56.9)$^{bcde}$ | 83.3 (66.0)$^{abc}$ | 56.7(49.3)$^{bcde}$ |
| | | 3.04 $dS\ m^{-1}$ | 23.3(28.9)$^{d}$ | 36.7(37.3)$^{d}$ | 50.0(45.0)$^{cd}$ | 70.0(56.9)$^{bcde}$ | 80.0(63.6)$^{abcdef}$ | 53.3(47.2)$^{g}$ |
| | | 150 ppm | 33.3(35.3)$^{a}$ | 43.3(41.2)$^{b}$ | 53.3(46.9)$^{c}$ | 70.0(56.9)$^{bcde}$ | 83.3(66.1)$^{ab}$ | 56.0(48.9)$^{cdef}$ |
| | | 300 ppm | 30.0(33.2)$^{b}$ | 33.3(35.3)$^{e}$ | 50.0(45.0)$^{cd}$ | 70.0 (57.0)$^{bcd}$ | 83.3(66.1)$^{ab}$ | 52.7(47.0)$^{gh}$ |
| | | 450 ppm | 23.3(28.9)$^{d}$ | 33.3(35.3)$^{e}$ | 50.0 (45.0)$^{cd}$ | 70.0(56.8)$^{bcdef}$ | 80.0(63.6)$^{abcdef}$ | 51.3(45.9)$^{ghij}$ |
| II | Collected samples | | | | | | | |
| | A) Rain water | | 33.3(35.3)$^{a}$ | 46.7(43.1)$^{a}$ | 63.3 (52.8)$^{a}$ | 76.7(61.3)$^{a}$ | 83.3(66.2)$^{a}$ | 59.3(50.9)$^{a}$ |
| | B) Canal water | | 33.3(35.3)$^{a}$ | 46.7(43.1)$^{a}$ | 63.3(52.8)$^{a}$ | 73.3(59.1)$^{ab}$ | 83.3 (66.2)$^{a}$ | 58.0(49.9)$^{abcd}$ |
| | C) Bore-well water | | 23.3(28.9)$^{d}$ | 43.3(41.2)$^{b}$ | 53.3(46.9)$^{c}$ | 70.0 (56.9)$^{bcde}$ | 80.0(63.8)$^{abcde}$ | 53.3 (47.2)$^{g}$ |
| | D) Sea water | | 20.3(26.9)$^{e}$ | 33.3(35.3)$^{e}$ | 43.3(41.2)$^{e}$ | 70.0(56.8)$^{bcdef}$ | 80.0 (63.5)$^{abcdefg}$ | 51.3(45.9)$^{ghij}$ |
| III | Control | | 7.0(15.3)$^{f}$ | 7.3(15.7)$^{f}$ | 8.3(16.7)$^{f}$ | 8.3(16.7)$^{g}$ | 7.0(15.3)$^{h}$ | 7.6(16.0)$^{k}$ |
| | SEm± | | 0.5 | 0.6 | 0.8 | 1.2 | 1.4 | 0.5 |
| | CD (P=0.05) | | 1.4 | 1.7 | 2.3 | 3.4 | 4.1 | 1.3 |
| | CV (%) | | 4.6 | 4.7 | 5.4 | 6.4 | 6.8 | 3.0 |

Values in parentheses are arcsine transformed values

In each column values with same alphabets are not significantly different at P=0.05

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